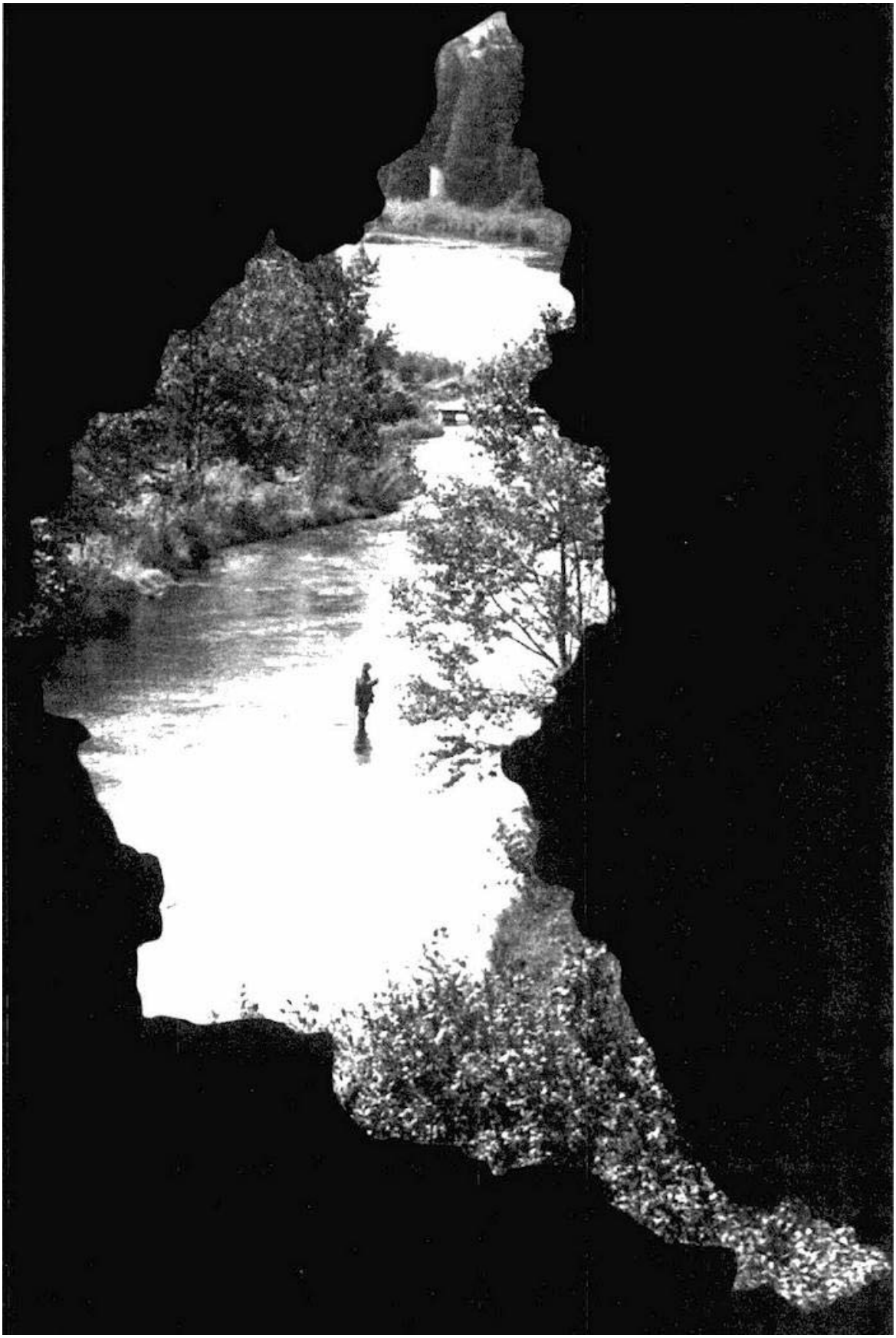
Grand River Basin Water Management Study

SUMMARY
AND
RECOMMENDATIONS

Ontario

Grand River
Implementation
Committee



Grand river basin water management study : summary and recommendations.
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THE GRAND RIVER

Grand River Basin Water Management Study

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Grand River
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1982

PREFACE

This report summarizes the water resource problems encountered in the Grand River basin and presents a set of recommendations to guide basin water management.

A more detailed discussion of the study finds and conclusions is available in a full-length report entitled **Grand River Basin Water Management Study.** Technical reports are also available which detail results of individual studies carried out by the study team.

The recommendations in this report were prepared by the Grand River Implementation Committee, made up of members from the following five participating ministries and agencies:

- Ontario Ministry of Agriculture and Food
- Ontario Ministry of the Environment
- Ontario Ministry of Municipal Affairs and Housing
- Ontario Ministry of Natural Resources
- Grand River Conservation Authority

The Committee was aided in making its recommendations by extensive municipal and public consultation programs. Basin municipalities were represented on technical sub-committees and they provided information and advice throughout the study. Public input was provided by four consultation working groups made up of citizens from different areas of the basin.

Additional copies of this "Summary and Recommendations" may be obtained from:

a) in person from the Ontario Government Bookstore, 880 Bay Street, Toronto, Ontario.

b) by mail from the Ontario Government Publications Centre, 5th Floor, 880 Bay Street, Toronto, M5S 1Z8.

c) Grand River Conservation Authority
Community Relations Division
400 Clyde Road
Cambridge,
Ontario, N1R 5W6

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Summary

The main investigative period of the Grand River Basin Water Management Study extended from 1977 to 1981. Its purpose was to define the water management problems confronting the Grand river basin, and to develop a viable set of alternative water management plans. These plans are designed to meet the following water management objectives:

1) reduce flood damages
2) provide adequate water supply
3) maintain adequate water quality.

