THAMES RIVER
BASIN STUDY

Bulletin

April 1st, 1974

Ontario

Ministry of the
Environment
Hon. William G. Newman, Minister
Everett Biggs, Deputy Minister

Ministry of
Natural Resources
Hon. Leo Bernier, Minister
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THAMES RIVER BASIN

WATER RESOURCE MANAGEMENT

BULLETIN

BACKGROUND

Since the mid 1930's the attention focused on the Thames River has been increasingly related to floods, water shortages, water quality impairment and erosion.

Records indicate that the Thames River has always been prone to overflowing its banks and flooding adjacent lowlands. This characteristic has become more critical throughout the years as land in the basin has been cleared for agriculture and urbanization.

Severe flooding has been documented. In 1937 heavy rains along the south branch of the River created severe flooding. Floodwaters originating in the North Thames River caused extensive damage again in 1947. Local floods, such as the McGregor Creek and Thamesville floods of 1968, occur frequently.

The Upper Thames and Lower Thames valley Conservation Authorities were established to develop programs to control the flooding problem in the Thames River system.

In the early 1950's a major flood control program was launched. This program included construction of the Fanshawe, Wildwood and Gordon Pittock dams and reservoirs. Also included were the construction of smaller reservoirs such as the Mitchell dam and reservoir, the Thomas Orr dam and Lake Victoria at Stratford. Channel improvements were made, especially on the south branch of the river at Woodstock and Ingersoll.

The flood control programs of the two conservation authorities and the existing dyke system along the river provided a partial solution to the flooding problems.

Urban growth in the basin continued, relying upon the surface and ground waters of the watershed for municipal water supplies. Inadequacy of supply became apparent necessitating the importation of water from beyond the basin. Major water supply pipelines were developed.

London began utilizing the Lake Huron pipeline for its water supply in 1967. Blenheim was supplied with water in 1971 by the Blenheim area water system. Chatham obtained a supply of higher quality Lake Erie water in 1973.

Having an adequate supply of water secured, the principle pressure on the municipalities in the watershed shifted to reducing the pollution load that their sewage treatment plants impose upon the river system. In several reaches of the river, water uses, including recreation and water supply, have been significantly curtailed as a result of the degradation of the quality of water in the river. The continued growth of municipalities in the basin will add to the existing pollution pressure.

Record high water levels in the Great Lakes system have accelerated the rate of erosion at several points along the dykes of the lower reaches of the Thames River. Large wakes generated by powerboats downstream from Chatham further aggravate the erosion problem.

The conservation authorities and local and provincial governments all dealt with various aspects of the problems afflicting the Thames River. In early 1972 the Ministries of Environment and Natural Resources launched a detailed two year study of the Thames River system. The study has investigated problems of pollution control, low flow augmentation, flood control, the control of algae and aquatic weeds and the prediction of the effect of future land use and urban development in the Thames River basin.

An inventory of the existing quality and quantity of water in the river system has been developed. This information, plus data defining the waste effluent discharges from municipal, industrial and other sources has been integrated using simulation modelling techniques. Reliable predictions of future stream conditions can now be undertaken.

Parallel to this work, flood routing models have been under development. The retention of excess spring streamflow for summer flow augmentation has been investigated.

At the same time that this technical work was proceeding, a program was underway to obtain information from the public regarding their preferences for the management of their water resources. Municipalities and interest groups in the basin were approached directly by the study team. Twenty-eight municipalities and 24 interest groups and related agencies attended meetings with the study team. Others, including the general public submitted their views through questionnaires. This public consultation has provided an insight into the dependency of the Thames River basin citizens on the river.

The study team has prepared this Bulletin to advise residents of the study findings. At this time a number of potential conflicts have been identified. Questions related to these conflicts have been identified. Questions related to these conflicts are presented in this Bulletin. Prior to recommending a solution to these problems, the Ontario Environmental Hearing Board will conduct a series of meetings at Chatham, Glencoe, London, Stratford and Woodstock. At these meetings the opinion of residents of the area will be heard, especially with regard to the following questions.

WHAT FACTORS SHOULD BE CONSIDERED IN EVALUATING THE COST-BENEFITS OF PROPOSED DAMS?

WHAT SHOULD BE CONSIDERED IN ESTABLISHING REVISED OPERATING POLICIES FOR THE EXISTING RESERVOIRS?

HOW MUCH LOSS OF AGRICULTURAL PRODUCTIVITY DUE TO WILDLIFE WOULD ACCOMPANY VEGETATIVE STABILIZATION OF DYKES?

WHAT FORM OF PROTECTION WORKS SHOULD BE USED ON THE VARIOUS SECTIONS OF DYKES?

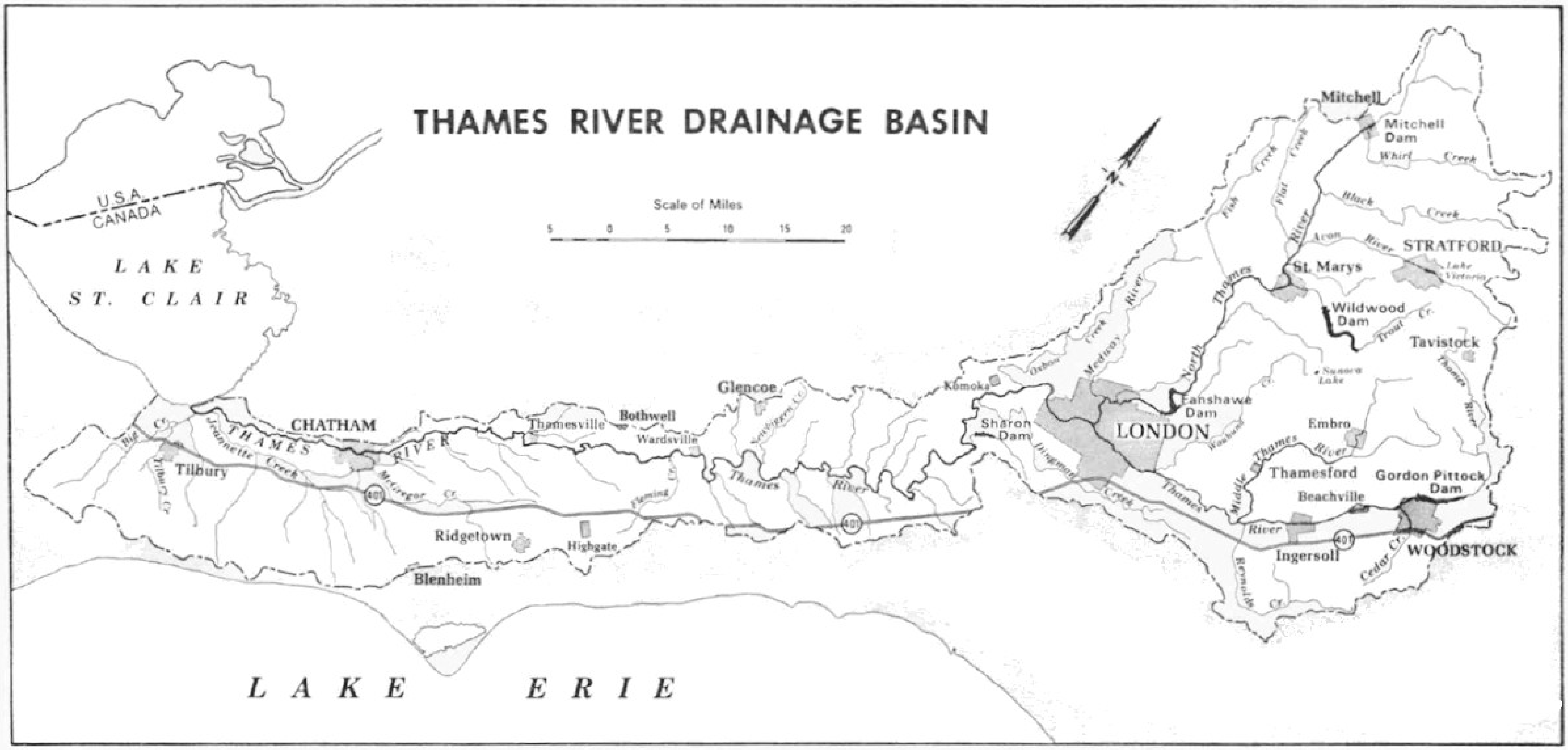
CAN AGRICULTURAL DRAINAGE SCHEMES AND MUNICIPAL CHANNEL IMPROVEMENTS BE MODIFIED TO FACILITATE RETARDING OF RUNOFF UNTIL AFTER CRITICAL FLOOD PEAKS HAVE PASSED DOWNSTREAM?

WHAT OPTION SHOULD THE MAJOR MUNICIPALITIES HAVE IN THE FUTURE WITH REGARD TO POPULATION GROWTH AND WASTE TREATMENT ALTERNATIVES AND ENVIRONMENTAL QUALITY?

WHAT ARE THE IMPLICATIONS OF PASTURING LIVESTOCK WITHOUT FREE ACCESS TO THE RIVER?

CAN STREAMBANK AREAS BE SWITCHED FROM PASTURE TO FORAGE CROPS? CAN RATES OF FERTILIZER APPLICATION BE REDUCED?

Following the deliberations of the Hearing Board the study team will proceed with the preparation of the final report on the study. This report will incorporate the input from the public and municipalities as expressed at the five public meetings to be held in May.


THAMES RIVER DRAINAGE BASIN
Scale of Miles
5 0 5 10 15 20
U.S.A.
CANADA
LAKE ST. CLAIR
LAKE ERIE
CHATHAM
Tilbury
THAMES RIVER
Thamesville
Bothwell
Wardsville
Glencoe
Ridgetown
Highgate
Blenheim
Komoka
Sharon Dam
LONDON
Fanshawe Dam
Mitchell
Mitchell Dam
St. Marys
STRATFORD
Wildwood Dam
Tavistock
Embro
Thamesford
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Ingersoll
WOODSTOCK

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INTRODUCTION

Information in this bulletin indicates the status to date of the Thames River Basin Study, undertaken jointly by the Ministries of Environment and Natural Resources. This study was initiated in 1971 to develop specific guidelines for the water resources management of the Thames River basin.

Technical, sociologic, and economic factors have been considered in working towards a comprehensive plan for the basin. New technology has been developed, analytic procedures revised, and the public involved. A comprehensive water resource picture is being developed, water uses have been enumerated and improved water management techniques considered. Work undertaken as part of the study has included field surveys and the application of a variety of mathematical modelling techniques to interpret data from these surveys and public consultations. The work has indicated a number of problem areas regarding water quality and quantity at various points in the basin.

This bulletin is to advise citizens and corporations in the Thames River basin of the alternatives that are being considered for future management of their water resources. The province will conduct public meetings at Chatham, Glencoe, London, Stratford and Woodstock to discuss this report.

