REPORT

EXAMINATION AND INVESTIGATION

OF

COUNTY DITCHES 2 AND 5

RAMSEY COUNTY, MINNESOTA

OCTOBER, 1966

FILE No. 6637

BANISTER ENGINEERING CO.
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October 31, 1966

Board of Ramsey County Commissioners
Ramsey County Court House
St. Paul, Minnesota 55102

RE: EXAMINATION OF COUNTY DITCHES 2 AND 5
Our File: #6637

Attention: Mr. Eugene A. Monick
County Auditor

Gentlemen:

Herewith is our report on County Ditches 2 and 5 prepared pursuant to the order of your Board of April 18, 1966, and Minnesota Laws 1957, Chapter 682. We have further conferred periodically with the offices of your County Engineer, County Attorney and County Auditor relative to the preparation and submission of the report.

This report is the result of our examination and investigation of subject ditches. Contained therein is a brief history of the ditches, since their establishment, together with a statement of problems in connection therewith. The discussion of the problems, together with the recommendations for solution thereof, takes into account the surface drainage needs of a substantial part of one of the most highly developed portions of suburban Ramsey County. Future needs of this tributary area are dependent upon the rate and extent of the development of certain lands which are now in a relatively unimproved state. Within the scope of this report, which is limited to Ditches 2 and 5, such needs are taken into account.

Included as part of this report are maps and drawings together with estimates of cost and supporting analysis and design computations. We respectfully suggest this report be carefully studied by members of your Board as well as other County officials and such professional and administrative advisors as you determine. Further, this report should be referred to appropriate State agencies for review and comments as well as the various affected municipalities.

We shall welcome the opportunity to discuss or explain this report to the extent you request such that further proceedings may be undertaken without delay.

Respectfully submitted,

BANISTER ENGINEERING COMPANY

Roger B. Short, P. E.

RBS/ed

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

DATE: OCTOBER 31, 1966 REG. NO. 3058

I N D E X

CONCLUSIONS AND RECOMMENDATIONS

As a result of our detailed investigation and studies which comprise a part of this report, it is concluded that:

1. Following spring runoff and heavy rains, severe flooding conditions occur within the watersheds of Ditches 2, 3 and 5 and particularly at certain locations adjacent to Ditch 2.

2. Ditches 2, 3 and 5 were established in 1906 to serve adjacent tributary agricultural lands, but the areas now served by the three ditches at this time bear only a slight resemblance to the original benefitted watersheds due to improvement within the overall combined watersheds and the construction of drainage systems now discharging either directly or indirectly into the ditches.

3. The areas of the various municipalities now served or proposed to be served by Ditches 2, 3 and 5 cannot be adequately drained by these ditches in their present undersized and deteriorated condition and unless the ditches are improved, more severe flooding conditions will be experienced and the further development of adjacent lands will be seriously handicapped or prevented.

4. Additional local municipal drainage systems proposed to drain into the system are necessary and proper since no practical alternates exist nor can a new parallel public drainage system be constructed due to the pre-empting of the only suitable drainage course location by the three established ditch systems.

5. If the drainage needs of the watersheds are to be met without extensive delays the improvement proposed in this report must be carried out within the framework of existing general and special ditch laws since such procedure is the only practical method available and since the proposed improvements can be authorized by proceedings of the Ramsey County Board of Commissioners.

6. The improvement of Ditches 3 and 5 cannot precede the improvement of Ditch 2.

7. The plan for improved ditch drainage proposed within this report utilizes all available existing lakes and temporary impounding basins to the greatest practical extent together with requirement that such use be continued and that other additional uses of the land must be compatible with such ponding.

8. The proposed overall watershed of Ditches 2, 3 and 5 serves portions of 6 different municipalities divided as follows:

	Area (acres)	%
Minneapolis	41	0.84
Columbia Heights	272	5.55
St. Anthony	706	14.41
New Brighton (including proposed municipal improvements)	1993	40.67
Arden Hills	114	2.33
Roseville (including proposed municipal improvements)	1774	36.20
	4900	100.00 %

9. During the past 25 years, Long Lake has experienced high levels of several weeks duration following high surface water runoff from the Rice Creek watershed, the highest being in 1944 which preceded residential and commercial development of tributary areas within the watershed of Ditches 2, 3 and 5.

10. The proposed overall watershed of Ditches 2, 3 and 5 comprises less than 4% of the total Rice Creek watershed.

11. That due to the extensive public ditch drainage systems which exist within the Rice Creek watershed (23 county and judicial ditches in Ramsey, Washington and Anoka Counties), plus the St. Paul Water Department controls and diversions, the improvement of Ditches 2, 3 and 5 cannot be considered as being inconsistent with other public uses of Rice Creek.

12. Lower Rice Creek between Long Lake and the Mississippi River lies principally in Fridley (Anoka County) and the improvement and regulation thereof cannot be carried out by Ramsey County acting alone.

13. The creation of a Rice Creek Watershed District has been proposed and supported by Ramsey County and the Villages of New Brighton and Roseville as being the only means under present laws to meet the long range need for regulating Rice Creek, particularly below Long Lake.

14. The nature and extent of Rice Creek regulation and/or improvement is beyond the scope of this report and must be the subject of a further engineering investigation and study made to provide an overall plan therefor.

15. The improvement of County Ditch 2 as proposed in this report will result in the relatively rapid conveyance of watershed runoff to Long Lake with discharge at a greater momentary rate than has been previously experienced, although design flows are based on complete development of the three ditch watershed and therefore will not occur under design conditions for many years.

16. Due to the character of the Rice Creek watershed, the accelerated runoff from Ditch 2 will have largely passed through Long Lake before the flood crest of Rice Creek runoff reaches the lake.

17. The improvement of Ditch 2 as proposed in this report can be carried out without causing immediate additional flooding problems on Long Lake or on Rice Creek below Long Lake, although the ultimate need for the improvement and regulation of lower Rice Creek must be recognized particularly in view of the probable accelerated development above Long Lake, an area which has relatively slow runoff.

18. Since the flows for which Ditch 2 improvements are designed are those resulting from complete land development within the watershed, ditch flows over the next several years will, under design rainfalls, be much less than ditch capacity and thus cause the ditch and its structures to appear to be substantially oversized.

19. The estimated cost of improvement of Ditch 2 is $300,255.00.

20. The improvement of Ditch 3 is the subject of a separate engineering investigation and report by another firm, and their recommendation is for the almost complete relocation of Ditch 3 with discharge directly into Ditch 2 at the Soo Line Railroad thus essentially by-passing Poplar and Jones Lakes.