This study provides a comprehensive framework to aid elected representatives, officials and citizens in resolving water management problems. The framework is flexible enough to accommodate changing water management priorities and needs. It provides a means by which new projects and other plans can be evaluated.

Large scale water management problems are largely confined to the urban and industrial middle portion of the basin. Here, the Cities of Cambridge and Brantford account for over 85 percent of the $980,000 average annual flood damages experienced within the basin. In the Kitchener-Waterloo-Cambridge area, the existing ground water supply for industrial and domestic consumption will have to be supplemented in the next five years by additional surface and ground water supplies. Low oxygen levels occur during the critical summer period in the central Grand river between Kitchener and Glen Morris and in the Speed river downstream from Guelph. This is caused by organic waste discharges and nutrient inputs from six municipal sewage treatment plants and by upstream rural non-point sources. While water management problems are often the most apparent in the middle portion of the basin, flooding, water shortages and water quality impairment are encountered throughout the basin in rural as well as urban areas. Pollution control measures recommended in this report to maintain or improve the water quality within the river basin will also benefit Lake Erie, particularly measures to reduce the input of nutrients.

The basin study examined twenty-six different water management plans and assessed their relative economic, social and environmental costs and benefits associated with meeting the water management objectives. An evaluation process narrowed these alternatives down to the following main plans:

1. plan A1 utilizes dyking and channelization to minimize flood damages, advanced sewage treatment to improve water quality, and induced infiltration wells and artificial recharge of aquifers using river water to augment ground water supplies

2. plan A4 is the same as plan A1, but, in addition, preserves the option of using the Montrose reservoir site for possible future water management purposes. Protection of the site can be achieved by acquiring the land as it becomes available and by various planning controls.

3. plan B2 proceeds immediately with construction of the Montrose multi-purpose dam and reservoir. Flood damage reduction is provided by the reservoir as well as by dyking and channelization. Water quality is improved by advanced sewage treatment and increased summer flow from the reservoir.

Requirements for advanced sewage treatment when compared with plan A are reduced or delayed. infiltration wells and artificial recharge are used to augment ground water supplies as in plan A1.

4. plan C1 is the same as plan A1 with respect to water quality and water supply measures. It provides flood protection through the construction of a single-purpose or dry reservoir on the Conestogo River at St. Jacobs.

5. plan D incorporates the flood protection and water quality measures of plan A1 and provides water supply by the construction of a Lake Erie pipeline.

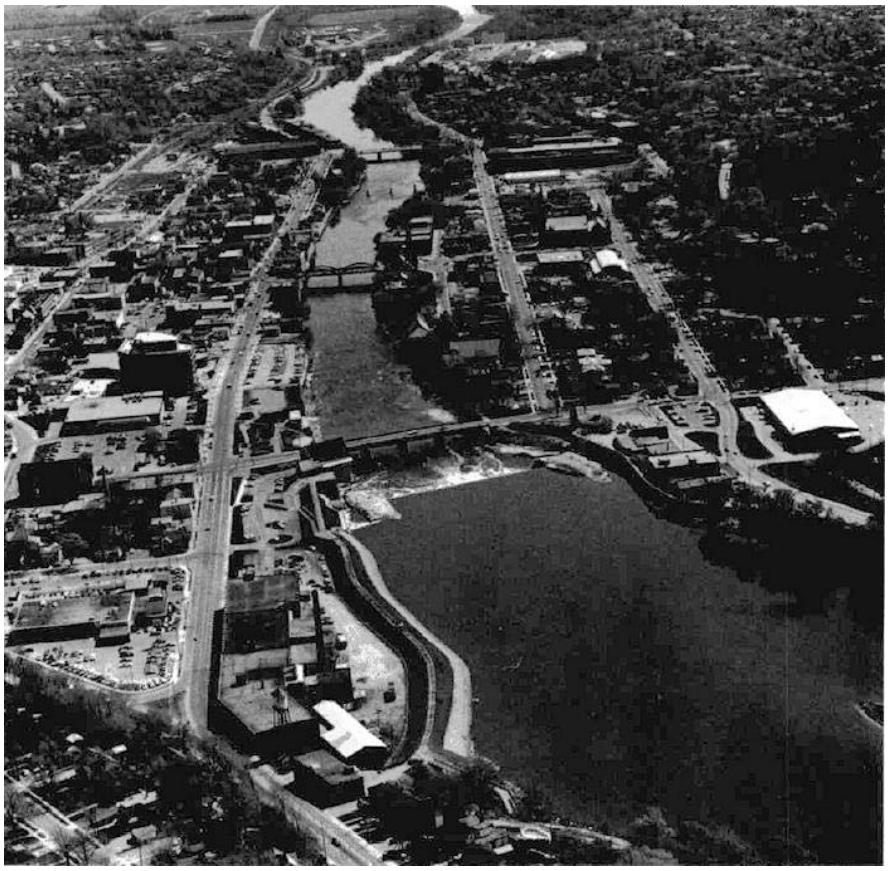
The advantages and disadvantages of these plans are compared in a Table on page 13.

In the initial review of these plans, the basin study assigned lower rankings to plans C1 and D. Plan C1, the St. Jacobs single-purpose reservoir option, will not give adequate flood protection and plan D, the Lake Erie pipeline option, was deemed to be too expensive.

A detailed evaluation of plans A1, A4 and B2 was then carried out. Three of the four public consultation working groups, made up of citizens from different geographical areas of the basin, preferred plan A1 with minimum environmental and social impacts. The fourth group representing the lower portion of the basin, preferred plan B2. The water managers who are charged with the day-to-day responsibility of operating major flood control, water supply and sewage treatment services preferred plan B2 because, in their view, it offered a more reliable and secure water management system.