Comments and briefs relating to specific questions regarding the water resources of the basin are invited and will be welcomed. Forward written comments to the Secretary of the Environmental Hearing Board, 1 St. Clair Avenue West, Toronto, Ontario M4V 1K7, to be received not later than April 30, 1974.

By mid-summer, the conclusions and recommendations of the study will be finalized. Firm recommendations as to the courses of action open for future management of the water resources of the basin will then be available for implementation. Much of the responsibility for managing the water resources of the Thames River basin has been assigned to the local conservation authorities, hence many of the findings of this study will apply directly to local authority programs. Other recommendations will be forthcoming dealing with urban growth, industrial development and agricultural practices.

You are invited to study the following document and make known your opinion as to the suitability of the proposals presented herein for the management of the Thames River basin water resources.

SURFACE WATER

QUANTITY

Stream water withdrawals, sewage effluent discharges and flow regulations by dams, modify streamflow in nearly all streams in the basin. Only the Fanshawe, Wildwood and Gordon Pittock impoundments are large enough to significantly reduce flood peaks and to provide long term streamflow augmentation.

There are a number of other dams in the basin with smaller storage capacities used primarily for recreation and limited local flood control. These dams do not affect streamflow significantly on the main branches of the river or locally over long periods.

Water withdrawals are usually small relative to streamflow. However, municipal sewage effluent discharges are frequently large in proportion to the flow in the receiving stream. Studies indicate that there is little or no natural storage in the basin to retard high flows. This lack of storage makes critical areas of the basin such as the Thames River near Chatham, particularly vulnerable to flooding.

Mean monthly flows have been evaluated for several locations throughout the basin. Generally, the highest mean monthly stream-flows occur in March with a few streams discharging peaks in April. Usually the March and April freshets provide much higher flows than found during other months. Generally, the flows in the various streams during the November-December period approach the mean annual level.

The lowest mean monthly discharges at individual stations generally occur during July, August or September. The difference between the average discharges for these months is usually small. Potential over-use of stream water is most likely to occur during this period, particularly since demands for stream water are usually highest at this time. Extremely low mean monthly yields at several locations during the summer suggest that the streams in question may be intermittent and thus must be considered as unreliable sources of water. The highest summer discharges per unit area of drainage basin have been recorded in Trout Creek and in the Avon River.

GROUNDWATER SUSTAINED STREAMFLOW

Significant quantities of groundwater contribute to the streamflow at several locations on the North Thames River, the south branch of the Thames River and on Trout Creek at St. Marys. A large portion of the water being continually pumped into the river downstream from St. Marys by the St. Marys Cement Company to de-water its quarry is of groundwater origin.

One source of groundwater discharge to Trout Creek is a series of springs in and near the Harrington swamp, about two miles south of Harrington West. During extremely dry periods, the total flow in this creek is believed to be sustained by these springs. Extensive sand and gravel deposits along the south branch of the Thames River, especially south of it, are sources of groundwater discharge to the river. In addition to groundwater seepage directly to the river, water is pumped continually into the south branch between Woodstock and Ingersoll by three quarries, Beachville Lime, Domtar and Stelco. The percentage of the pumpage that is groundwater is not known.

In the lower reach of the Thames River, the potential for groundwater discharge to tributaries is relatively high since this area is largely sand covered. However, due to the flatness of land in this area, there is a low hydraulic gradient, and only a limited amount of groundwater actually flows to the streams.

FLOODING

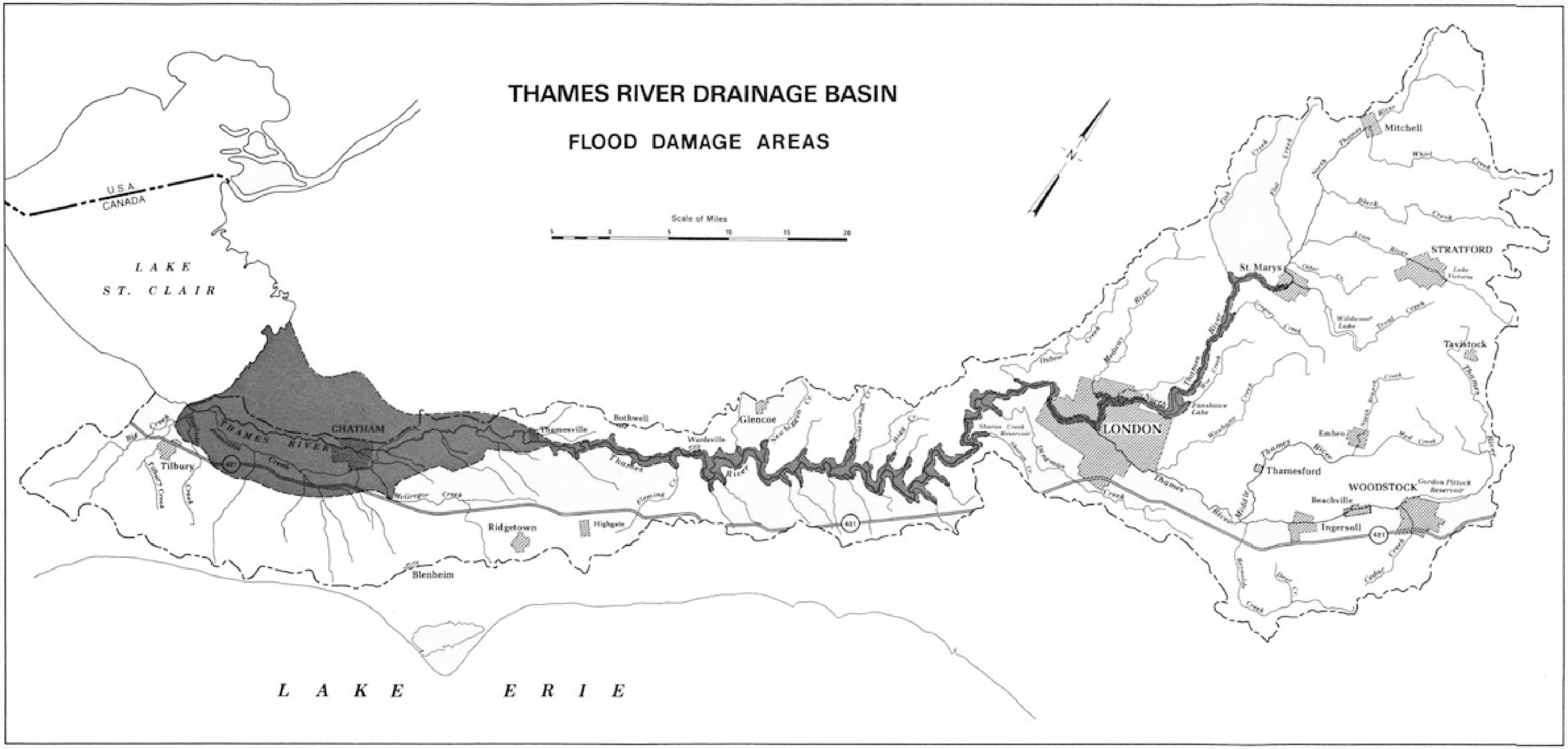
Much of the following information has been extracted from a study (Thames River Flood Damages, February, 1973) conducted by Acres Consulting Services Limited, commissioned by the Ministry of Natural Resources.

Most of the waters flowing through the lower reaches of the Thames River originate in the upper portions of the watershed. Floods may occur at any time of the year, but spring floods caused by a combination of ice, snowmelt and rain, are most frequent. Severe summer floods caused by major thunderstorms have occurred in the past, and the probability exists that, due to a tropical hurricane, a severe flood could occur in the autumn. Typically, summer floods have sharper peaks than the more frequent spring run-off floods.

Downstream from Byron, the magnitude of the peak flood discharge tends to decrease rather than increase. Extensive overbank storage and limited lateral inflow are the main reasons for this characteristic. Further downstream, south of Chatham, floodwaters overtopping the north bank actually leave the watershed and flow directly into Lake St. Clair.

Major floods occurred in 1937, 1947 and 1948. The 1937 flood was caused by heavy rainfall, mainly in the south branch of the Thames River. In 1947, a large flood occurred with floodwaters originating largely in the North Thames River basin. Extensive documentation of this flood includes mapping of the area underwater at the flood-peak.

Many local floods have also occurred, such as the McGregor Creek *and* Thamesville floods of 1968. These floods have been documented in various newspaper accounts. Documentation


THAMES RIVER DRAINAGE BASIN
FLOOD DAMAGE AREAS
Scale of Miles
U.S.A.
CANADA
LAKE ST. CLAIR
LAKE ERIE
CHATHAM
THAMES RIVER
Tilbury
Thamesville
Bothwell
Wardsville
Glencoe
Ridgetown
Highgate
Blenheim
LONDON
St. Marys
Mitchell
STRATFORD
Tavistock
Embro
Thamesford
WOODSTOCK
Beachville
Ingersoll
401

of floods which have resulted from overtopping and breaching of dykes is not available. The main areas which have been regularly subjected to flooding are Mitchell, Stratford and St. Marys on the North Thames River; Woodstock, Beachville and Ingersoll on the south branch of the Thames River; London and the stretch from Thamesville through Chatham to Lake St. Clair.

In order to reduce the flood hazard, reservoirs have been constructed in the Upper Thames basin near St. Marys, London and Woodstock, creating storage volumes of 20,100, 39,100 and 13,400 acre-feet respectively. Of the total 72,500 acre-feet about 43,270 acre-feet are available for flood control storage. Other flood control projects include the Mitchell Dam and channel improvement at Mitchell, the Thomas Orr Dam and channel improvement at Stratford, the Ingersoll channel improvement and dykes in sections of London and along the lower reaches of the Thames River.

Downstream from Chatham, dykes have been developed to protect the rich delta agricultural land from flooding. These dykes are overtopped regularly due to high stages that frequently occur during the spring break-up. Other floods have occurred because of the malfunction of flap gates. In recent years, erosion caused by natural river processes and the wave action of power boats has made the dykes unstable, causing concern among farmers whose lands depend on dyke protection. If remedial works are not undertaken, the dykes, in a matter of time will fail at several points, causing severe flooding of agricultural land.

Many other projects have been proposed which will increase the flood control storage capacity of the Upper Thames River basin. The most common proposal is the Glengowan Reservoir with a capacity of approximately 20,000 acre-feet.

Controversy has developed over Proposals to develop a flood control dam in the Lower Thames River basin. Although increased protection would be afforded to downstream areas by the dam, major losses of agricultural land to the proposed reservoir would result. Also, irreparable damage would be dealt to the Lake St. Clair area pickerel fishery by the destruction of the Thames River spawning grounds. Possible alternatives to the original dam proposal are now under consideration which could forseeably avoid the flooding problem while assuring the viability of the fishery.