21. The improvement of Ditch 5 within Roseville will be required before further development can be made within its upper watershed, and such ditch improvement must be based upon providing impounding basins for temporary storage of surface runoff to prevent the overloading of piped portions of the ditch located under Minnesota Highway Department bridges and interchanges.

In considering the foregoing, it is recommended that:

1. The improvement of Ditch 2 be made in accordance with the plan proposed in this report at an estimated cost of $300,255.00.

2. The Ramsey County Board of Commissioners proceed with all reasonable dispatch towards the completion of proceedings which will permit the early improvement of Ditch 2.

3. In connection with the proposed improvement of Ditch 2, permanent ditch easements with specific legal descriptions be obtained across affected properties to enable maintenance of and access to the ditch in the future.

4. The improvement of Ditch 3, which is the subject of a separate engineering report, be made a separate proceeding or be joined with the improvement of Ditch 2 upon determination of the Ramsey County Board of Commissioners, provided, however, that the improvement of Ditch 3 cannot precede that of Ditch 2.

5. The improvement of Ditch 5 within Roseville awaits the establishment of overall land use and zoning in the ditch watershed.

FOREWORD

County Ditches 2, 3 and 5 are important drainage courses largely located within New Brighton and Roseville and serving portions of these and adjacent communities. With runoff from tributary lands increasing yearly, the limited capacity of these ditches has become a problem of serious magnitude.

Recognition of this situation by the two above mentioned villages together with the Minnesota Department of Highways led to the submission of petitions from the two villages to the Ramsey County Board requesting the repair and improvement of the ditches. Also petitioned for was the right to utilize said ditches as outlets for additional municipal storm sewers.

Other units of government including St. Anthony, Columbia Heights, Arden Hills and Minneapolis as well as Ramsey County are aware of the problem but are not concerned as petitioners in the proceeding under which this report is prepared.

This report is concerned only with Ditches 2 and 5 while a separate investigation and report has been prepared for Ditch 3. Since Ditch 3 now discharges directly into Jones Lake, the upper extremity of Ditch 2, the watershed of Ditch 3 thus becomes an integral part of Ditch 2 watershed. Accordingly, certain detailed study of Ditch 3 has been, of necessity, conducted as a part of the investigation of Ditch 2. However, no recommendations for the improvement of Ditch 3 are contained in this report and we therefore refer you to the separate report dealing with Ditch 3. The cooperation and assistance of the following has been indispensible in the compilation of data for this report, and gratitude and acknowledgement is hereby given.

County of Ramsey, its Board of Commissioners and offices of the Assessor, Auditor and Engineer.

City of Columbia Heights and its City Engineer.

City of Minneapolis and its office of the Sewer Division of the Department of Public Works.

City of St. Paul Water Department and its General Manager

Village of New Brighton and its Village Manager, Village Engineer and firm of consulting engineers.

Village of Roseville and its Village Manager and Director of Public Works.

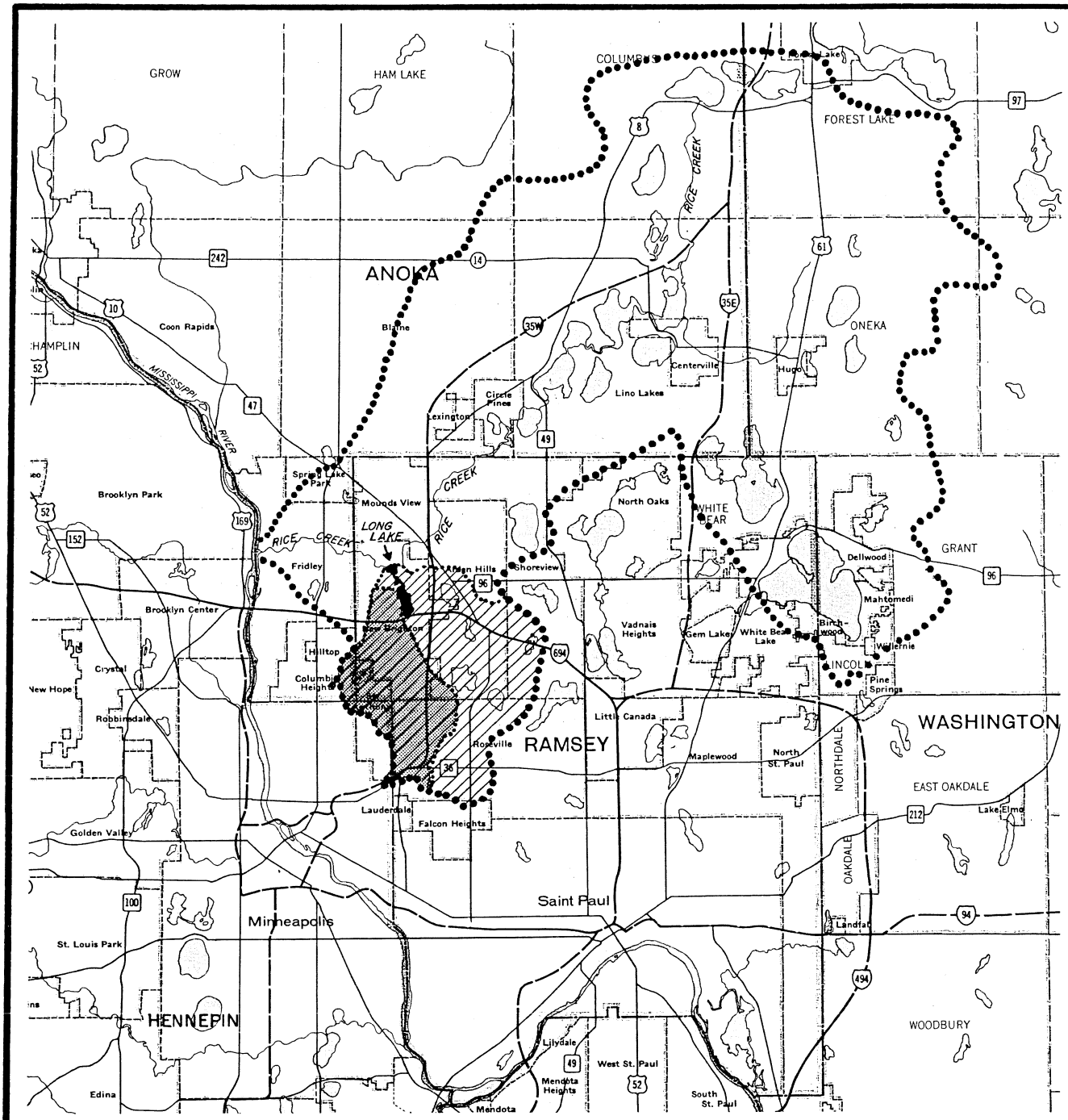
Village of St. Anthony and its Village Manager and firm of Consulting Engineers.