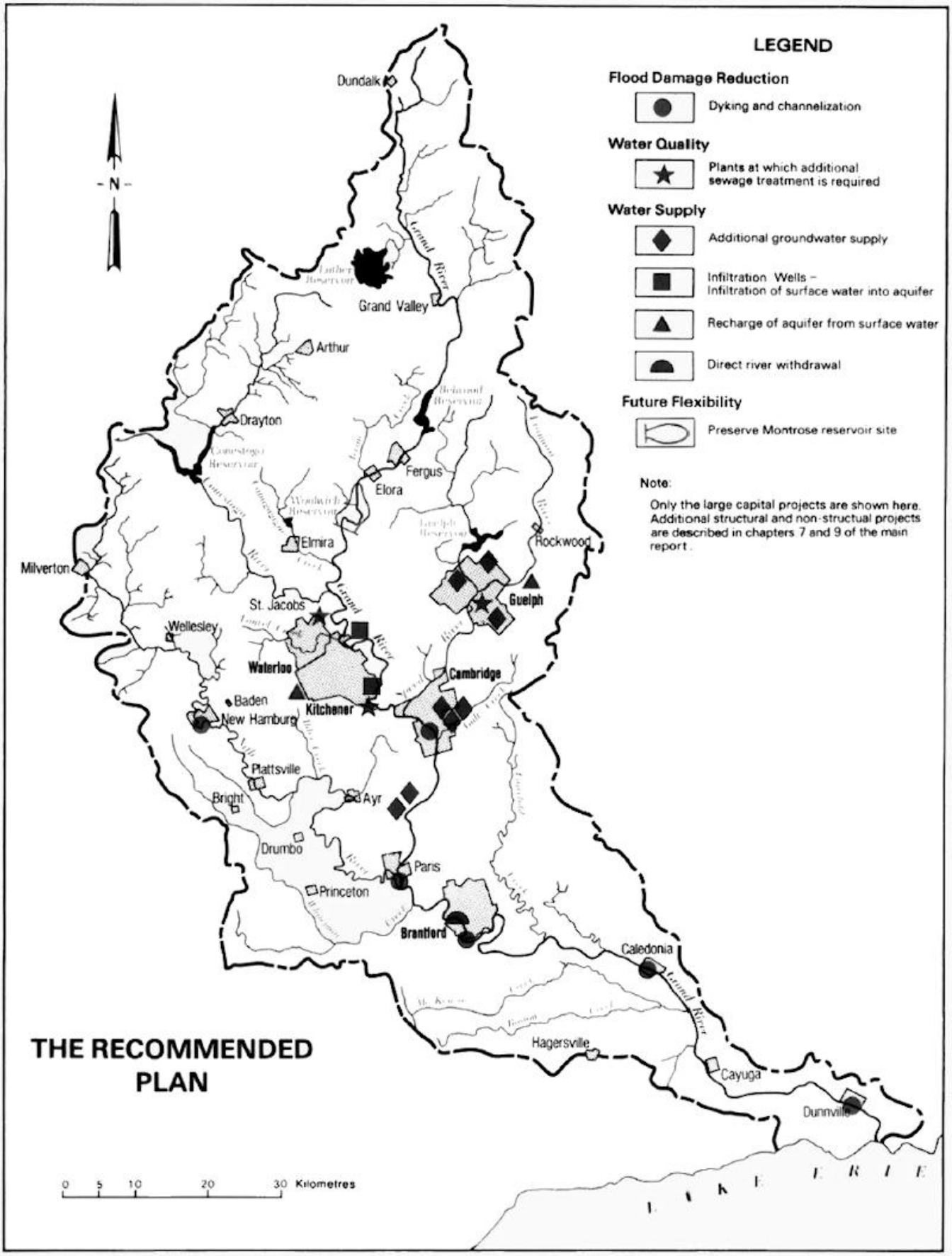
The overall results of the evaluation incorporating the preferences of all those who participated showed that plans A1, A4 and B2 were ranked very closely.

After a detailed review of the various inputs, the Grand River Implementation Committee, the basin study's co-ordinating committee, identified plan A4 as the preferred plan to meet the water management needs of the basin.



The Urban Grand River

The Rural Grand River


LEGEND
Flood Damage Reduction
Dyking and channelization
Water Quality
Plants at which additional sewage treatment is required
Water Supply
Additional groundwater supply
Infiltration Wells – Infiltration of surface water into aquifer
Recharge of aquifer from surface water
Direct river withdrawal
Future Flexibility
Preserve Montrose reservoir site
Note:
Only the large capital projects are shown here. Additional structural and non-structual projects are described in chapters 7 and 9 of the main report.
- N -
Dundalk
Grand Valley
Arthur
Drayton
Fergus
Elora
Elmira
Milverton
Rockwood
Guelph
St. Jacobs
Wellesley
Waterloo
Cambridge
Kitchener
Baden
New Hamburg
Plattsville
Bright
Ayr
Drumbo
Paris
Princeton
Brantford
Caledonia
Hagersville
Cayuga
Dunnville
0 5 10 20 30 Kilometres
THE RECOMMENDED PLAN

Recommendations

A. The Recommended Plan

1. It is recommended that plan A4 and the measures described in the following recommendations be implemented.

The basin study concluded that plan A4 is cost-effective in meeting the water management objectives. It was preferred over plan B2 (the Montrose dam option) for the following reasons:

a) it is approximately $25 million cheaper than plan B2.

b) its environmental and social impacts are moderate. The public participation program indicated that there would be opposition to the selection of plan B2.

c) it maintains future flexibility by preserving the option of constructing the Montrose dam if future water quality or water supply problems require it.

d) it provides a high degree of flood protection for urban areas.

e) it provides for population growth by fully meeting projected municipal water demands and improving water quality in the central Grand river.

f) improves water quality in the central Grand river, although the dissolved oxygen levels will not fully meet the provincial water quality objectives. While plan A4 does not provide as high a water quality as plan B2, it provides a reasonable level of protection for most water uses at a substantially lower cost.