The effectiveness of reservoirs and other impoundments in reducing flood peaks depends on several operational factors, including the reliability with which impending floods can be forecast. The operating principal in the past has been to discharge the maximum downstream channel capacity early in the flood, to conserve storage and minimize extensive flooding. The determination of the maximum potential and actual effectiveness of the reservoirs will require a detailed simulation of the movement of floodwaters through the total system.

RESERVOIRS

There are several dams and reservoirs in the Thames River basin, which have changed, to varying degrees, the hydrologic characteristics of downstream flows (example, Fanshawe, Wildwood and Gordon Pittock). The pattern of dam operation can be manipulated to alter the impact of reservoirs on streamflows. If the present schedule of reservoir drawdown is adhered to, minimum flows of 15 cubic feet per second (cfs) downstream from the Gordon Pittock Dam and 40 cfs downstream from the Wildwood Dam will be maintained throughout the summer and fall.

Wildwood

Wildwood Dam, on Trout Creek east of St. Marys was built to control floods and to store water for recreation and for streamflow augmentation. Construction began in 1963 and was completed in 1965; operation of the dam began in 1966 and initial drawdown of water in the reservoir commenced that summer.

The total reservoir capacity is 20,100 acre-feet, the area drained at the dam being 55 square miles. Initial or maximum storage of 14,480 acre-feet for recreation and streamflow augmentation is obtained in early summer, leaving 5,620 acre-feet of storage available for flood control during the summer. In winter, only 1,950 acre-feet of water is stored, thereby, reserving 18,150 acre-feet of storage for controlling winter and spring floods.

Water in the reservoir is released according to a predetermined schedule to satisfy recreational requirements and to augment streamflows. Drawdown begins during mid-June and continues until about mid-December when the winter holding level in the reservoir is reached. The volume of stored water available for release is 12,530 acre-feet and the release rate is tentatively 40 cfs.

Water released from Wildwood Reservoir during summer and autumn has not always maintained downstream flows at 40 cfs as expected. During approximately 27 percent of the time, the average daily flow was less than 40 cfs and 7 percent of the time, flow was less than 20 cfs. During July to "November, an average monthly discharge of 40 cfs has been maintained downstream for most of the time since the commencement of reservoir operation by releasing water from storage.

Fanshawe

Fanshawe Reservoir has 39,000 acre-feet of storage and was built primarily to control floods which may persist for three to four days Part of the storage in the reservoir is also used for recreation. Construction on the dam began in 1950 and was completed in 1953.

The dam is operated only during periods of potential flood when one of two criteria is used to determine how and when the dam is to be operated. One criterion is based on the rate of rise of the water level in the reservoir, and the other on the rate of increase in flow at the gauge on the North Thames River near Thorndale. The water stored during periods of high flow is released after the danger of flooding subsides, usually within a few days. Storage in the reservoir is continually maintained at 10,000 acre-feet when the dam is not operated.

During exceptionally dry summers some water is released from the reservoir by a control valve thereby lowering the water level below the normal holding level. Fanshawe Dam and Reservoir reduces downstream flows not only during high flows but also on occasions during low flows. During the period 1954 to 1971 (216 months), monthly average inflow to the reservoir was higher than the outflow from the reservoir for 84 months. For the same 18 year period and the months of June to November (108 months), this occurred for 51 months. A portion of the decrease in flow is likely due to evaporation from the reservoir.

Gordon Pittock

The Gordon Pittock Dam and Reservoir in Woodstock controls floods on the south branch of the Thames River and stores water for recreation and for streamflow augmentation in summer and fall.

The dam was built during 1964 to 1966. Initial drawdown of stored water commenced in 1967.

The total capacity of the reservoir is 13,400 acre-feet and the area drained at the dam 93.5 square miles. A maximum of 4,750 acre-feet of storage is used to retain water in the spring for summer recreation and streamflow augmentation. The remaining 8,650 acre-feet of storage is reserved for flood control.

In winter the reservoir is maintained empty, thus making the entire 13,400 acre-feet available for flood control. The maximum storage for recreation and streamflow augmentation is reached in late spring and reservoir drawdown begins on about June 20 according to a predetermined schedule. This schedule indicates that storage in the reservoir is reduced from 4,750 acre-feet to 2,550 acre-feet from June 20 to September 10. As a result, downstream flow is maintained at about 15 cfs. Drawdown continues until the reservoir is empty on about December 1.

A release of water from storage in the Gordon Pittock Reservoir has successfully maintained downstream flow at 15 cfs during summer and fall. During the period July to November 1967 to 1971, daily discharges immediately downstream from the dam were less than 15 cfs only four percent of the time. In winter and spring, the dam is utilized to impound flood peaks, but the impounded water is released shortly after the danger from flooding subsides.

Thomas Orr

The dam, built on the Avon River in Stratford, serves to store water for recreation and the control of local floods. The total reservoir capacity is 670 acre-feet and normally about 300 acre-feet of water is retained in the reservoir for recreational use. The water level in the reservoir, known as Lake Victoria, is raised in the spring and is maintained more or less throughout the summer and fall. The reservoir is emptied in late fall to provide storage for flood control during the winter and spring. Because of the manner in which the dam is operated and the small volume of water normally conserved, the impact of the Thomas Orr Dam on downstream flow is not considered significant.

Mitchell

This dam and reservoir is located on the North Thames River at Mitchell. The reservoir capacity is 620 acre-feet, but only 185 acre-feet of water is normally conserved in the reservoir. This dam is operated in the same manner as the Thomas Orr Dam and for the same purposes. The impact of this dam on downstream flow is also considered insignificant.

Springbank

The Springbank Dam raises and maintains a stable water level in the Thames River in Springbank Park at London during the period from May to September each year. The impoundment created facilitates boating and other recreational activities in the park during the summer and fall. The effect of this darn on downstream flows is not substantial.

Sharon

The Sharon Dam, located on Sharon Creek near Delaware, is the only significantly large, multi-purpose streamflow control structure in the Lower Thames River basin. The total capacity of the reservoir is 3,500 acre-feet, of which 1,400 acre-feet is used for conserving water and 2,100 acre-feet for flood control. The conserved water is intended to serve both recreation and the irrigation of tobacco; however, no stream water taking permits have been issued for water takings in excess of 10,000 gallons per day either from the reservoir or from the stream. The reservoir is emptied in late fall. The operation of this dam does not significantly affect downstream summer flows.

QUALITY

People of the Thames River basin are generally concerned over what they interpret as the poor quality of the Thames River. Some high exposure areas within the basin including the Avon River in Stratford, the Fanshawe Reservoir, the Gordon Pittock Reservoir, and sections of the river downstream from Woodstock, London and Chatham have serious water quality problems. These problem areas have overshadowed other areas of the basin where high quality water exists. The following information describes the areas of both good and poor quality water in an effort to set the water quality problems in proper perspective.

NORTH THAMES

Bottom fauna associations upstream from Mitchell exhibited good variety but the low number of organisms found suggested intermittent streamflow. An increase in the bacterial contamination of the North Thames River occurs downstream from the Town of Mitchell. Levels of total and fecal coliforms and fecal streptococci increase five to ten fold from marginally acceptable levels upstream. As a result, in 1973, the local Medical Officer of Health (MOH) closed the Mitchell Reservoir for swimming and bathing. Total phosphorus concentrations also increase from approximately 0.1 mg/L to 0.25 mg/L downstream from Mitchell.

Severe dissolved oxygen fluctuations were observed downstream from the town, levels falling below generally accepted levels of 5.0 mg/L to as low as 1.5 mg/L. The severe fluctuations generate a significant pressure on any local fishery. During the survey in which dissolved oxygen levels as low as 1.5 mg/L were observed, flows ranged from approximately 3 to 5 cfs in the stream. A study of the hydrology in the stream indicates that streamflows can be expected to go to zero for extended periods of time. The Mitchell lagoon effluent discharge subtly impaired the downstream biological stream community. The variety of numbers of organisms increased gradually from Mitchell to the mouth of the Avon River, the growth of aquatic vegetation occurring in minor proportions.

Immediately upstream from St. Marys, the excellent diversity exhibited by the bottom fauna association and the heavy aquatic vegetation growth were indicative of nutrient-rich waters with adequate levels of dissolved oxygen.

The Town of St. Marys has recently constructed a new sewage treatment plant to correct the public health problems resulting from failing septic tank systems. Prior to the construction of the pollution control facilities, high numbers of pollution-tolerant or facultative benthic animals and considerable *Cladophora* growth illustrated major enrichment immediately below this municipality. With St. Marys, bacterial contamination from the failing septic tank systems was evident in both Trout Creek and the North Thames River. Variable waste loadings from the Campbell Soup Company plant aggravated water quality problems. Considerable qualitative recovery was evident in the benthic association at the Highway 7 bridge, although ferric sulphide deposits on the bottom of rocks were indicative of anaerobic conditions in the sediments which settled out in this stretch. Luxurious growth of aquatic vegetation persisted from this point to the headwaters of the Fanshawe Reservoir indicating nutrient-rich waters.

Historically, Fanshawe Dam has been operated utilizing a surface water withdrawal. Recently, experiments have been conducted using a partial bottom discharge. When surface discharge is employed, anoxic conditions develop in bottom waters and it is conjectured that nutrients are released from sediments contributing to severe algae blooms. On occasion, the severity of these blooms has forced the closure of the swimming area.

Downstream from the Fanshawe Dam, limited flow is available from the reservoir. The Adelaide sewage treatment plant discharge to this section of the river causes further water quality degradation. The additional oxygen demand exerted by waste materials discharged by this plant coupled with diurnal dissolved oxygen fluctuations attributable to the extensive algal growths in the river cause dissolved oxygen levels to fall to unacceptable levels

The macroinvertebrate community found at the Richmond Street bridge in London was depressed significantly in diversity with high numbers of pollution-tolerant forms dominating the population Algae growth was heavy and anaerobic conditions were evidenced by black ferric sulphide deposits in the riverbed. Considerable recovery was evident upstream from the confluence of the North Thames River the south branch of the Thames River at the Black-friar's Bridge in London, although heavy weed growth prevailed.

The following streams tributary to the North Thames River were also studied.

Avon River

Extended low flows in the Avon River have contributed to the frequent recurrence of poor water quality. During periods of low flow, the streamflow in the river downstream from Stratford is virtually all sewage effluent. Bacterial contamination of the Avon River is common with high levels of total and fecal coliform organisms upstream from the town indicating sources of contamination in upriver rural areas. Additional contamination occurs from the Stratford storm sewer system. During the summer of 1973, Lake Victoris was closed to swimming for the first time by the local MOH. Despite decreases noted downstream in the bacterial levels following the discharge of the chlorinated effluents from the Stratford sewage treatment plant, bacterial levels generally remain in excess of acceptable levels for swimming and bathing.