State of Minnesota, Department of Highways, its Hydraulics Division and District 9 Office and District 9A Maintenance Area Office.

State of Minnesota, Conservation Department, Division of Waters.

Soo Line Railroad Division Engineer.

The physical area served by Ditches 2, 3 and 5 and their orientation in the Twin City Metropolitan Vicinity may be seen on Drawing No. 1.



RICE CREEK WATERSHED

PORTION OF RICE CREEK WATERSHED TRIBUTARY TO LONG LAKE EXCLUSIVE OF RICE CREEK DISCHARGE FROM THE NORTHEAST.

PORTION OF RICE CREEK WATERSHED DRAINED BY COUNTY DITCHES NO. 2, 3 & 5

N

SCALE: 1" = 4 MILES

LOCATION MAP

DRAWING NO. 1

HISTORY

GENERAL

Since the late 1800's and over a period of many years, the Minnesota Legislature has dealt with the problem of drainage resulting in the enactment of general and special laws providing for the construction, maintenance, repair and improvement of public drainage systems to drain lands tributary thereto.

Under current laws, county ditches must be located within a single county as distinguished from judicial ditches which are located in more than one county. Authority over county ditches and their proceedings is vested in the Couny Board of the county concerned. Also under current laws, the establishment of such public drainage systems is based upon the determination that such improvements would be of public benefit and utility and promote the public health and that the system is practicable and that further, the benefits to improved property to be assessed are greater than the total cost of the system.

In looking back to the years following the turn of the century, the general problems confronting property owners and county boards were essentially rural in nature, even in Ramsey County. Drainage laws then existing, while not in the form of current drainage laws, were generally responsive to the drainage needs of agricultural lands.

ESTABLISHMENT OF RAMSEY COUNTY DITCHES 2, 3 AND 5

Upon receipt of proper petitions of various landholders in Ramsey County, the County Board of Commissioners, in 1906, established Ditches 2, 3 and 5, respectively, and ordered their construction.

County Ditch #2 was described in the original petition as follows:

> Commencing at the northwest corner of the lake known as Jones Lake, in the northwest 1/4 of Section 32, Township 30, Range 23, thence running in a northwesterly direction through the northwest

1/4 of Section 32 and the west of Section 29 also through the southwest 1/4 of Section 20 all in Township 30, Range 23, to the lake known as Pike Lake to the lake known as Long Lake and terminating at same.

On the recommendation of the Engineer, Branch Ditch No. 1 of Ditch No. 2 was constructed as a part of the Ditch No. 2 project. Branch No. 1 of Ditch No. 2 originated in a pond in Block 22, Soo Marie Park, Mounds View Township and ran in a northeasterly direction along and under the Minneapolis, St. Paul and Sault Ste Marie Railroad tracks into Poplar Lake and then southeasterly and easterly, terminating in Jones Lake.

County Ditch #3 was described in its original petition as follows:

Commencing at a point on the Silver Lake Road seven hundred and forty seven feet (747') north of the center post on the 1/4 section line of Sec. 31, T. 30, R. 23, said point of beginning 747' north of the northwest corner of the southeast 1/4 of said Sec. 31, T. 30, R 23; thence running along the following route: to wit - in an easterly and southeasterly direction for a distance of near 1/2 mile and terminating in a pond in Block 22, Soo Marie Park, Mounds View Township.

County Ditch #5 was described in petition as follows:

Commencing at a point 300' south of a point 600' west of the SE corner of Sec. 32, T 30, R 23, thence running along the following route: In a northwesterly direction to the Belt Line Railway right-of-way in Sec. 32, T 30, R 23, thence in a northwesterly direction and parallel to said railway to a waterway and culvert under said railroad tracks in the NE 1/4 of said Sec. 32, T.30, R 23,

thence in a westerly and northerly direction and terminating at the lake known as Jones Lake, in Sec. 32, T. 30, R 23.

The engineer, with the consent of the petitioner, changed the course of Ditch 5 to:

"a point about 200' N and 120' W of the SE 1/4 of Sec. 5, T29, R 23".

The revision thus provided a link between old Poplar Lake and Wilson Lake, and provided an outlet therefor.

Thus, the west central part of Ramsey County, which has no well-defined natural watercourse, was provided with an interconnecting drainage system outletting through Ditch #2 into Long Lake and subsequently into the Mississippi River through Rice Creek.

In 1944, a physical survey of various county ditches was made from which topographical maps of each respective ditch was made. That portion of Ditch 2 lying westerly of Jones Lake and originally designated as Branch 1 of Ditch 2 was designated as a portion of Ditch 3. As a result, the public ditch extending west of Jones Lake and reaching to Silver Lake has subsequently been referred to in total as Ditch 3. This terminology, while perhaps not technically correct, will be continued in this report since common use and subsequent ditch proceedings by the County Board have also followed this revised designation.

Periodic cleaning and maintenance was required on the system to keep it functioning properly. However, with the urbanization of rural Ramsey County and the increased rates of runoff inherent to urbanization, low areas and properties adjacent to points of limited ditch capacity experience flooding conditions with increased frequency. The need for major improvement is at hand

since routine cleaning operations of the existing ditchways will no longer meet the needs of the watersheds.

Further, the need has grown for a drainage outlet for areas adjacent to but not originally a part of the watershed of the ditch system. Thus, the engineering problem at this time is twofold; that of providing an outlet for an increased area as well as an increased rate of runoff.

RECENT PETITIONS AND LITIGATION

In addition to the maintenance and more or less minor improvements referred to in the foregoing section, in 1960-61 several petitions were received and acted upon by the County Board.

The Minnesota Department of Highways in April, 1961, petitioned for and was granted approval to alter Ditch 2 as a part of the construction of Interstate 694 by encasing the ditch in a culvert at the same approximate location as previous T.H. 100. At this point an existing 36" culvert was replaced by an extended 48" culvert.

In May, 1961, the Minnesota Department of Highways was granted, upon petition, the right to relocate and reconstruct a portion of Ditch 5 above Jones Lake in connection with the construction of Interstate 35W. In June, 1964, a further relocation and ditch enlargement was granted for the same purpose.