Plan A4 is the same as plan A1 except that land acquisition raises total plan costs by $4 million and increases the social impacts. It was preferred over plan A1 primarily because it maintains future flexibility by preserving the Montrose reservoir lands.

In the opinion of the Grand River Implementation Committee, plan A4 represents the best overall solution to basin water management problems. The recommendation of this plan does not necessarily preclude selection of all or part of another. This report defines the water management problems confronting the Grand river basin and establishes a framework within which water management projects and measures can be implemented. The framework is flexible enough to accommodate future water management priorities and needs.

B. Recommendations for Reduction of Flood Damages

The basin study investigated both structural and non-structural methods of reducing flood damages. Structural methods include dyking, channelization, reservoirs and flood proofing. Non- structural methods include regulations, zoning and land use practices.

1. It is recommended that channelization and dyking be constructed to reduce flood damages at the major flood damage centres.

Average annual flood damages at Cambridge, Brantford, Paris, Caledonia, Dunnville and New Hamburg can be reduced 91 percent by channelization and dyking as compared to a 54-56 percent reduction by the Montrose reservoir, the most efficient of the eight reservoirs investigated. Channelization and dyking is the most cost-effective structural method of reducing flood damages. In order to be effective, each dyking and channelization project should be completed as soon as possible.

2. It is recommended that Grand River Conservation Authority policies for regulating floodplain development be continued in accordance with provincial policies and guidelines and that basin municipalities incorporate floodplain restrictions in their official plans and zoning by-laws.

Regulating floodplain development is the best means of reducing or eliminating future flood damages. While structural projects such as dyking and channelization are useful in reducing flood damages, they do not guarantee immunity from floods at all places and at all times.

3. While existing Grand River Conservation Authority policies control the placing and dumping of fill in defined areas, it is recommended that these policies be strengthened by the inclusion of a registered fill line along the river valleys.

Section 28 (f) of the Conservation Authorities Act enables conservation authorities to prohibit or control the placing or dumping of fill in defined areas. In order to enforce this section of the Act, the Authority must designate the area affected by such dumping with fill lines. At present, only specific source areas are protected by fill lines. Designated areas should be expanded to include basin watercourses.

4. It is recommended that the Eramosa valley wetlands be preserved and protected from development by planning controls and by acquisition.

These wetlands adjacent to the river reduce flows by retarding runoff and reducing peak flows. They also maintain a high water quality by acting as buffer strips between the adjoining agricultural lands and the river. A high water quality ensures a low cost supplementary water supply for Guelph and a suitable habitat for a cold-water fishery in the Eramosa river.

5. It is recommended that a study be carried out to determine what land use practices are causing an increase in flood flows and flood volumes on the Grand river and what the effects of future land use practices upon flood flows might be.

At Cambridge (Galt), flood volumes have increased 18 percent and the frequency of flood occurrences has more than doubled in the last forty years, but the study was unable to come to a firm conclusion as to the causes.

C. Recommendations for Providing Adequate Water Supply

The basin study determined that the future water needs of the major urban areas can be obtained by:

a) developing new ground water sources for Cambridge and Guelph
b) developing a new surface water source from the Grand river for Waterloo and Kitchener
c) continued withdrawal from the Grand river for Brantford.

All other basin communities except Elora and Fergus can meet future demands from existing supplies. Elora and Fergus can meet future demands by developing new ground water sources.

1. It is recommended that the municipal ground water supplies for Kitchener-Waterloo be supplemented by further water withdrawals from the Grand river.

These withdrawals can be accomplished by induced infiltration wells near the river and by pumping from the river to recharge ground water at the Mannheim well field. Testing is presently being carried out by the Regional Municipality of Waterloo to determine the feasibility of this scheme.

2. It is recommended that prior to the final development of the above water supply system:

a) industrial organics presently seeping from abandoned industrial waste disposal sites at Breslube Enterprises, near Kitchener, be eliminated or prevented from reaching the adjacent Grand river,
b) a water quality surveillance program be established to evaluate risks from possible contamination of the water supply from any sources of synthetic organic compounds.

The most notable potential sources of organic chemicals are the Uniroyal Ltd. plant at Elmira on Canagagigue creek and the Waterloo sewage treatment plant on the Grand river. The recommended surveillance program should be developed to protect existing and future surface water supplies, particularly for the Cities of Kitchener, Waterloo and Brantford.

3. It is recommended that:

a) new ground water supplies be developed near Cambridge to meet future demands,
b) the City of Guelph investigate the feasibility of developing new ground water supplies, directing its attention toward the southeast of Guelph in order to meet future demands past the year 2001,
c) Elora and Fergus carry out test drilling in a nearby buried bedrock valley to assess its potential for future municipal supplies.

A recent study by the Regional Municipality of Waterloo indicated that there are additional ground water supplies located in the areas east and south of Cambridge.

For Elora, Fergus and Guelph, it is estimated that existing supplies can meet average daily demands for a 2001 medium population projection. The Grand river basin study has identified favourable locations for test drilling in these areas.

4. It is recommended that a ground water quality network be established to monitor the major water supply aquifers within the basin.

A ground water surveillance network should be established in the basin to deal with existing site-specific problems of contamination or possible contamination of usable ground water supplies. In particular, the network should monitor heavy metal, pesticides and other inorganic and organic compounds. This network should be established as soon as possible. This undertaking should be carried out in conjunction with the surface water surveillance program recommended in C.2 (b).

5. It is recommended that the water conservation program be continued in the Regional Municipality of Waterloo, particularly in Waterloo, Kitchener and Cambridge, in order to reduce municipal water demands. For other municipalities, the pursuit of water conservation programs should be evaluated in relation to future needs and supply capabilities.