Runoff to the river from upstream agricultural areas contribute significant quantities of phosphorus and nitrogen. Upstream from Lake Victoria, heavy growths of weeds and algae thrive. Reductions in the level of these growths downstream from the lake support the theory that Lake Victoria is trapping significant quantities of the nutrients associated with suspended material in the river. Heavy beds of algae and aquatic weeds persists downstream from the Stratford STP to the confluence of the Avon River with the North Thames River. High uptake of phosphorus and nitrogen occurs in this reach of the river. Dissolved oxygen depletion, resulting from the discharge of oxygen consuming wastes from the sewage treatment plant, is further exaggerated by the nocturnal consumption of oxygen during the respiration cycle of the aquatic flora.

Mathematical models have been developed for the Avon River based upon the existing conditions and then extrapolated to predict the effect of nutrient removal and effluent polishing at the sewage treatment plant on water quality in the downstream sections of the river. It would appear that a significant improvement could be anticipated; however, it is not likely that the stream will ever be of exceptionally high quality.

It is not forseeable that any significant quantity of flow augmentation could be provided for the Avon River. At present, the serious water quality impairment in the Avon River has a deleterious effect on the quality of the North Thames River in the St. Marys area. The Avon River likely contributes to the quality problems that occur in Fanshawe Lake.

Public consultations confirm that residents of the area perceive water quality in the Avon River, particularly near Stratford, as "very poor" to "fair" and deteriorating. In particular, excessive weed and algal growths are seen by the public to be the major water-related problem in the Perth County area of the basin.

Trout Creek

Wildwood Reservoir is located on this tributary. Flow entering the reservoir contains elevated levels of bacteria but is otherwise of excellent quality. Within and downstream from the reservoir, levels of bacterial organisms decrease to acceptable levels for swimming and bathing, although an algae bloom in 1973 interfered with body contact recreation. Anaerobic reservoir water discharged by low-level valves at the dam was likely responsible for the depressed levels of dissolved oxygen and impaired bottom fauna populations.

Medway River

Upstream from London the Medway River has elevated levels of nitrates, relatively low levels of phosphorus and marginal bacterial quality. One small lagoon system is in operation having discharge to the river during the spring and fall freshets. The high streamflow to effluent ratio, the short duration of discharge and the low stream temperature at the time of discharge provide assurance that the effect of the discharges on water quality will be negligible. Near the mouth of the creek, a good variety of organisms were found, although the enriched conditions as illustrated by *Cladophora* growths during a 1970 survey were obvious again in 1971.

Samples collected near the mouths of several other tributary streams revealed diverse and well-balanced bottom fauna communities. Such results were found on Whirl, Black, Fish and Flat creeks.

SOUTH BRANCH OF THE THAMES RIVER

In the upper reaches of the south branch of the Thames River, a poor representation of intolerant bottom fauna, such as mayflies and caddisflies, is attributed to both low flows and minor impairment of water quality. In the vicinity of Tavistock, dissolved oxygen levels fell as low as 2.7 mg/L during July 1971. Water quality progressively improved to immediately downstream from Innerkip as indicated by the increasing variety of intolerant mayfly and caddisfly larvae and well-balanced bottom fauna associations.

In the Gordon Pittock Reservoir, a seriously degraded aquatic environment is illustrated by heavy algae blooms, black floating sludge matts, and fish kills. Nearly 50 percent of the total coliform analyses of water entering the reservoir from upstream indicate levels of coliform organisms in excess of the accepted standards for swimming and bathing. However, bacterial quality improves with progress downstream in the reservoir to acceptable levels in the swimming area.

Surveys indicate that a significant portion of the water quality problems in the Gordon Pittock Reservoir can be attributed to the highly enriched bottom deposits that have accumulated in the reservoir, high temperatures and minimal flow that occurs during the summer. Furthermore, the physical characteristics of the reservoir, including the shallow depth and its relatively small size tend to encourage algal growth throughout the reservoir. Aquatic life is severely impaired immediately downstream from the reservoir.

Woodstock is a significant contributor of phosphorus and organic material to the south branch of the Thames River. Upstream from the city, levels of 0.16 mg/L total phosphorus and 2.8

mg/L BOD (biochemical oxygen demand) exist. Downstream from the city, levels are in the order of 0.61 mg/L total phosphorus and 4.8 mg/L BOD. The effects of organic enrichment on bottom fauna communities downstream from Woodstock were evident to Beachville. Mayfly and caddisfly larvae were virtually eliminated from populations to this point and midge larvae and sludgeworms dominated populations. Heavy weed growth and siltation occurred in this stretch. A significant portion of the problems found in the south branch of the Thames River in the Woodstock area are attributable to the amount of sewage bypassing that occurs during periods of storms.

Severe bacteriological contamination and the virtual elimination of benthic organisms in Cedar Creek within the city limits were observed.

Generally, water quality appeared to be improved at Beachville, although elevated levels of bacterial organisms recurred within the village. Further recovery was evident just upstream from Ingersoll. Although increased vegetation growth caused greater daily variation in concentrations of dissolved oxygen, average concentrations of oxygen increased *with* progress downstream.

The recovery apparent upstream from Ingersoll was shortlived as organic wastes from Ingersoll again reduced the number of intolerant forms and caused major increases in the numbers of sludge-worms and midges. The growth of *Cladophora* on any suitable substrate was evidence of nutrient-rich water. However, dissolved oxygen levels were generally found to be satisfactory.

In the south branch of the Thames River from the Gordon Pittock Reservoir to downstream from Ingersoll, four major fish kills have been investigated from 1969 to I972. This figure does not include the annual natural mortality of catfish in the reservoir itself which on occasions are mistaken as accidental fish kills.

The macroinvertebrate association found half-way between the mouth of the Middle Thames River and Dorchester was indicative of good water quality. Downstream from Dorchester, minor enrichment was apparent but from there to London populations exhibited the excellent diversity found upstream from Dorchester.

Impaired water quality at the Highbury Street Bridge downstream from the Pottersburg sewage treatment facility was reflected by the limited bottom fauna association particularly on the north side of the river. However, the entire cross-section of the river did not appear to be affected nor were the less tolerant forms totally eliminated. Across the entire riverbed, severe interference with the aquatic animal population was noted downstream from the Vauxhall plant.

Septic conditions were illustrated by the widespread occurrence of sewage fungus and reduced oxygen concentrations which were depressed to below 5 mg/L. Neither number nor variety of organisms approached upstream reference levels as far downstream as its confluence with the North Thames River. Models developed for the south branch of the Thames River in London indicate that during low flow conditions, and present waste inputs, concentrations of dissolved oxygen fall to unacceptable levels. A significant portion of the oxygen deficit can be rectified by improved sewage treatment.

In general, the public perceives the waters of the south branch of the Thames River as being of poor quality. Much of the responsibility for this opinion is attributable to the unpleasant aesthetic conditions in, and downstream from the Gordon Pittock Reservoir.

Tributaries

In major streams tributary to the south branch of the Thames River, water ranged from excellent to very poor quality. Benthic associations upstream and downstream from Thamesford indicated some of the best water quality in the watershed.

Populations at the mouth of Waubuno Creek also were well balanced although the bottom was cluttered with garbage. In contrast, a severe reduction in numbers and types of aquatic macroinvertebrates in Cedar Creek in Woodstock were indicative of a toxic pollutant.

Pottersburg Creek exhibited severely impaired conditions with a high number of sludgeworms and midges indicating that the cause was a significant burden of organic wastes. An oily film covered the surface and a septic odour emanated from the creek.

THAMES RIVER

A pollution tolerant benthic community was observed along the Main Thames River throughout London. Downstream from the Green-way sewage treatment plant the benthic population was reduced in number, indicating a possible toxic effect of the Greenway effluent. Downstream from the Springbank Park Dam and the Oxford sewage treatment plant water quality impairment continued to persist with major recovery from the effects of the effluent discharges to the river in the London area not being observed until Muncey. Aquatic vegetation became more prevalent from Komoka to Delaware. If the oxygen demand of effluent from the five London sewage treatment plants were to be reduced to the level of demand from the Greenway plant, water quality conditions in the Thames River in the vicinity of London would improve significantly.

In the London area the public sees the Thames River as a poor quality river. However reports also indicate that the public feels that water quality has improved over the last decade.

From Muncey to Wardsville, bottom fauna populations were extremely productive and the excellent variety of organisms found at most points in this stretch indicated water of good quality. Higher levels of turbidity in the river are the result of accelerated bank erosion *as the* river enters a clay plain at Muncey. The resulting reduction in light penetration effectively eliminates problems associated with extensive beds of aquatic vegetation. Between Wardsville and Thamesville, somewhat enriched conditions were illustrated by chemical and biological data.

From Kent Bridge to Chatham, the numbers of organisms were low but intolerant mayflies and clams were found. The low numbers are likely the result of the substrate (silt or hardpan) which is unfavourable for most aquatic invertebrates.

Within Chatham upstream from the sewage treatment facility, a fine organic detritus yielded a solitary midge indicative of sterile conditions at that point. Persistent impairment downstream from the Chatham STP was illustrated by low numbers of tolerant midges and sludgeworms and the septic odour of sediments. Investigations indicated that a significant portion of the water quality degradation in the Chatham vicinity may be attributable to the sludge banks that have accumulated downstream from raw sewage bypassess.

Unproductive bottom fauna populations extended from Chatham to Lake St. Clair in what could best be described as an ooze which constituted the top layer of the bottom. Such depressed populations are likely the result of constant sedimentation and continuous dredging and dyking activities. This, coupled with reversible flows in the lower reaches, probably produces a very unstable benthic environment for aquatic organisms.

Tributaries

Water quality of the tributaries in the Lower Thames basin varies significantly. Springers (Oxbow) and Komoka creeks are good quality streams capable of supporting cold water fisheries. Other tributaries experience varying degrees of water quality impairment.

Dingman Creek

The Westminster and Southland Park sewage treatment plants near Lambeth generate significant bacterial impairment of the creek. Treated sewage effluent volumes equal streamflow during summer low flow periods. Dissolved oxygen depletion results in the stream. Downstream at the mouth the dominance of facultative forms of bottom fauna indicates that recovery has not yet occurred. Three of four fish mortalities reported and investigated in the

Lower Thames basin were regarded as severe and occurred on Dingman Creek. All were caused by accidental discharges of wastes, each from a different industrial source.