In 1960, the Village of St. Anthony petitioned the County Board for the improvement of Ditch 3 to permit the discharge of an extensive storm drainage system into said ditch. Upon investigation of the matter by an engineer designated by the County Board, it was found that the improvement could not be feasibly undertaken under the proceedings originally instituted. As a result, nothing was done to

reconstruct or improve Ditch 3, but rather St. Anthony constructed its system with an extensive impounding basin as an integral part thereof to limit maximum discharge to be somewhat in line with the capacity of the ditch.

In 1961, the relocation and reconstruction of Ditch 3 between Poplar Lake and Jones Lake was petitioned for by the owners of adjacent private property in New Brighton. This petition was approved and the requested ditch changes completed in accordance with the plan prepared for the work.

In late 1965, St. Anthony commenced a legal action by filing a complaint against New Brighton, Ramsey County, and certain private developers and land owners demanding that the defendants be enjoined from acts of obstructing and impairing flowage in Ditch 3 and further demanding the defining, protecting and maintaining of Ditch 3 easements and right-of-way. New Brighton and Ramsey County in turn enjoined Minneapolis, Columbia Heights, Roseville, Arden Hills, and the Minnesota Highway Department as third party defendants demanding relief by subjecting them to any order arising out of the initial complaint and further demanding that they be enjoined from permitting any construction of additional drainage systems outletting into Ditches 2, 3 and 5 or permitting acts resulting in increases in volume or speed of drainage into said ditches. Answers have been filed by the various defendants but to date the case has not been heard.

In early 1966, petitions for the repair and improvement of Ditches 2, 3 and 5 were submitted to the County Board by Roseville and New Brighton. The petitions pointed out the need for such work to allow additional storm sewers to be constructed utilizing said ditches as outlets. The County Board on April 11 and 18, 1966, held a public hearing on the matter and on April 18th ordered the examination, survey and investigation with a full report thereon. Ditches 2

and 5 are the subject of this report and Ditch 3 is the subject of a separate report by another engineering firm.

RECENT STEPS BY MINNESOTA DEPARTMENT OF HIGHWAYS

As a result of the heavy surface runoff during the Spring of 1965, the Minnesota Department of Highways found that certain trunk and interstate highways within the combined Ditch 2, 3 and 5 watershed were subject to flooding which was caused by the inability of Ditch 2 to satisfactorily convey accumulated storm flows to Long Lake. The capacity of Ditch 2 is generally limited throughout its course due to the deteriorated condition of the ditch and also due to undersized and poorly functioning culverts at certain highway, street and railroad crossings.

In April 1965, the Department of Highways sponsored a conference of municipalities and other public agencies concerned with the combined watershed of the three ditches. Due to the interest of the foregoing, the District 9 office of the Department of Highways solicited the support of the various municipalities in undertaking the improvement of Ditch 2 by means of a cooperative approach.

Having received necessary municipal backing, the Department of Highways, through its District 9 office and Hydraulics unit, completed a preliminary study of the proposed ditch improvement. Certain proposals were recommended and the total cost estimated to be $100,000.00. However, computation by Highway Department hydraulic engineers determined that the flow to Long Lake would be materially increased by the proposed improvement and the discharge of Long Lake to Rice Creek would also be increased.

As a conclusion it was recommended that a consultant be retained and a detailed study of Ditch 2 and its effect on Rice Creek be undertaken.

The Department of Highways has taken no further steps in the matter to date.

GENERAL FEATURES OF DITCH WATERSHEDS

GENERAL DESCRIPTION

The total watershed which outlets or is proposed to outlet through Ditch 2 into Long Lake consists of approximately 4900 acres. Of this approximately 1250 acres drain directly into Ditch 2 whereas approximately 1500 acres are delivered or will be delivered through Ditch 3 and the balance or approximately 2150 acres are delivered or will be delivered through Ditch 5. A breakdown of areas between the six municipalities is as follows:

	Area (acres)	%
Minneapolis	41	0.84
Columbia Heights	272	5.55
St. Anthony	706	14.41
New Brighton (including proposed municipal improvements)	1993	40.67
Arden Hills	114	2.33
Roseville (including proposed municipal improvements)	1774	36.20
	4900	100.00%

The ditch system as it now exists is comprised basically of open ditch, culverts, section of encased pipe lines, lakes, natural ponds, and certain impounding basins normally dry but subject to temporary ponding.

The ditches and pipe obviously convey water during and following thaws or rains. No less important a part of the ditch system are the lakes, ponds and temporary impounding basins which both provide passage for ditch water and also temporarily store water. Such temporary storage results in the lake, pond or impounding area being capable of receiving a given total volume of water at a high instantaneous rate of inflow while actually releasing the stored water downstream at a lower instantaneous rate of outflow over an extended length of time.

Thus it may be seen that this holding ability of a lake, pond or impounding basin has a substantial economic value when related to the construction cost of

a drainage system due to the decreased capacity requirements of the downstream system.

The various communities within the combined ditch watersheds contain storm sewer systems of varying sizes. Some of these have been constructed by the Minnesota Department of Highways as an integral part of interstate and trunk highway construction. Others have been a part of Ramsey County highway improvements. Still others have been undertaken as municipal storm drainage improvements or have been constructed by developers under municipal supervision.

Some, but by no means all, of the foregoing systems discharge directly into the county ditches. Most, however, discharge to natural low ground where, under high runoff conditions, the flow eventually reaches one of the three ditches. In the case of municipal systems, in few instances has the letter of the existing ditch law been complied with wherein express authority must be secured from the county board before lands not assessed for ditch benefits may utilize an existing ditch for an outlet.

Examination of maps and plans for original ditch systems indicate that the present combined tributary ditch watershed is much greater than the original agricultural lands considered to be benefited (and assessed) by ditch construction. In short, there is little relevance between the original defined watersheds and the one presently being served by the combined three ditch system.

The features of existing or proposed tributary municipal drainage systems are not shown on maps within this report. The detail of such systems is of little consequence since the purpose and scope of this report is to determine the condition of the existing ditches and the character, extent and expense of necessary ditch improvements. The exact nature of branch systems does not materially affect the required ability of the improved ditch to adequately

convey surface waters to a point of discharge.

TOPOGRAPHY, GEOLOGY AND SOILS

The area within the three ditch watersheds varies from the broad, shallow lake and swamp filled basin adjacent to the ditches to high irregular hills along the westerly line of Ramsey County. The lowest land surrounds Long Lake (normal lake level elevation 864.9) with the highest ground being approximately elevation 1080 just north of Silver Lake. The general trend of the ground's surface is downward to the north to Rice Creek and thence westerly to the Mississippi River.