Water conservation programs embrace a range of actions that aim at reducing average and maximum day municipal water demands. A moderate conservation program could be expected to reduce average day demand in Kitchener-Waterloo by 10 percent, and in Cambridge by 15 percent.

Conservation practices that have been adopted in Guelph are supported and encouraged in light of the potential water supply problem that may occur after the year 2001.

Included in any conservation program should be the consideration of revising the existing rate structure. Where appropriate, municipalities should consider moving from a decreasing rate structure to a rate structure that encourages water conservation.

System losses or unbilled consumption appear to be approximately 9 percent higher than the provincial average for Guelph and Brantford. Existing programs to trace and reduce these losses should be continued.

D. Recommendations to Maintain Adequate Water Quality

The basin study concluded that water quality in the central Grand river can be improved by increased levels of sewage treatment at the Kitchener and Waterloo sewage treatment plants. Some improvement in water quality can also be obtained by reducing upstream rural non-point sources, particularly through the use of erosion control measures.

Water quality in the Speed river will be improved by the recently completed advanced sewage treatment facilities at Guelph. If required, further improvement can be attained by the installation of additional phosphorus removal facilities.

1. In order to increase dissolved oxygen levels and eliminate ammonia toxicity in the central portion of the Grand river, it is recommended that advanced sewage treatment facilities be installed at the Kitchener sewage treatment plant as soon as possible, and at the Waterloo sewage treatment plant at a later date depending on population growth (advanced treatment at the Waterloo plant would *be* needed by the year 2001 for a medium population projection).

An increased level of sewage treatment at Kitchener and Waterloo will improve the water quality to a reasonable level in the central Grand river, but the provincial water quality objective for dissolved oxygen of 4 mg/L will not always be met in certain sections. Plan B2, through the use of flow augmentation from the Montrose reservoir, comes closest to achieving the objective.

Converting ammonia nitrogen to the nitrate form using rotating biological contactors (RBCs) and accompanying dual-media filters at Kitchener and Waterloo is one method of improving the quality of sewage effluent, thus increasing dissolved oxygen levels and reducing ammonia toxicity in the rivers. The cost of this treatment is included in all plan cost estimates.

Achieving the dissolved oxygen objective continuously in all sections of the central Grand river would require drastic deductions of oxygen-demanding wastes and phosphorus from all point and upstream rural non-point sources. Such large reductions from all point sources would be exceedingly expensive. Large reductions from non-point sources may be difficult to achieve. Reductions will require long-term, continuing improvements in technology and land use practices.

2. It is recommended that the impact of the Guelph advanced sewage treatment facilities on the water quality of the lower Speed River be evaluated throughout the next few years to determine if additional treatment is required.

The total effluent characteristics of the recently completed sewage treatment addition (rotating biological contactors and dual-media filtration) are not yet known. Assumed effluent characteristics were used for analyzing the basin study water management alternatives. If after a 2-3 year evaluation period, the Speed river between Guelph and Cambridge (Hespeler) is still experiencing very low oxygen levels, consideration must be given to reducing further the levels of phosphorus in the sewage effluent. One method of reducing phosphorus considered by the basin study is the addition of chemical treatment and multi-media filtration at the Guelph sewage treatment plant. The cost of this treatment is included in all the plan cost estimates.

3. In order to evaluate the effects of existing and proposed water quality improvements it is recommended that the Ministry of the Environment and the Grand River Conservation Authority jointly maintain the existing six continuous water quality monitoring stations in the central Grand river and the lower Speed River.

With the addition of remote sensing, these gauges would also aid in the real-time operation of existing reservoirs and sewage treatment plants.

4. It is recommended that the Ministry of Agriculture and food, as the lead agency, carry out studies to determine the effectiveness, type and site specific locations of rural non-point source controls. Initially, efforts should be concentrated in the Canagagigue creek, middle Grand river, Irvine creek, Cox creek, Conestogo and Nith River sub-basins.

Studies should be carried out to determine:

a) those critical areas contributing the greatest loadings of sediments and nutrients to the streams. Improved management practices should be concentrated in these areas.

b) the applicability and effectiveness of various rural non-point source management practices

c) the relation between the costs of these measures and the agricultural and water quality benefits obtained

d) priority of the areas to be treated.

5. It is recommended that urban areas adopt storm water management practices to reduce local flooding and improve stream water quality.

This study has shown that urban runoff does not affect the flood peak flows of the major rivers nor does it materially affect the dissolved oxygen regime in the Grand or Speed rivers. However, urban runoff increases bacteria levels immediately downstream of the major urban centres on these rivers. Increased levels of bacteria pose potential health hazards for incidental contact such as children playing at the river's edge. Urban runoff causes more serious flooding and water quality problems in small tributaries by raising stream levels rapidly and increasing concentrations of metals, bacteria and nutrients.

6. In order to achieve the flow requirements of plan A4 for both water supply and water quality, it is recommended that the Grand River Conservation Authority operating policy for the existing reservoirs be modified to achieve the following target flows:

Location	Period	Minimum Flow Targets		Operating Range *	
		Present	Recommended	Present	Recommended
Grand R. at Shand Dam	June-Sept.	2.8 m^3/s	2.8 m^3/s	N/A	N/A
	May-Oct.	2.8 m^3/s	2.8 m^3/s	N/A	N/A
	Nov.-Apr.	None	2.8 m^3/s	N/A	N/A
Grand R. at Doon	May-Oct.	11.3 m^3/s	9.9 m^3/s	11.3- 12.7 m^3/s	9.1- 10.8 m^3/s
	Nov.-Dec.	No Target	7.1 m^3/s	N/A	6.2 - 7.9 m^3/s
	Jan.-Apr.	Ice Conditions **			
Grand R. at Brantford	May-Oct.	17.0 m^3/s	17.0 m^3/s	17.0 -	15.6 - 18.4 m^3/s
	Nov.-Dec.	No Target	No Target	N/A	N/A
	Jan.-Apr.	Ice Conditions **			
Conestogo R. at Conestogo Dam	May-Oct.	2.1 m^3/s	2.1 m^3/s	N/A	N/A
	Jan.-Apr.	No Target	No Target	N/A	N/A
Speed R. at Guelph Dam	May-Oct.	0.6 m^3/s	0.6 m^3/s	N/A	N/A
	Jan.-Apr.	No Target	No Target	N/A	N/A
Speed R. at City of Guelph (Hanlon Expressway)	June-Sept.	1.1 m^3/s	1.7 m^3/s	N/A	N/A
	May-Oct.	1.1 m^3/s	1.1m^3/s	N/A	N/A
	Jan.-Apr.	Ice Conditions **			

* Because of the travel time from the reservoirs to the point of interest, the daily flows can vary from the target flow. The travel times from the reservoirs to Doon and Brantford are 30 and 48 hours respectively.

** When the river is ice covered, flows cannot be continuously measured.

N/A Not Applicable

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	May-Oct.	2.8 m^3/s	2.8 m^3/s	N/A	N/A
	Nov.-Apr.	None	2.8 m^3/s	N/A	N/A
Grand R. at Doon	May-Oct.	11.3 m^3/s	9.9 m^3/s	11.3 -12.7 m^3/s	9.1 - 10.8 m^3/s
	Nov.-Dec.	No Target	7.1 m^3/s	N/A	6.2 - 7.9 m^3/s
	Jan.-Apr.	Ice Conditions**			
Grand R. at Brant-ford	May-Oct.	17.0 m^3/s	17.0 m^3/s	17.0 - 18.4 m^3/s	15.6 - 18.4 m^3/s
	Nov.-Dec.	No Target	No Target	N/A	N/A
	Jan.-Apr.	Ice Conditions **			
Conestogo R. at Conestogo Dam	May-Oct.	2.1 m^3/s	2.1 m^3/s	N/A	N/A
	Jan.-Apr.	No Target	No Target	N/A	N/A
Speed R. at Guelph Dam	May-Oct.	0.6 m^3/s	0.6 m^3/s	N/A	N/A
	Jan.-Apr.	No Target	No Target	N/A	N/A
Speed R. at City of Guelph (Hanlon Expressway)	June-Sept.	1.1 m^3/s	1.7 m^3/s	N/A	N/A
	May-Oct.	1.1 m^3/s	1.1 m^3/s	N/A	N/A
	Jan.-Apr.	Ice Conditions**			

* Because of the travel time from the reservoirs to the point of interest, the daily flows can vary from the target flow. The travel times from the reservoirs to Doon and Brantford are 30 and 48 hours respectively.

** When the river is ice covered, flows cannot be continuously measured.

N/A Not Applicable

E. Recommendation to Protect the Montrose Reservoir Site

1. It is recommended that the Montrose reservoir site be protected for possible future water management purposes.

Protection of the Montrose reservoir site can be achieved by land acquisition and planning controls. Acquisition can be carried out over time by purchasing the land at the prevailing market price. Planning controls can be utilized in the form of land use regulations and zoning.

At some time in the future the land can either be sold, used for construction of a dam and reservoir, or preserved for other uses. In the meantime, the existing agricultural land use can be maintained and the site protected from development.

F. Recommendations to Implement the Plan and Co-ordinate Government Activities

1. It is recommended that the water management plan be implemented by existing government agencies.

Traditionally, the components of plan A4 have been implemented by the following agencies:

Flood control, flood warning, dyking and channelization	-	Grand River Conservation Authority Municipalities Ministry of Natural Resources
Flood proofing	-	Individual landowners
Water supply projects and sewage treatment plants	-	Municipalities Ministry of the Environment
Acquisition of Montrose reservoir land	-	Grand River Conservation Authority
Non-point source pollution control	-	Individual landowners Municipalities Grand River Conservation Authority Ontario Ministry of Agriculture and Food Ministry of the Environment Ministry of Natural Resources
Planning controls	-	Municipalities Grand River Conservation Authority Ministry of Municipal Affairs and Housing Ministry of Natural Resources

2. It is recommended that a committee be established to co-ordinate the activities of the existing agencies in implementing the water management plan preferred by governments.

The committee would consist of members from implementing ministries and agencies and basin municipalities. The committee would deal with the scheduling and implementation of measures selected to meet the water management needs of the basin.

3. It is recommended that such a co-ordinating committee play a lead role in carrying out a periodic re-evaluation of the plan, co-ordinating investigations and recommending new or modified alternatives to achieve the water management objectives of the Grand river basin.

The selected basin plan should be reviewed on an on-going basis and re-evaluated every five years. This will ensure that the plan is kept abreast of the latest developments in water resources management and that the assumptions made in deriving the original plan are still valid.

4. It is recommended that the co-ordinating committee be assisted in its on-going review by a small technical staff responsible to the co-ordinating committee.

The technical staff would aid the co-ordinating committee in reviewing the management plans and undertaking specific water management studies. The capability of this staff can be expanded as the need requires, by drawing upon the expertise of the basin universities and other agencies.