Sharon Creek

Sulphur groundwater gaining access to the stream in the vicinity of the Sharon Reservoir causes hydrogen sulphide levels in the reservoir to be high when bottom draw of the reservoir is not practiced during the summer. Recent modifications in the management of the reservoir have generally improved water quality in the reservoir and downstream reaches of the creek.

Newbiggin Creek

Glencoe, located in the headwaters of Newbiggin Creek, imposes a high organic and bacterial load on the creek. Consequently, severe bacterial contamination and dissolved oxygen depletion exist.

McGregor Creek

Near the mouth of McGregor Creek water quality impairment is evidenced by garbage on the streambed, a limited population of benthic animals, high levels of total nitrogen and total phosphorus and severe bacterial contamination of the water.

Jeannette Creek

Bottom fauna populations were found to be unproductive in the creek, likely the result of the unfavourable bottom conditions which were similar to those in adjacent sections of the Thames River.

GROUNDWATER

QUANTITY

In the Thames River basin, groundwater is a source of supply for two cities, five towns, seven villages and almost the entire rural population. Of a total basin population of approximately 413,000 (1971), 152,000 or 37 percent depend on groundwater: approximately one half this number are rural residents and rely on individual wells while the other half are supplied from high capacity communal wells.

Groundwater contributes significantly to streamflows in the Thames River and its tributaries. Approximately 35 percent of total annual streamflow originates as base flow; however, the portion of base flow in a given stream is seasonally dependent. During the spring, base flow constitutes only 10 to 20 percent of the streamflow; but during the June to October period of low flows, base flow accounts for as much as 90 percent of the observed flow. The high water demand in the summer and fall accentuates the significance of groundwater and the importance of safeguarding its quality and ensuring its continued availability.

GROUNDWATER IN THE OVERBURDEN

Fifty-five percent of the wells in this basin obtain suitable supplies of good quality water from sand and gravel deposits in the overburden. Generally, the poor quality of water in the bedrock aquifers of the lower and middle portions of the basin dictate the trend in these areas to developing overburden groundwater supplies. The overburden ranges in thickness from non-existant near Innerkip and Ingersoll where bedrock outcrops, to 350 feet in the moraine south of London. Yields of wells in surficial deposits vary from more than 1,000 gallons per minute for the Woodstock municipal wells to one to two gallons per minute from shallow private wells constructed in less permeable formations.

The infiltration rate in surficial sand and gravel deposits is high and accounts, in large part, for the maintenance of water in both the shallow formations and those at greater depth. Developments in areas of sand and gravel will have to proceed with caution in order to avoid hindering the quantity and quality of water recharging the groundwater aquifers. Deeper aquifers in the overburden exist throughout the lower and middle sections of the basin but are infrequent in the north. Yields of 100 gallons per minute are possible locally; however 10 to 15 gallons per minute is a more realistic probable yield from these deeper aquifers.

GROUNDWATER IN BEDROCK

Bedrock aquifers are located primarily in rock formation containing fractures. Fractures are plentiful in limestones but rare in the shales which, in part, is the reason that the limestones are superior sources of groundwater. In the basin, limestones underlie the upper basin while shales characterize the lower portion of the watershed. In general, there is little problem obtaining suitable supplies from bedrock aquifers in the upper basin although the presence of hydrogen sulphide in some areas has caused many users to utilize supplies from overburden aquifers. Municipal wells at Ingersoll, Stratford, St. Marys and Mitchell all utilize bedrock as a source of water supply; however, sulphurous water in two of the bedrock wells at Woodstock has restricted their use.

WATER LEVEL FLUCTUATIONS

Ten observation wells presently being monitored throughout the basin vary in depth from 20 to 455 feet. Groundwater levels reach a maximum in the early spring, usually April, followed by a gradual decline to a minimum in late fall, usually October.

It is uncommon for summer precipitation to cause the water level to rise although rates of decline may be slowed. This annual trend applies to most wells, but the magnitude of the annual fluctuation depends in part on the well depth. Based on information from observation wells, shallow aquifers have an annual fluctuation range of 3 to I0 feet. Water level fluctuations in deeper overburden aquifers are between 1 and 2 feet, while in the deeper bedrock wells water level variations are only a few inches.

QUALITY

Water quality is a significant use-determining factor in the basin. In the Upper Thames basin, a general hydrogen sulphide presence restricts the use of bedrock water for domestic purposes and has prompted many users to rely on groundwater from the overburden. Chloride concentrations in the upper basin are in the range of 5 to 25 mg/L while in the lower basin they range from 200 to 2000 mg/L. Similar differences apply to hardness and conductivity.

Calcium-bicarbonate type waters characterize the upper basin while sodium-bicarbonate and sodium chloride types are most common in the lower basin. These types are a direct consequence of the geochemical differences between limestones and shales and the overburden which has been derived from them.

Discussions with local residents and Medical Officers of Health indicate that several problems of well water quality exist throughout the basin. In particular: several Oxford County wells are contaminated; Komoka area wells suffer from high levels of nitrates and bacteria; Muncey reservation Indians are hindered by both well water contamination and the lack of suitable sites for developing wells.

LAND USE

The Thames River watershed contains 18 urban municipalities (four cities, seven towns and seven villages) and occupies to varying degrees the areas of 48 rural townships in seven counties.

Urban municipalities account for five percent (112 square miles) of the total area of the watershed. Farmland occupies approximately 85 percent (1924 square miles) and other non-farm rural uses including roads, industries and hamlets cover approximately 10 percent (214 square miles) of the basin.

Land within the boundaries of the urban municipalities of the basin includes significant acreage classed as agricultural or vacant that can accommodate future growth. This is demonstrated in the following table.

Present Designation of Urban Land	Percentage of Total Urban Area
Agricultural and Vacant	40
Residential	33
Industrial	10
Institutional	3
Open Space	5
Commercial	3

Approximately 88 percent of the farmland in the basin is classified as improved farmland including productive land used for crops, improved pasture, summer fallow and other uses as defined by the Canada Census. The unimproved farmland category includes wood-lots and managed forests representing approximately 7 percent of the total farmland acreage. Within the basin the type of agricultural activity is diversified and varies from area to area, depending upon soil and climate conditions.

LAND USE TRENDS

Between 1941 and 1971, the population of the Thames River watershed rose from about 214,000 to 415,000 and grew at an average annual rate of approximately 2.2 percent. The fastest growth occurred during the decade 1951 to 1961 with a population increase of 31 percent and a growth of 2.8 percent per annum over the ten years.

In 1971, 333,700 persons, or 80 percent of the total population of the watershed lived in cities, towns and villages. The City of London was the largest urban centre with a population of 219,900, or about 53 percent of the total population in the watershed. Other significant urban populations were concentrated in Chatham, Woodstock, and Stratford.

In 1971, there were 81,600 persons in the rural townships representing close to 20 percent of the total population of the watershed. Middlesex County had the highest proportion of the rural population with 5.7 percent, followed by Oxford (4.4 percent) and Kent (4.4 percent). These counties were not only the largest in area but also contained the largest urban centres. Non-farm residents (or "urban commuters") living adjacent to urban centres, contributed to the rural population increases.

Over the period 1961 to 1971, the urban population increased by 21.8 percent at a rate of 2.5 percent per annum. The rural population increased 7.6 percent at a rate of 0.7 percent per annum. More and more of the growth in the watershed population during the last decade was in the urban centres with the focus of expansion in the City of London which grew at an average of 3.1 percent per annum. Only Bothwell, Thamesville, St. Marys and Wardsville experienced negative annual growth rates. The rural townships comprising 22.5 percent of the total watershed population in 1961 decreased to 19.6 percent of the total population in 1971.

Cities, towns and villages in the watershed are expected to expand by emphasizing and intensifying their existing land uses and capitalizing on a particular resource or proximity to a resource. This growth pattern will refer to present acreage within city and town boundaries as opposed to a dependency on increases in municipal areas.

Urban growth in the City of London is anticipated to continue at a rate of three percent per annum. A general intensification of existing land uses is expected with emphasis on industry. The projected population of London is estimated at 390,000 in 1991.

The continued growth of Chatham to 48,000 in 1991 is contingent upon the encouragement of industrial and commercial activities.

Assuming continued residential development and industrial growth, the projected 1991 population of Woodstock is 39,100.

The projected population for Stratford in 1991 is estimated at 35,000. Manufacturing will continue to be the major segment of the economic base of Stratford with the expansion of existing industries and establishment of new ones.

The rural land use of the Thames River basin between 1961 and 1971 proved to be relatively stable in terms of total farmland acreage. The small decline experienced in total farmland acreage was mainly due to the various forms of urban encroachment, a phenomenon not unique to this watershed. The decline in acreage of the improved farmland sector has been almost nil, with acreage devoted to crops increasing in virtually every township. Urban expansion has taken either unimproved farmland, or unimproved land has been improved to offset the loss of improved farmland to urbanization.

One agricultural trend in the region is that of farm consolidation in which marginal operations have been absorbed by the remaining farms in an effort to become more viable and efficient units of production.

As the rural farm population and number of farms decline, the number of rural non-farm people is increasing in the Thames River watershed.

The recently announced provincial park in the Komoka area will increase the acreage of land within the basin now devoted to recreational activities. This park, particularly in view of its proximity to London will reduce the present deficit of recreational land within the watershed.

In the last quarter century a significant effort has been expended on the development of flood control facilities to reduce the risk of flooding throughout the basin. Recently, public opinion has indicated the need for additional flood protection, especially in the lower reaches of the river, but the public also opposes the development of dams on the lower river. Future flood management programs will see attempts to resolve this conflict through the development of flow retarding and flow routing structures.

To date utility corridors have not been developed in this section of the province. Highways, pipelines and powerlines have tended to utilize separate rights-of-way. The recent controversy over the Highway 402 and the present concern over the construction of a Sarnia to Montreal crude oil pipeline, indicates the development of trends that will culminate in greater use of common utility corridors.

WATER SUPPLY

Watertaking for municipal purposes represents the greatest consumptive use of water in the basin. The demand for water for municipal purposes is such that not all communities can be adequately served from within the watershed. The Lake Huron pipeline, West Elgin area water system, and the Blenheim area water system overcome the problem of inadequate local groundwater supplies. The Chatham pipeline provides a reliable supply of higher water quality raw water than can be obtained from the Thames River, thereby reducing the cost of treatment at Chatham.

Eighty-three percent of the population of the Thames River watershed relies on municipal and communal systems for its domestic water supply. An average of over 38 MGD (28 MGD come from the Great Lakes and about I0 MGD from the groundwater sources within the basin) are required to meet this domestic demand and the related industrial and commercial supplies. The remaining 17 percent of the population residing in rural areas use close to 4 MGD from groundwater supplies for domestic purposes.