A brief geologic description of the watershed would define the shallow basin and immediate surrounding land as being the bed of ancient and glacier formed Lake New Brighton. As ancient water levels receded, the lake was drained and eventually the lake bed formed a part of the flood plain along Rice Creek. Long, Pike, Rush, Jones, Langdon, and Wilson Lakes lie within the old lake bed. Other shallow lakes have gradually become swamps. The higher adjacent land was the result of glacical and post-glacical erosion and deposition.

The soils encountered in the watershed are grouped as to texture by the University of Minnesota Agricultural Extension Service as varying from coarse to moderate fine. The majority of the combined ditch watershed is so grouped by smaller area pockets are defined as variable and medium over coarse. The soils vary as to permeability accordingly from freely to moderate with some small pockets being very slow to drain.

PRECIPITATION

The climate of the Twin City Metropolitan area is characterized by considerable variations. Rainfall records for the Twin Cities Metropolitan area have been

compiled by the U. S. Department of Commerce and have been used in computations in this report. Drawings No. 2 and 3 indicate rainfall intensity and duration and mass rainfall infiltration.

Precipitation variations over many years (1891 - 1965) follow:

Precipitation -	Maximum	(Mpls.-St. Paul)	40.15" (1911)
	Minimum	(Mpls.-St. Paul)	11.59" (1910)
	Average	(Mpls.-St. Paul)	26.64

Average of nearly 40 thunder storms may be expected each year.

LAND USE

Present land use varies from uncultivated farms and low swampy vacant land to intensely developed commercial and industrial tracts. Zoning maps of the various communities have been assembled and utilized in determining the proper runoff coefficients for each type of land use.

The various municipalities have zoned their lands lying within the combined watersheds according to the needs and dictates of each city or village and no generalization of the zoning in each community can be made. However, analysis of land use versus zoning will disclose that a major portion of the residential land is now developed whereas the majority of nonresidential zoned land awaits improvement and development.

CONDITION OF EXISTING DITCHES

A physical examination of Ditches 2 and 5 was made together with an engineering survey of all culverts, bridges and other structures except those of the Minnesota Department of Highways and Ramsey County where "as constructed" plans were available.

DITCH 2

In brief the condition of the entire of Ditch 2 may be described as being very bad. The ditch is badly overgrown with small trees, brush and all types of seasonal growth. The ditch is also badly silted up with deposition of soil of various types from the adjacent tributary lands, particularly in the vicinity of recent construction, both public and private. The ditch now consists generally of a narrow channel varying in width between two and four feet and at higher grade than was originally constructed. The culverts under streets, highways and railways are undersized and partially filled with silt and debris and the grade and alignment is generally poor.

As the result of the foregoing, the ditch has a severely restricted capacity totally inadequate to convey the volumes of storm runoff reaching the ditch. The existing culverts, if clean and properly graded and aligned, are incapable of providing passage for the high flows experienced in the past without considering those to be anticipated upon more development in the watershed.

The culvert under Interstate 694 is an exception to the foregoing, being in good condition, but its capacity is well below that needed for future flows. The most severe culvert restrictions are encountered at Seventh Street North and adjacent to the intersection of Old T.H. 8 and First Street S.W. where severe upstream ponding has resulted.

The features of existing Ditch 2, particularly in respect to existing culverts, may be seen on the plan-profile sheets of the proposed Ditch 2 improvement plan, Drawings No. 4 through 7.

DITCH 5

The conditions in Ditch 5 where it is located in its original bed is much the same as that of Ditch 2. However, Ditch 5 at present resembles only slightly the ditch constructed under 1906 proceedings. As previously stated, this ditch was relocated, reconstructed and/or paralleled between Jones Lake and County Road "D" by the Minnesota Department of Highways as a part of the construction of Interstate 35W. From Jones Lake to the Minnesota Transfer Railway, the recently constructed open ditch is of adequate size, grade and alignment and is reasonably clean.

The ditch crosses under the Minnesota Transfer tracks and new T.H. 8 as a 42" concrete culvert and continues southerly along 35W right-of-way as an open ditch to a point just north of County Road "D". As this point and extending 250' feet across County Road "D", the ditch is encased in a 51" span (equivalent to 42") concrete culvert. However, from a point just west of the Minnesota Transfer tracks to the south end of the new 51" span culvert, Ditch 5 still exists as a 24" concrete storm sewer roughly paralleling the newer relocated ditch having been so converted from an open ditch at the time of World War II.

From County Road "D" to Wilson Lake, Ditch 5 remains an underground 24" storm sewer which is so badly silted up and poorly aligned as to prevent a precise determination as to condition within the scope of this investigation. However, this 24" line is now functioning, but its true condition can only be determined upon an internal cleaning job and perhaps excavation at certain specific points. In connection with the construction of Interstate 35W and at the request of Roseville, a new 36" concrete sewer was constructed from the upper end of the

51" span pipe and extending about 450 feet south easterly to the right-of-way limits of 35W. This line is capped and has never been opened and utilized. Wilson Lake at Cleveland Avenue and County Road "C-2" has been filled in so extensively as to bear little resemblence to its natural state. The original Poplar Lake (not to be confused with the other Poplar Lake in Ditch 3 in New Brighton) which drained northeasterly through a 20" clay sewer to Wilson Lake is now largely a pond located within the right-of-way of Interstate 35W and is now drained northerly through a 24" storm sewer on highway right-of-way to rejoin Ditch 5 at County Road "D" at the upper end of the 51" span pipe.

Ditch 5 is seriously handicapped in draining Interstate 35W near County Road "D" due to the frequent high levels of Jones Lake caused by the inability of Ditch 2 to adequately convey flood waters from the Lake.

Development in Roseville in the vicinity of old Wilson Lake (Cleveland and County Road "C-2") is retarded due to poor drainage adjacent to the upper reaches of Ditch 5 caused by the limited capacity and apparent poor condition of the existing 24" line.

The features of existing Ditch 5 may be seen on Drawing No. 9.

OUTLET

The discharge of Ditch 2, and thus the entire flow from the combined watershed of Ditches 2, 3 and 5, is into Long Lake at a point on its western shoreline. This lake is entirely within New Brighton, and at normal Lake level (elevation 864.9) has an area of about 185 acres. Rice Creek enters and leaves the lake through its northern extremity, from east to west, in its course to discharge into the Mississippi River.