COMPARISON OF MAIN PLANS - MEDIUM POPULATION PROJECTION

Plan	Costs (Present value at 6% millions of 1979 $)	Benefits (Present value at 6% millions of 1979 $)	Advantages	Disadvantages
Plan A1, A2 • Dyking and channelization at New Hamburg, Cambridge (Galt and Preston), Paris. Brantford, Caledonia and Dunnville • Advanced sewage treatment for Kitchener, Waterloo and Guelph • Local sources of water supply Plan A1 - new ground water supplies for Cambridge Plan A2 - new water supply to Cambridge via Mannheim re-charge system	68* 66*	121 121	1. Lowest cost solution. 2. Minimal environmental and social impacts, localized to dyking and channelization sites. 3. Water quality on Grand and Speed rivers generally is improved, but does not meet MOE D.O. objective fully near Kitchener and Guelph. 4. Provides urban flood protection against floods greater than 100-year flood at sites with dyke protection (91% reduction to flood damages). 5. Meets water supply needs. 6. Socially most acceptable as reflected by Public Consultation Working Groups	1. Lower water quality on Grand river (Waterloo to Paris) than B1, B2. 2. No additional flood protection for areas not provided with dykes. 3. Hood damage reduction provided only if dyke projects are carefully planned and co-ordinated.
Plan A3 • Same as A1 plus Everton reservoir on Speed river	84*	121	1. Flood protection and water supply same as A1. 2. Water quality an Speed river below Guelph is better than A1, but still doesn't meet MOE D.O. objective fully	1-3. Same as A1. 4. Has detrimental impact on cold water fishery in reservoir site. 5. Reservoir increases A1 costs by $16 M.
Plan A4 • Same as A1 plus appropriate measures to be taken to preserve the Montrose reservoir site for possible future use	72* (Montrose lands disposed of in 2001) 83* (Reservoir constructed in 2001)	121 121	1. Water quality, flood protection and water supply same as A1. 2. Minimal environmental impacts (unless dam is constructed in the future). 3. Gradual social impacts during land acquisition. 4. Flexibility to handle future water quality uncertainties is increased. 5. Permits continued agricultural use of lands in reservoir acquisition area.	1-3 Same as A1. 4. Does not eliminate uncertainty about future land use. 5. No assurance that land-use planning can preserve the reservoir site except through provincially imposed regulations or purchase. 6. $4 M more costly than A1 if the reservoir is not built and $15 M more costly if the reservoir is built.
Plan B1 • Montrose darn • Advanced sewage treatment at Kitchener and Guelph • Local sources of water supply same as A1	74*	116	1. Water quality on Grand and Speed rivers is improved over plan A but still does not meet MOE D.O. objectives fully near Kitchener and Guelph. 2. Provides flood protection against a 10-year flood. 3. Provides additional flood protection for rural areas, 4. Meets water supply needs with greater flexibility for possible future needs. 5. Reservoir provides additional recreational opportunities.	1. Costs $8 M more than A1. 2. Has detrimental social and environmental impacts. 3. Provides less flood protection than A1. 4. Has considerable local opposition.
Plan B2 • Montrose dam. • Dyking and channelization same as A1. • Advanced sewage treatment at Kitchener and Guelph. • Local sources of water supply same as A1.	97*	122	1. Same as B1. 2. Provides urban flood protection against floods greater than a 100-year flood (96% reduction in flood damages) as A1. 3. Reduces the risk of dyke failure by reducing flood peaks. 4. Provides added protection if future flood flows increase due to changing land-use practices. 5. Provides additional flood protection for rural areas. 6. Meets water supply needs with greater flexibility for possible future needs. 7. Reservoir provides additional recreational activities.	1. Costs $29 M more than A1. 2. Has detrimental social and environmental impacts. 3. Has considerable local opposition.

Plan C1 • St. Jacobs dry reservoir with dyking and channelization at New Hamburg. • Advanced sewage treatment same as A1.	70*	115	1. Less environmental impact than Montrose dam. 2. Provides urban flood protection against a 10-year flood and reduces flood damage by 50-49%. 3. Water quality on the Grand and Speed rivers improved, but does not meet MOE D.O. objective fully near Kitchener and Guelph, 4. Meets water supply needs. 5. $25 M less costly than B2.	1. Has detrimental social impact. 2. Provides less urban flood protection than A1, A2, B1 and B2. 3. $4 M more costly than A1.
Plan C2 • Montrose small dry reservoir, 24.7 million m^3 (20,000 acre-ft) with dyking and channelization at New Hamburg. • Advanced sewage treatment same as A1. • Local sources of water supply same as A1.	73*	116	1 - 4. Same as C1. 5. $22 M less costly than B2. 6. Reduces flood damages by 56-54%.	1 - 3. Same as C1. 4. $7 M more costly than A1.
Plan C3 • Montrose large dry reservoir. 77.7 million m^3 (63.000 acre-ft) with dyking and channelization at New Hamburg. • Advanced sewage treatment same as A1. • Local sources of water supply same as A1.	87*	116	1-4. Same as C1. 5. $8 M less costly than 82. 6. Reduces flood damages by 57-56%	1-3. Same as C1. 4. $21 M more cosily than A1.
Plan D • Pipeline from Lake Erie. • Dyking and channelization same as A1. • Advanced sewage treatment same as A1.	331*	80	1. A secure source of water supply (water supply needs are met). 2. Provides urban flood protection against floods greater than a 100-year flood at sites with dyke protection (91% reduction in flood damages). 3. Water quality on the Grand and Speed rivers improved, but does not meet MOE D.O. objective fully near Kitchener and Guelph 4. Services cities along the Grand river from one source with capacity limited only by design and cost considerations.	1. Highest cost plan. 2. Large short-term environmental impact along route. 3. High energy use for pumping - over $5 M annual operation costs. 4. Flood damage reduction provided only if dyke projects are carefully planned and co-ordinated.

* Costs listed do not include discounted cost of $89 M for conventional sewage treatment plant expansions.