Water consumption data are not available for industries obtaining water from municipal sources. Industrial water takings from other sources use a total of about 25 MGD, of which about 14 MGD are recirculated with some loss to the atmosphere. Approximately 11 MGD withdrawn in dewatering processes actually drains to the surface water courses in the Thames River basin.

Agricultural water usage for livestock is estimated to be about 6.5 MGD. This figure is based on the number of livestock and the average consumption figures for various types of livestock. Of greater potential demand on the agricultural water supply is the use of water for irrigation purposes. Watertaking permits authorize maximum irrigation takings of about 35 MGD; 21 MGD coming from surface water sources and 14 MGD from groundwater sources. These values represent the maximum potential which is much greater than actually occurs during a year with adequate precipitation. Studies indicate that on the average approximately 25 percent of the irrigation takings occur simultaneously. However, the consideration of the potential irrigation demand is important, especially as the maximum withdrawal of water for this purpose occurs during periods of minimum flow.

The known water uses of the basin total an average of 108 MGD (assuming maximum withdrawal for irrigation) of which about 14 MGD is not returned to the system. However, 28 MGD of the total 108 MGD demand is imported from beyond the watershed.

WASTEWATER DISPOSAL

NORTH THAMES RIVER UPSTREAM FROM LONDON

Upstream from London, the principle sources of wastewater are Mitchell and St. Marys discharging to the North Thames and Stratford discharging to the Avon River.

MITCHELL

A three cell, 66.6 acre lagoon provides sewage treatment for the Town of Mitchell. Average flow to the lagoon during 1971 was 0.52 MGD. The lagoons are scheduled for discharge each spring and fall. During the summer, lagoons often reach their maximum storage capacity prior to the fall necessitating an effluent discharge for approximately fifty days each year. Effluent from the system is generally of high quality.

STRATFORD

The Town of Stratford is serviced by a 6.0 MGD activated sludge sewage treatment plant which is being upgraded to include effluent polishing by sand filters and phosphorus removal.

ST. MARYS

The Town of St. Marys is serviced by a new 0.8 MGD activated sludge sewage treatment plant. Discharge is not at the 0.8 MGD hydraulic design level, leaving additional capacity still available in the plant. In addition, the Campbell Soup Company Ltd. have waste treatment facilities which discharge 0.5 MGD to the North Thames River. Considerable variation occurs in waste loading from the company treatment facilities.

SOUTH BRANCH OF THE THAMES RIVER UPSTREAM FROM LONDON

TAVISTOCK

The Town of Tavistock is serviced by a 32-acre lagoon designed to discharge semi-annually to the headwaters of the South Branch of the Thames River. To avoid conflicts with downstream livestock owners, the lagoon effluent is not released during the summer when cattle are on pasture and using the river for watering. A change to an annual discharge would necessitate enlarging the holding capacity of the lagoons. An annual discharge of effluent, chemically treated to remove phosphorus, released in early December would fulfill agreements with livestock owners and minimize the effect of the effluent on water quality down river.

WOODSTOCK

The City of Woodstock is serviced by a 4.5 MOD activated sludge sewage treatment plant presently at full capacity. A significant portion of the water quality problems found in Woodstock are attributable to the amount of sewage bypassing that occurs during storms. Further upgrading is required in the Woodstock STP to reduce the oxygen demand from the sewage treatment plant effluent and to increase the hydraulic capacity such that all sewage arriving at the plant can be treated eliminating the bypassing that presently occurs.

BEACHVILLE

A sewage lagoon with effluent discharge once per year is now being designed for the Village of Beachville. The William Neilson Company industrial wastewater discharge, while small in organic load, creates aesthetic problems which could be avoided by having the industrial wastewater discharged to the Beachville lagoon for additional treatment with the town wastes.

INGERSOLL

Ingersoll is serviced by a 2.25 MGD activated sludge sewage treatment plant. In 1973 the average daily flow to the plant was 1.2 MGD.

LONDON AREA

The City of London operates five sewage treatment plants. The Adelaide plant discharges to the North Thames River, the Pottersburg and Vauxhall plants discharge to the south branch of the Thames River upstream from the confluence with the North Thames River and the Greenway and Oxford plants discharge to the Thames River downstream from the confluence with the North Thames River.

The Adelaide sewage treatment plant is a 2.0 MGD activated sludge plant which was expanded from 1.0 to 2.0 MGD in 1971.

In 1972, the average daily flow to the plant was 2.74 MGD. The plant effluent does not meet Ministry of the Environment guidelines for effluent quality. Plans are under consideration to divert 0.25 MGD to the Greenway plant and another 0.25 MGD to the Pottersburg plant. Expansion of the treatment plant is also planned.

The Pottersburg sewage treatment plant is a 4.0 MGD activated sludge plant. Originally, the plant capacity was 1.6 MGD. A 2.4 MGD extension to the plant was completed in 1967. In 1972, the plant was receiving 3.55 MGD.

The Vauxhall sewage treatment plant is a 3.5 MGD activated sludge plant. On occasion, during short periods of heavy rain, flows to the plant have been as high as 8.0 MGD. Severe shock loadings of industrial wastes extremely toxic to the biological life within the plant have reduced treatment efficiency. Effluent quality generally exceeds the Ministry of the Environment requirements.

The Greenway sewage treatment plant consists of three separate treatment modules sharing common influent and effluent structures. Each module was constructed as the needs of the city increased.

At present, the total capacity of the plant is 18.3 MGD with an expansion to 21.3 MGD being planned. Effluent from the plant generally meets the level of BOD and suspended solids as accepted by Ministry of the Environment guidelines.

The Oxford sewage treatment plant is a 1.5 MGD activated sludge plant operating at approximately 50 percent of capacity. Generally, effluent quality is within the Ministry of the Environment guidelines (for BOD and suspended solids).

Reducing the oxygen demand of effluent from all London sewage treatment plants to the level of the present Greenway effluent would significantly reduce water quality impairment in the London area.

THAMES RIVER DOWNSTREAM FROM LONDON

WESTMINSTER

The Westminister treatment plant is a 0.25 MGD activated sludge plant discharging to Dingman Creek. Although effluent quality is good, the limited flow available for effluent assimilation in Dingman Creek results in water quality problems in the creek.

SOUTHLAND PARK

The Southland Park sewage treatment plant is a 0.02 MGD activated sludge plant serving the Police Village of Lambeth. The plant, which does not meet the Ministry of the Environment criteria for effluent quality, discharges to Dingman Creek. This discharge compounds problems already generated by the Westminster plant.

CHATHAM

Chatham is serviced by a 4.5 MGD activated sludge sewage treatment plant. Considerable bypassing of raw sewage from the combined sewer system occurs during periods of storm flow. Prior to the completion of the present Thames River Basin Study modelling work, recommendations were made by the Ministry of the Environment for effluent polishing at Chatham.

Further investigations indicate that a significant portion of the water quality degradation in the Chatham vicinity may be attributable to the sludge banks that have accumulated downstream from raw sewage bypasses. Upgrading the existing sewage treatment plant to provide secondary treatment of all sewage and eliminating infiltration and bypassing of sewage in the collector system should eventually eliminate the sludge banks in the vicinity of the city. The waste loading discharged from the upgraded sewage treatment plant should be sufficiently reduced to avoid dissolved oxygen depletion in the river. Ensuring the complete nitrification of the effluent prior to discharge to the river would significantly reduce the effect of the plant on the river. A sewer separation program is underway and sewage pumping stations are to be enlarged to reduce the occurrence of sewage bypassing. A plant expansion is to be undertaken.

TILBURY

The town is serviced by a 36 acre lagoon. Discussions on the development of improved facilities are underway.

OTHER MUNICIPAL FACILITIES

Several other municipal sewage treatment facilities are now in various stages of design or construction. Included in this category are facilities for Dorchester, Kilworth, Glencoe, Newbury, Bothwell, Thamesville, Ridgetown, Blenheim and the Township of Tilbury.

A number of small private systems servicing commercial developments and institutions also have treatment facilities which discharge to waters of the Thames River system at various times of the year.

INDUSTRIES

A large proportion of industry in the Thames River basin is located within municipalities. Generally, industries discharge wastes to the local sewer systems for treatment at the municipal treatment facilities. Usually sewer use bylaws are enforced by the local municipality to ensure that wastes sewered by industries are not toxic or corrosive. If such corrosive or toxic wastes are produced, the industry is required to neutralize the harmful characteristics of the waste prior to discharge to the sewer system.

A number of sewage treatment facilities including Beachville, Glencoe and Ridgetown are being developed that could receive industrial wastes that now discharge directly to the river system.

Several dairy products companies in the watershed use land disposal of waste, resulting in no impact upon the river.

A number of quarries discharge water from the dewatering process in the quarry. Usually this water is treated for solids removal and, if necessary, pH control prior to discharge.

Several industries discharge uncontaminated cooling water directly to the river.

A few industries produce a waste effluent that is discharged to the river following chemical or biological treatment.

RECREATION

The Thames River watershed provides a variety of recreational activities. Recreation varies from passive non-consumptive activities to active consumptive practices.

The Upper Thames and the Lower Thames Conservation Authorities are the principal operators of water related recreational facilities within the basin. It is estimated that facilities of the two authorities attract approximately 230,000 visitors a year. Within the Lower Thames Conservation Authority, there are eight conservation areas totalling about 480 acres. Total acreage administered by the Lower Thames Conservation Authority is about 700 acres (including 210 acres of managed forest areas).

The Upper Thames Conservation Authority administers a larger area of public land. Included are fourteen conservation areas totalling 8,513 acres. The three largest are the Wildwood Conservation Area (3,100 acres), the Gordon Pittock Conservation Area (2,640 acres) and the Fanshawe Conservation Area (2,465 acres), all of which offer camping facilities. Total acreage administered by the Upper Thames Conservation Authority is about 8,652 acres including 139 acres of managed forest lands.

Passive recreational activities such as hiking, scenic viewing and picnicking are popular throughout the basin, particularly at areas offering public access to the river and its tributaries.

On the wider and deeper sections of the river (especially in the Fanshawe, Wildwood and Gordon Pittock reservoirs) sailboating and canoeing are popular pastimes. Every spring, a canoe race, attracting a large number of entrants, is staged from St. Marys to the Fanshawe Reservoir.

Power boating is popular on the Wildwood and Springbank Park impoundments as well as the lower reaches of the river. Large cruisers frequent the reach from the mouth of the river to Chatham. Boating on the lower Thames River is now under Federal regulation (enforced by the Ontario Provincial Police).

There are 26 campgrounds having a total of approximately 2,200 tent and trailer sites within the watershed. Twenty-three of the campgrounds (accounting for 718 acres and 1645 tent and trailer sites) are under private ownership. The relative paucity of camping facilities within the basin necessitates that campers rely on provincial and private parks bordering lakes Erie and Huron.