Examination of lake levels, taken and recorded by Ramsey County, indicates that over the past 25 years (1941-65) an extreme variation of 3.9 feet has been experienced. The high was 867.9 in May, 1944, and the low was 864.00 in August, 1964. A high level of 867.8 was experienced in June, 1965. At such high levels low lying properties on the lakeshore are flooded and buildings must be protected from damage.

The average annual variation (over the 25 year period) is about 1.8 feet with the year's high level normally being encountered in the spring and the low level in late summer or mid-winter. This is not surprising in view of high runoff from the melting of accumulated snow followed by frequent rains causing the high spring levels followed by descending levels during the dry late summer and extending into the winter with little melting during the cold months.

Graphs of typical high, normal and low lake levels may be seen in Appendix "C" of this report as given below. These graphs were prepared by the Office of the Ramsey County Engineer.

Level	Year	Yearly Precipitation	Drawing No.
High	1944	39.94"	C-1
Normal	1961	25.74"	C-2
Low	1958	16.20"	C-3

Rice Creek rises in Clear Lake near the Village of Forest Lake and flows southwesterly to its discharge into the Mississippi River in Fridley, the point of outlet being approximately four miles west of Long Lake. The creek flows through an extensive chain of lakes which roughly parallel existing Trunk Highway 8 from Forest Lake southwesterly. The upper portion of the lake chain is an important source of supply of the water for St. Paul, flow being diverted by pumping at Centerville Lake into the St. Paul supply lake system.

The amount of flow diverted to the St. Paul system will vary from year to year depending upon precipitation and storage in Petlier and Centerville Lakes. During normal years, flow is diverted during and following spring runoff and rains and continuing into the early summer. Also, the level of the two lakes is lowered preceding the late winter thaws to allow storage and diversion of spring runoff. For instance, during 1966, from January through late June, nearly all of the water used by St. Paul has come from these lakes with a lesser amount being pumped directly from the Mississippi River. The St. Paul diversion pumps at Centerville Lake have a capacity of 40 million gallons per day (62 cubic feet per second).

The total watershed of Rice Creek is slightly less than 200 square miles. Of this, the combined watershed of Ditches 2, 3 and 5 has an area of 7.65 square miles or less than 4% of the entire Rice Creek watershed. The relative area of the individual and overall watershed may be clearly seen on Drawing No. 1.

The Rice Creek watershed drain portions of four counties as follows:

Anoka	82 square miles
Washington	67 square miles
Ramsey	50 square miles
Hennepin	less than 1 square mile
Total	200 square miles

The major portion of the Rice Creek watershed consists of flat to rolling land, containing lakes and low marshy areas. Within the watershed there are many extensive public drainage systems in the form of county and judicial ditches (23 in number) as well as several creeks and private ditches. A majority of existing municipal storm drainage systems in the watershed outlet into county or judicial ditches or small natural water courses rather than directly into Rice Creek or the series of lakes through which Rice Creek flows.

In the southern and western portions of the watershed, considerable development is present with further improvement being made at a high rate in all of the Ramsey County communities and in many of the newer, rapidly growing Anoka County municipalities. Through Circle Pines, Blaine, Shoreview, Arden Hills, Mounds View, New Brighton and Fridley, the creek passes through or is adjacent to residential or commercial and industrial tracts. In certain of these the proximity to improved property is such as to seriously restrict the use of the land immediately adjacent to the creek as a flood plain during and following high runoff.

An examination of Rice Creek establishes a fall of 7 feet from its source in Clear Lake (elevation 889) to Peltier and Centerville Lakes (elevation 882 to 885 as regulated by St. Paul) over a distance of about 9 miles. Over the next 5 miles the fall is only 3 feet to Baldwin Lake (elevation 879) with an additional fall of 14 feet in the following 6 miles to Long Lake (864.9). However, between Long Lake and Locke Lake in Fridley (elevation 818) a fall of 47 feet occurs in just over 4 miles with an added fall of 5 to 15 feet in the last 1/4 mile to the Mississippi River, depending upon river levels.

Thus, it may be seen that Rice Creek has an average gradient or fall of about one foot per mile between Clear Lake and Long Lake with a gradient of about

12 feet per mile between Long Lake and Locke Lake .

Since Rice Creek is classified as a public water, channel changes and installation of bridges and structures can only be made upon the granting of a permit by the Minnesota Department of Conservation, Division of Waters. During the past several years a number of application have been received and permits granted for changes in the channel and/or the construction of bridges or other structures over Rice Creek. The majority of such structures between the River and Long Lake have been designed to accommodate a flow of about 1200 c.f.s. (cubic feet per second) without causing a restriction or backing up of flow. On June 8, 1965, the U. S. Geological Survey, at the request of the Minnesota Department of Highways, measured the flow in Rice Creek at T.H. 47 (University Avenue) and determined it to be 606 c.f.s. at slightly below the maximum level encountered during that particular flood. The single structure having a capacity of less than the foregoing design flow of 1200 c.f.s. would appear to be at the outlet of Locke Lake (just east of East River Road) where the modification of an existing bridge to serve as a dam to impound waters in the lake has been determined to be of substantially less capacity at normal crest elevation.

PENDING PROPOSED MUNICIPAL DRAINAGE IMPROVEMENTS

NEW BRIGHTON

In connection with other municipally supervised drainage improvements in New Brighton, an open ditch has been constructed along the north right-of-way of the Minneapolis, Sault Ste. Marie Railroad from a point due north of Poplar Lake and extending about 1200 feet northeasterly to Ditch 2. This ditch, however, has not been opened at its northeastern extremity to allow discharge into Ditch 2.

In the report prepared and submitted previously as a result of County Board action in connection with the improvement of Ditch 3, the aforementioned open ditch is incorporated as an integral feature of the proposed ditch improvement plan. This plan proposes the relocation of Ditch 3 from its existing location between Silver Lake and Poplar Lake and its reconstruction as an enclosed pipe line from Silver Lake Road to 16th Avenue (Highcrest Road extended). From this point 800' of open ditch and 600' of 60" pipe are proposed to join the southwestern end of the above mentioned existing open ditch discharging into Ditch 2. The plan also proposes continuing existing Ditch 3 between Poplar Lake and Jones Lake to provide drainage service to that portion of the watershed south of the Soo Line Railroad. This relocation plan can be seen on Drawing No. 9.

To date no permission has been granted by the County Board for New Brighton to utilize the existing open ditch proposed to discharge to Ditch 2 as would be required under present law. Were improvement proceedings successful for the improvement of Ditch 3 in the manner proposed in the report thereon, such would preclude the requirement for New Brighton obtaining specific County Board approval to discharge the existing recently constructed open ditch into Ditch 2.