COMPARISON OF MAIN PLANS - MEDIUM POPULATION PROJECTION

Plan	Costs / Benefits Present value at 6% millions of 1979 $	Advantages	Disadvantages
Plan A1, A2 • Dyking and channelization at New Hamburg, Cambridge (Galt and Preston). Paris. Brantford, Caledonia and Dunnville. • Advanced sewage treatment for Kitchener, Waterloo and Guelph. • Local sources of water supply Plan A1 - new ground water supplies for Cambridge. 68* 121 • Plan A2 - new water supply to Cambridge via Mannheim re- charge system. 66* 121		1. Lowest cost solution. 2. Minimal environmental and social impacts, localized to dyking and channelization sites. 3. Water quality on Grand and Speed Rivers generally is improved, but does not meet MOE D.O. objective fully near Kitchener and Guelph. 4. Provides urban flood protection against floods greater than 100-year flood at sites with dyke protection (91% reduction in flood damages). 5. Meets water supply needs. 6. Socially most acceptable as reflected by Public Consultation Working Groups.	1. Lower water quality on Grand river (Waterloo to Paris) than B1, B2. 2. No additional flood protection for areas not provided with dykes. 3. Flood damage reduction provided only if dyke projects are carefully planned and coordinated.
Plan A3 • Same as A1 plus Everton reservoir on Speed River. 84* 121		1. Flood protection and water supply same as A1. 2. Water quality on Speed river below Guelph is better than A1, but still does not meet MOE D.O. objective fully.	1 - 3. Same as A1. 4. Has detrimental impact on cold water fishery in reservoir site. 5. Reservoir increases A1 costs by $16 M.
Plan A4 • Same as A1 plus appropriate measures to be taken to preserve the Montrose reservoir site for possible future use. 72* 121 (Montrose lands disposed of in 2001) 83* 121 (Reservoir constructed in 2001)		1. Water quality. flood protection and water supply same as A1. 2. Minimal environmental impacts (unless dam is constructed in the future). 3. Gradual social impacts during land acquisition. 4. Flexibility to handle future water quality uncertainties is increased, 5. Permits continued agricultural use *of* lands in reservoir acquisition area.	1 - 3. Same as A1- 4. Does not eliminate uncertainty about future land use. 5. No assurance that land-use planning can preserve the reservoir site except through provincially imposed regulations or purchase. 6. $4 M more costly than A1 if the reservoir is not built and $15 M more costly if the reservoir is built.
Plan B1 • Montrose dam. 74* 116 • Advanced sewage treatment at Kitchener and Guelph. • Local sources of water supply same as A1.		1. Water quality on Grand and Speed rivers is improved over Plan A. but still does not meet MOE D.O. objectives fully near Kitchener and Guelph. 2. Provides flood protection against a 10-year flood. 3. Provides additional flood protection for rural areas. 4. Meets water supply needs with greater flexibility for possible future needs. 4. Reservoir provides additional recreational opportunities,	1. Costs $6 M more than A1. 2. Has detrimental social and environmental impacts. 3. Provides less flood protection than A1. 4. Has considerable local opposition
Plan B2 • Montrose dam. 97* 122 • Dyking and channelization same as A1. • Advanced sewage treatment at Kitchener and Guelph. • Local sources of water supply same as A1.		1. Same as B1. 2. Provides urban flood protection against floods greater than a 100-year flood (96% reduction in flood damages) as A1. 3. Reduces the risk of dyke failure by reducing flood peaks. 4. Provides added protection if future flood flows increase due to changing land-use practices. 5. Provides additional flood protection for rural areas. 6. Meets water supply needs with greater flexibility for possible future needs. 7. Reservoir provides additional recreational activities.	1. Costs $29 M more than A1. 2. Has detrimental social and environmental impacts. 3. Has considerable local opposition.

Plan C1 • St- Jacobs dry reservoir with dyking and channelization at New Hamburg • Advanced sewage treatment same as A1	70*	115	1. Less environmental impact than Montrose dam. 2. Provides urban flood protection against a 10-year flood and reduces flood damage by 50-49%. 3. Water quality on the Grand and Speed Rivers improved, but does not meet MOE D.O. objective fully near Kitchener and Guelph. 4. Meets water supply needs. 5. $27 M less costly than B2.	1. Has detrimental social impact. 2. Provides less urban flood protection than At, A2, B1 and B2. 3. $2 M more costly than A1.
Plan C2 • Montrose small dry reservoir, 24.7 million m^3 (20,000 acre-ft) with dyking and channelization at New Hamburg. • Advanced sewage treatment same as A1. • Local sources of water supply same as A1.	73*	116	1-4. Same as C1. 5. $24 M less costly than B2. 6. Reduces flood damages by 56-54%.	1-3. Same as C1. 4._$5 M more costly than A1.
Plan C3 • Montrose large dry reservoir, 77.7 million m^3 (63,000 acre-ft) with dyking and channelization at New Hamburg. • Advanced sewage treatment same as A1. • Local sources of water supply same as A1.	87*	116	1-4. Same as C1. 5. $10 M less costly than 2. 6. Reduces flood damages by 57-56%.	1-3, Same as C1. 4. $19 M more costly than A1.
Plan D • Pipeline from Lake Erie. • Dyking and channelization same as A1. • Advanced sewage treatment same as A1.	331**	80	1. A secure source of water supply (water supply needs are met). 2. Provides urban flood protection against floods greater than a 100-year flood at sites with dyke protection (91% reduction in flood damages). 3. Water quality on the Grand and Speed Rivers improved, but does not meet MOE D.O. objective fully near Kitchener and Guelph. 4. Services cities along the Grand River from one source with capacity limited only by design and cost considerations.	1. Highest cost plan. 2. Large short-term environmental impact along route. 3. High energy use *for* pumping - over $5 M annual operation costs. 4. Flood damage reduction provided only if dyke projects are carefully planned and co-ordinated.

* Costs fisted do not include discounted cost of $94 M for conventional sewage treatment plant expansions

** Costs listed do not include discounted cost of S89 M for conventional sewage treatment plant expansions