In addition to camping parks, municipal day use parks (the largest being Springbank Park in London) provide recreational facilities for area residents.

The first provincial park within the Thames River basin is planned for the Komoka-Kilworth area. The park, to occupy approximately 1300 acres in the Thames River valley about 8 miles west of London, will be oriented to the needs of urban users from the London area. Angling, sightseeing and canoeing are foreseen as the principal river oriented uses within the park. Separate facilities will likely be provided for swimming and bathing.

Presently, Sunova Lake and the Wildwood and Gordon Pittock reservoirs provide recreational nature viewing especially during the spring and fall migration flights of waterfowl and shorebirds. With increasing demands for open space and with improved water management conducive to attracting more birds, significantly more non-consumptive recreation could be achieved.

Winter ski facilities are offered at clubs in London, Thamesford and Woodstock. Conservation areas in the vicinity of London, Stratford, Woodstock, and Chatham provide facilities for skating, cross-country skiing, tobogganing, snowshoeing, and snowmobiling. Snowmobiling facilities are provided in county forests throughout the basin and at a number of privately owned locations. Winter recreational activities are limited due to a relatively flat terrain and low snowfall.

The Thames River fishery provides significant recreational value which is discussed in the Natural Resources Section.

The largest commercial tourist attraction is the Stratford Shakespearean Festival. Surveys indicate that approximately $8,000,000 a year are generated by tourists in Stratford. Storybook Gardens, in Springbank Park, is another major commercial attraction.

Recreation is not a leading industry in the basin, but it does play a significant role in the life of residents of the watershed.

NATURAL RESOURCES

FISH

The fishery resource of the Thames River is significant for both its commerical and recreational value. However, in recent years, problems originating from land and water use have inflicted serious pressures on the resource.

A total of forty-four different species were captured in the Thames River basin. Smallmouth bass, rock bass, suckers and carp are common to the entire river. The greatest variety of fish was found in the lower Thames River where artificial barriers do not interfere with the movement of populations between the river and lake environments. Smallmouth bass, largemouth bass, yellow pickerel, channel catfish, white bass, carp and yellow perch are common catches in the lower reaches.

The Thames River is particularly important to the Lake St. Clair - Lower Lake Huron yellow pickerel fishery. The three major spawning areas propagating this fishery are the Thames River, the Sydenham River and Lake St. Clair. Present estimates indicate that the Thames River supports the greatest percentage of the pickerel spawning activity, the Sydenham River rating a poor second, followed by Lake St. Clair.

Yellow pickerel migrate into the Thames River to spawn in the gravel riffles of the river as far upstream as London. The most significant pickerel spawning areas include reaches of the river from Kent Bridge, downstream from Wardsville, upstream to Big Bend and sections of the river near Delaware and Komoka.

Pickerel seldom utilize fish ladders, hence, the viability of this fishery depends largely upon the maintenance of the lower portion of the Thames River free from dams and long term flooding. At present, dams within the City of London are the first barriers obstructing fish passage. Upstream from these dams, the river fishery is more dependant upon resident species, fish stockings and impoundment fishing.

Fanshawe Lake has a sustaining population of smallmouth bass; the Gordon Pittock Reservoir sustains northern pike. Carp proliferate in poorer quality waters imposing pressures on preferred species.

Present impoundments with public fishing areas supply the heaviest concentration of angling pressure, accounting for over half of the fishing effort expended in the Thames River watershed. These impoundments, unfortunately, do not realize their full potential as a result of repeated water releases for flood control and low flow augmentation. At present, high turbidity, high water temperatures, depressed oxygen concentrations and high nutrient levels encourage the proliferation of coarse fish species and decrease the number of man-days of fishing use.

Fish stockings have been relatively unsuccessful throughout the Thames River basin. In order to maintain certain fish populations, stockings have had to be repeated annually at a higher cost.

Recent changes in the operation of reservoirs within the watershed have improved water quality opening the way for more successful fish stocking programs. For example, a largemouth bass population has been introduced in the Sharon Reservoir.

Since 1969, 22 fish kills have been reported in the Thames River basin, I3 being attributed to industrial sources (mainly agribusiness), two to municipal-industrial, and six to natural causes. The cause of one incident was not determined.

WATERFOWL

There is no major breeding ground for waterfowl in the Thames River basin; however, there is an extensive distribution of suitable habitat to support small colonies throughout te watershed.

The limitation of the production can be attributed to a number of factors, including intensive agricultural practices which have resulted in the clearing and draining of much of the original wetland habitat of the watershed. Reduced stream edge cover due to overgrazing and severe water level fluctuations on reservoirs for flood control and flow augmentation has destroyed potential waterfowl habitats. There are areas that if properly managed, could have high potential for waterfowl production. These areas include wetlands such as the Ellice and Zorra swamps.

WILDLIFE

The Thames River basin supports a diverse population of wildlife including small animals (field mice, chipmunks); small game (squirrels, cottontail rabbits, hares); fur bearing animals (muskrats, racoons, fox, mink); game birds (ruffled grouse, quail woodcock, pheasants); predatory birds (hawks, owls) and large animals (white tail deer).

Large scale clearing of land has provided open land to produce feed grain and cash crops. The large open fields combined with a scattering of woodlots, miles of fence rows and semi-wildland riverbanks provide an adequate mixture of habitats to support a healthy balance of wildlife.

Hunting is a major recreational pastime with rabbit hunting providing over one half of the small game hunting.

In some areas, trapping is a part time occupation for local residents. In 1972, 288 trapping licenses were issued in Kent, Elgin and Middlesex counties. A total of $42,000 in fur value was produced which represents an average per capita gain of $140 after purchasing the necessary licenses.

TIMBER

The Thames River watershed is part of what was originally a deciduous forest stretching from the shores of Lake Erie to the vicinity of London. Today, there are very limited forested timber stands in the watershed. Most of the remaining productive forests are concentrated along the river or its tributaries. In the upper sections of the basin, the floodplain is extremely rugged with deep valleys and undulating topography. In these areas which are generally unsuited for agriculture, little clear cutting has been done.

In 1966, the Woodlot Improvement Act was enacted in Ontario to encourage replanting and proper management of woodlots. The province assists the landowner in looking after timber stands and replanting new areas where necessary. This and other programs aimed at improving the quality of forest cover in Ontario have promoted improved quality woodlots within the basin. These improved woodlots also help upgrade the water resources of the watershed by retarding flow and stabilizing floodplains and thereby reducing erosion.

SAND, GRAVEL AND CRUSHED STONE

Deposits of sand, gravel and limestone are plentiful in the Thames River basin. Glacial spillways and moraines deposited large volumes of sand and gravel. Sand is more plentiful in the lower reaches of the watershed with gravels closer to the headwaters. Large deposits of limestone are also available in the upper portion of the watershed. Over 50 operators extract sand, gravel and crushed stone within the Thames River basin. Most of the large producers have permanent plants on the excavation sites. A large quantity of sand and gravel production comes from medium-sized and small producers using portable crushing and screening plants. Many of these portable plants are used by contractors requiring large quantities of granular material.

The extraction of granular material and the quarrying of limestone must be undertaken with care to avoid damaging the quality of groundwater or drawing down the water table so as to interfere with groundwater users.

CRUDE OIL AND NATURAL GAS

A number of petroleum resources exist along the Thames River in Middlesex, Kent and Elgin counties. These three counties produce 23.5 percent of the total Ontario natural gas production and 55 percent of the crude oil production. Kent leads natural gas production and Elgin leads crude oil productions with 50 percent of the provincial crude oil production.

WATER USE CONFLICTS

A major objective in managing the natural resources of a river basin is to resolve or at least minimize conflicts arising from the competing demands for the resources.

With the ever increasing demands on the resource it is not possible to totally eliminate conflict. However, it is possible to identify the benefits and drawbacks of various possible actions in order that a benefit tradeoff can be made. Programs can thus be established which are economically acceptable and also minimize the degree of conflict. Water use conflicts become a problem of priority which usually reflect economic feasibility and the desire to provide the most good for the greatest number of people possible, consistent with providing the highest practical standard of preservation of the water resource.

In this text, water resource related conflicts of the Thames River basin are identified. The Ontario Government intends to publish recommendations on an optimum resource management policy in the final Thames River Basin Study report later this year. To develop this policy a number of alternatives for resource management are being considered. The following are some of these alternatives including questions that must be answered before any specific programs can be launched.

DAMS

The building of dams may create conflict. While benefitting one region in terms of providing flood protection and recreation it may be necessary to sacrifice agricultural land or other uses. Impoundments can degrade the aesthetic value of a river valley and disrupt the fish and aquatic biology of the river in question. Reservoir levels can be maintained at relatively constant levels favouring recreational sports use such as fishing, swimming and boating, or the water level can be drawn down annually providing flood control or flow augmentation.

The following specific 'dam related' conflicts have been identified in the Thames River basin:

(a) Proposed Thamesford Reservoir

Some of the finest water quality in the basin exists in the Middle Thames River. A proposed dam and reservoir at Thamesford could seriously affect the quality of this water. Over I200 acres of land would be removed from agricultural and other uses. These negative factors must be weighed against benefits that such an impoundment could generate including additional downstream flood control and flow augmentation.

(b) Proposed Glengowan Reservoir

The proposed Glengowan Dam would impound the North Thames River upstream from St. Marys. The backwater of the impoundment would also affect the lower reaches of the Avon River. The proposed reservoir would occupy approximately 1195 acres. The high level of nutrients in the Avon River and to a lesser degree in the North Thames River indicate a risk of water quality problems developing in the proposed reservoir. The loss of land to other uses imposes a second constraint on the reservoir. However, the additional benefits in terms of flood control, low flow augmentation and additional reservoir oriented recreation must be considered.

(c) Proposed Wardsville Reservoir

The most contentious reservoir proposal within the basin to date has been the Wardsville Dam and reservoir which would flood approximately 6300 acres and could require up to 12,000 acres of land. The dam would increase flood protection for farms and municipalities downstream, but at the cost of permanently losing good agricultural land at the reservoir site. The reservoir could affect the Caradoc and Oneida Indian Reservations both through land loss and the blockage of the pickerel and sucker migration which contribute to the food supplies and income of the reservation.

The blockage of the passage of yellow pickerel migrating up the Thames River to spawn in the gravel riffles between Wardsville and London would have a serious effect on the Lake St. Clair and lower Lake Huron pickerel fishery.

In view of the severity of the potential damages of the Wardsville Dam, an alternative proposal for the construction of flow retarding structures that would pass only the volume of water that the downstream channel could accommodate while permitting fish passage, is being studied. The alternative would create local short term floods in the floodplain upstream from Wardsville. If found to be feasible and if implemented, the permanent loss of agricultural land would be a minimum.