ROSEVILLE

To meet the drainage needs of a substantial part of the industrial area within

western Roseville, a preliminary investigation was conducted resulting in the submission of a preliminary engineering report on September 15, 1965.

Said report recommended the improvement and extension of the open ditch along and adjacent to Minnesota Transfer Railway Company's right-of-way from just north of County Road "B-2" and extending northerly to join Ditch 5 in New Brighton. Said ditch improvement required deepening and realignment of the existing ditch and the addition of new and/or larger culvert crossings under streets, highways and railroads encountered through the approximately 9000 foot course of the proposed ditch.

A large holding pond north of County Road "C-2" was proposed as a part of the ditch plan to reduce peak flows to Ditch 5. Such pond is an integral part of the grading and improvement of the Minnesota Transfer industrial tract now under construction between County Roads "C-2" and "D".

As a part of the overall storm drainage improvement, a storm water pumping station was proposed with its discharge being into the south end of the aforementioned proposed ditch paralleling the Minnesota Transfer tracks. The lift station is required to drain a small isolated low area of about 300 acres of residential and industrial land containing considerable highway right-of-way.

The proposed drainage plan, with the exception of the principle of pumping the small area, is quite similar to existing public drainage systems which have been constructed by other municipalities wherein the drainage ultimately reaches a county ditch, but where in most instances no authority was petitioned for or granted by action of the County Board. However, permission for the right to discharge waters into Ditch 5 under the proposed plan has been requested of Ramsey County.

Copies of said report have been provided to Ramsey County and Minnesota Depart-

ment of Highways.

A public hearing supported the need for the drainage improvements although to date Roseville has not elected to proceed with the project authorized at the hearing.

BASIS OF ANALYSIS AND DESIGN

Because of extensive property development adjacent to the lakes and ponds involved in this drainage system, a flood produced by a storm of 25 years frequency was selected for the analysis and design of the system. In weighing construction cost against property damage cost due to periodic flooding, a frequency greater than 25 years would yield excessive construction costs. A frequency of less than 25 years, conversely, would yield excessive periodic flood damage costs.

The 25 year flood analysis was modified in determining inflow to utilize rainfall intensities for a 10 year frequency storm. This was done in order to estimate more accurately the actual rate of delivery to the respective impounding basin, since most urban storm sewer systems are designed for a storm frequency of 10 years or less.

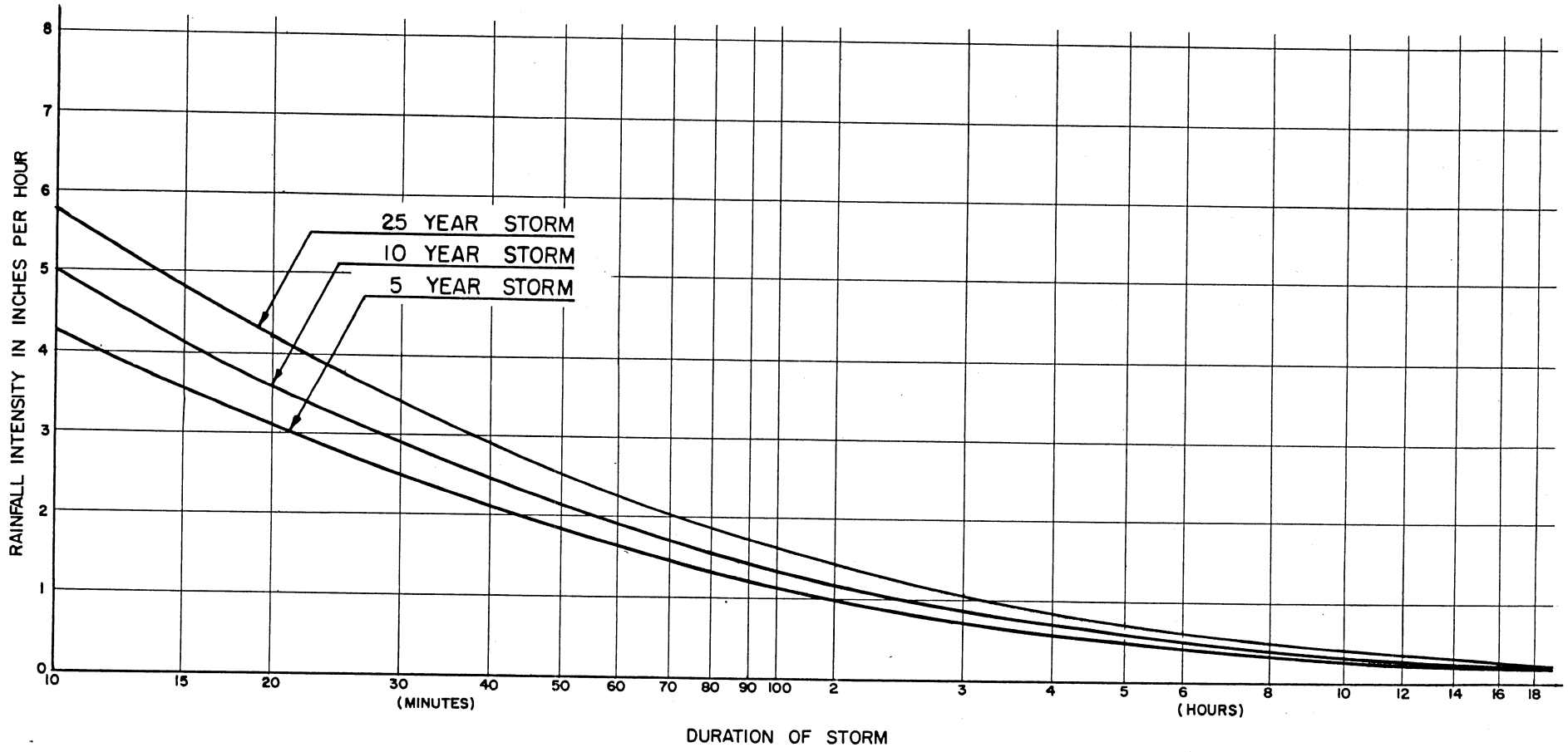
For determining peak outflow and routing of the design flood through the system, modified triangular hydrographs and the Beta or Culp Formula, as employed by the Soil Conservation Service of the U. S. Department of Agriculture were used. Due to the lack of any stream flow measurements and specific meteorological data for the watershed, it was impossible to develop a unit hydrograph for the analysis. However, the approach used provides results that have been found to be within 10% of actual, with deviations being on the conservative or safe side.