It has been outside the scope of this study to calculate cost-benefit ratios for the proposed reservoirs which incorporate socioeconomic and environmental considerations. The primary purpose of inviting comments from interested citizens is to allow government to make the best decisions reflecting public attitudes. The information thus gathered here and contained in the final report should serve as excellent basis for an all encompassing evaluation of the costs and benefits of the proposed reservoirs.

WHAT FACTORS SHOULD BE CONSIDERED IN EVALUATING THE COST-BENEFITS OF THE PROPOSED DAMS?

EXISTING RESERVOIRS

The Wildwood, Fanshawe and Gordon Pittock reservoirs are the most important impoundments in the watershed in terms of flood control, recreation and low flow augmentation.

The Wildwood reservoir in providing recreation does not always provide adequate low flow augmentation. Hence, downstream flows fall below the desired level which in turn contributes to the degradation of downstream water quality due to the lack of flow to assimilate residual organic material already in the river and waste discharges from downstream sewage treatment plants. However, significant changes in the mode of operation of Wildwood to provide additional flow augmentation could interfere with the recreational benefits afforded by the reservoir.

The emphasis on recreation in the Fanshawe reservoir has encouraged an operation policy focused on constant water level in the reservoir. During critical summer flows, Fanshawe has on occasion actually reduced the downstream flow in the river. This in turn, contributes to additional water quality impairment in London.

The Gordon Pittock reservoir is operated with emphasis on flow augmentation, hence, local residents complain that the best recreational use of the reservoir is not being met.

Attempts to utilize existing reservoirs for multi-use has generated problems with various user groups disagreeing as to what priority should be assigned to each use and subsequently what mode of operation should be enforced for each reservoir.

WHAT SHOULD BE CONSIDERED IN ESTABLISHING REVISED OPERATING POLICIES FOR THE EXISTING RESERVOIRS?

DYKE IMPROVEMENTS

Along some sections of the lower Thames River, dykes are seriously eroded generating a significant threat of dyke failure and extensive farm flooding. A number of alternatives are available for repairing and stabilizing the dykes. Earth fill and vegetative cover with shallow water growths of cattails and other aquatic plants to dampen wave action along the shore could be considered. Protection could also be provided along the shore by the use of concrete or rock lining of the dykes. Vegetative stabilization of dykes can provide an economical answer to some of the erosion problems, but the accompanying increase in wildlife, including muskrats, shorebirds and waterfowl could prove to be undesirable in some farming areas. Concrete or rock revetment works, although effective, are also quite expensive.

HOW MUCH LOSS OF AGRICULTURAL PRODUCTIVITY DUE TO WILDLIFE WOULD ACCOMPANY VEGETATIVE STABILIATION OF DYKES?

WHAT FORM OF PROTECTION WORKS SHOULD BE USED ON THE VARIOUS SECTIONS OF DYKES?

DRAINAGE SCHEMES

Agricultural drainage schemes and municipal channel improvement programs often solve a local flood or wet land problem, but in doing so contribute to a more severe problem by accelerating the rate of runoff at a critical point downstream. Hence, a conflict arises between the upland farm and municipal practices and landowners on flood prone land downstream.

CAN AGRICULTURAL DRAINAGE SCHEMES AND MUNICIPAL CHANNEL IMPROVEMENTS BE MODIFIED TO FACILITATE RETARDING OF RUNOFF UNTIL AFTER CRITICAL FLOOD PEAKS HAVE PASSED DOWNSTREAM?

URBANIZATION

In general, adequate supplies of land and water for domestic supply are available to support urban growth. Most municipalities have already acquired significant acreages of formerly rural farm land to facilitate growth. However, uncontrolled growth will result in additional future losses of farmland.

Major municipalities throughout the watershed are faced with a lack of streamflow for receiving and assimilating sewage treatment plant effluent. As urban communities grow, they discharge larger quantities of wastewater, placing heavier loads on the stream, and thereby require more streamflow. At the same time the increase in population is usually accompanied by a greater demand for water related recreation which places pressure on reservoir operation encouraging less streamflow. To continue to grow and to maintain an adequate quality and quantity of water for recreation, the municipality is forced into more expensive treatment facilities.

At present, this problem faces several municipalities in the basin including Chatham, London, Ingersoll, Woodstock and Stratford.

If suitable environmental quality is to be maintained in the future, these municipalities must consider such alternatives as providing higher degrees of sewage treatment, limiting growth or exporting effluent directly to the Great Lakes.

WHAT OPTION SHOULD THE MAJOR MUNICIPALITIES HAVE IN THE FUTURE WITH REGARD TO POPULATION GROWTH AND WASTE TREATMENT ALTERNATIVES AND ENVIRONMENTAL QUALITY?

AGRICULTURE

Some agricultural practices in the Thames River watershed conflict with other users. The free ranging of cattle contributes to the trampling of stream banks and the acceleration of erosion. The defecation of livestock in and adjacent to watercourses contributes to the bacterial and organic pollution of the stream. Maximum cultivation of land removes streambank cover and accelerates erosion, especially in fields through which intermittent streams flow. A comparison of fertilizer sale records and recommended application rates indicates a possible 50 percent over application of nitrogen and a 70 percent over application of phosphorus in the watershed. Throughout the basin, the subtle increases in organic materials, bacteria and turbidity are signs of these practices. As a result the general level of water quality in the basin is lowered and the ability of the Thames River watershed to support a choice fishery, additional recreation and continue receiving waste inputs is reduced.

WHAT ARE THE IMPLICATIONS OF PASTURING LIVESTOCK WITHOUT FREE ACCESS TO THE RIVER?

CAN STREAMBANK AREAS BE SWITCHED FROM PASTURE TO FORAGE CROPS?

CAN RATES OF FERTILIZER APPLICATION BE REDUCED?

The preceeding discussion of conflicts and related questions are not the only problems that exist or questions that are outstanding with respect to the resources of the Thames River watershed. These are some of the key questions for which the Thames River Basin Study Team are seeking answers. Hence, anyone wishing to address a brief to any of the above questions or raise additional questions and comments is invited to do so.

Briefs and comments should be forwarded to the Secretary of the Environmental Hearing Board, I St. Clair Avenue West, Toronto, Ontario M4V 1K7, not later than April 30, 1974.

GLOSSARY

In order to keep the public informed, this Thames River Basin Study bulletin has been produced in tabloid newspaper form to facilitate mass distribution. Technical terminology has been retained to ensure accuracy. However, as an aid to the reader, the following glossary has been prepared.

Algae	an assemblage of simple, non-vascular plants containing chlorophyll and consisting of a great number of genera and species, both microscopic and large in size. Algae carry on photosynthesis which differentiates them from fungi. Some algae may produce nuisance conditions when environmental conditions are suitable for prolific growth.
Anaerobic	refers to organisms requiring, or not destroyed by, the absence of air or free (elemental) oxygen.
Anoxic	refers to a condition or state absent of air or free (elemental) oxygen.
Aquatic plants	the aquatic plants of lakes and other kinds of standing water bodies are those whose seeds germinate in the water or in the lake-bottom soil.
Aquifer	a water bearing zone in overburden or bedrock which contains and transmits groundwater in usable quantities.
Association	see Community
Bacteria	group of unicellular or multicellular, microscopic organisms lacking chlorophyll.
Base flow	groundwater flow.
Basin	the geographical area within which all surface water tends to flow into a single river or stream via its tributaries.
Benthos	those animals and plants living on or in the bottom region of the watercourse (also benthic community).
BOD	biochemical oxygen demand. The total amount of oxygen required for the life processes of organisms and for the aerobic biochemical decomposition of organic matter present in water.
cfs	cubic feet per second. A measure of flow.

Cladophora	an algae species.
COD	chemical oxygen demand. A measure of the oxygen-consuming capacity of inorganic and organic matter present in water or wastewater. It does not differentiate between stable and unstable organic matter and thus does not necessarily correlate with biochemical oxygen demand.
Coliform Bacteria	a group of bacteria, predominantly inhabiting the intestines of man or animal, which are common in fecal wastes, but also include *forms* associated with plants and grains.
Community	a naturally occurring group of different organisms inhabiting a *common* benthic environment, interacting with each other especially through food relationships. Community refers to both *numbers* and types of organisms.
Detritus	disintegrated rock materials detached from and overlying bedrock.
Dewater	the removal of water, usually by pumping, from quarry operations.
Discharge	the rate of flow of surface water or groundwater.
Dissolved Oxygen	the amount of dissolved oxygen in mg/L present in water.
Diversity	the variation in the association or community of organisms.
Drawdown	a decrease in the levels of reservoirs or other impoundments by releasing top or bottom water through the dam.
Effluent	the discharge of wastewater, normally from a point source, to a receiving water.
Enrichment	an over abundance of nutrients, thereby greatly increasing the growth potential for algae and other aquatic plants.
Facultative	organisms which have two alternative energy-yielding metabolic pathways. In the presence of oxygen, the organism is aerobic and in the absence of oxygen, the same organism is anaerobic.
Fauna	animal population.
Ferric sulphide	a black deposit formed on the bottom of rocks during anaerobic conditions.

Fish kill	a minor kill involves less than 100 individuals in a limited stretch of the river. A moderate kill involves 100-1000 individuals in a I/4 - 1 mile stretch of the river. A severe kill involves greater than 1000 individuals along an extended length of the river.
Flora	plant population.
Groundwater	water in the ground that is in the zone of saturation, from which wells, springs, and ground water runoff are supplied.
Influent	inflowing stream. Normally refers to raw sewage entering a sewage treatment plant.
Macroinvertebrate	an animal lacking a backbone structure and which is clearly visible to the eye.
mgd	million gallons per day (Imperial).
mg/L	milligrams per litre. One milligram per litre is approximately equal to one part per million.
Midge	a tiny insect spending the greater part of its life in the larval stage living on the bottom of lakes or streams.
MOH	Medical Officer of Health.
Moraine	a depositional, unconsolidated, glacial landform. It normally is ridge-like shaped and provides a source of sands and gravels.
Nocturnal	pertaining or belonging to or occurring at night.
Organism	any living body exhibiting organization.
Outcrop	bedrock exposed above the ground surface.
Overburden	unconsolidated materials overlying bedrock.
Pollution tolerant	refers to an organism that can withstand degraded water quality conditions.
Reservoir	applied to waters held in storage in either artificial or natural basins.

Sludge	a term used to define settled organic waste materials. Term used to describe waste materials in sewage treatment plants and deposits on stream beds.
Sludgeworm	a pollution tolerant organism associated with sludge deposits.
STP	sewage treatment plant.
Surficial	pertaining to surface geologic materials.
Turbidity	the presence of an amount of very fine sediment suspended in water. Turbidity is measured by determining the degree of interference to the passage of light rays through the water sample.