Composite runoff coefficients based on the ratio of land use have been arrived at from the following table of coefficients.

Residential:	0.25 to 0.35
Multiple Dwelling-Mixed Business:	0.50 to 0.65
Commercial & Industrial:	0.80 to 0.90

Design flows are based on ultimate development of the watershed and are, therefore, far greater than flows to be realized from the watershed as it now exists.

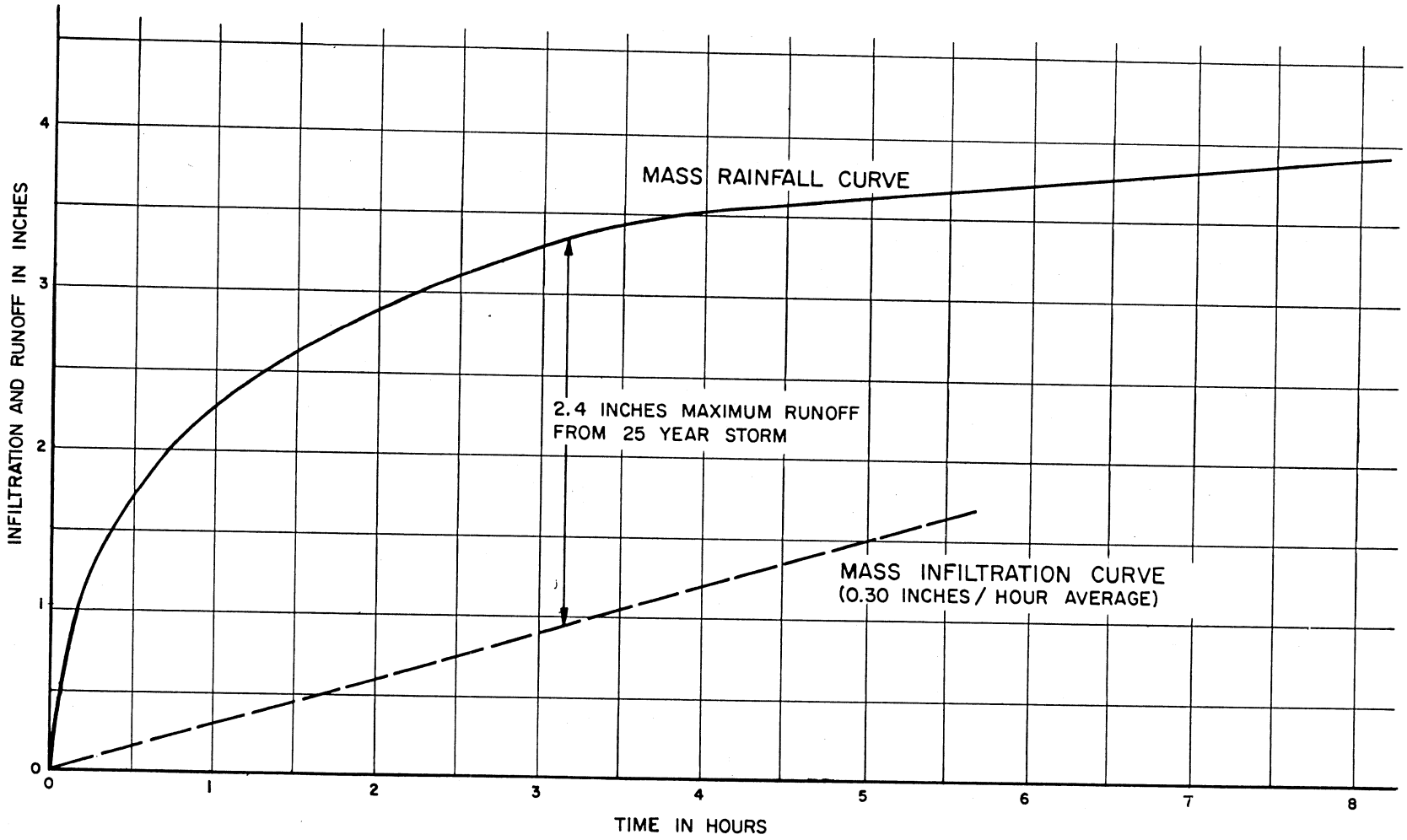
Design computations and hydrographs are included in Appendix "B" of this report.



RAINFALL INTENSITY-DURATION CURVES FOR THE TWIN CITY METROPOLITAN AREA

DATA TAKEN FROM U.S. DEPT. OF COMMERCE TECH. PAPER NO. 25

DRAWING NO. 2



MASS RAINFALL & INFILTRATION CURVES
FOR 25 YEAR STORM IN THE
TWIN CITY METROPOLITAN AREA

RAINFALL DATA TAKEN FROM U.S. DEPT. OF COMMERCE TECHNICAL PAPER NO. 25

DRAWING NO. 3

PROPOSED PLAN

GENERAL

The plan proposes the improvement of Ditch 2 in its present location to permit the adequate conveyance of tributary surface runoff water to Long Lake. The surface water runoff to be thus conveyed includes that from the watershed of Ditch 2 proper as well as that delivered by Ditches 3 and 5 from their respective watersheds. The runoff waters proposed to be conveyed, as stated previously, include those from the existing watershed which no longer resembles the original 1906 ditch watersheds, together with those from pending and/or petitioned for expansions of the existing watershed. The total 3 ditch watershed of 4900 acres may be best seen on Drawing No. 9 and the various tributary drainage sub-districts are identified and enumerated thereon.

In preparing the proposed plan, certain controlling factors had to be carefully considered and complied with. The more important of these follows:

1. The grade of the ditch must be at such depth as to drain adjoining lands and maintain natural ponds and lakes at reasonable levels under normal low flow conditions.

2. As much as is practical, existing properties adjoining the improved ditch must be protected from damage to esthetic appearance as well as physical flooding.

3. Existing New Brighton municipal utilities, particularly gravity sanitary sewers, must be undisturbed as to grade and capacity and maintained in service with the exception of water main where grades can be modified but protection against freezing must be provided.

4. All possible use of impounding facilities must be made to keep out-

flow rates to an absolute minimum, but such temporary water storage in both temporary impounding basins as well as natural ponds and lakes must be such as to limit maximum levels and to hold damage to adjacent properties to a minimum.

5. That facilities be designed to permit use of construction methods which will cause a minimum of interference with the normal use of highways, streets and railroads.

DITCH 2

The general plan, Drawing No. 9 and the preliminary plan-profile sheets, Drawing Nos. 4 through 7 indicate the plan proposed for the improvement of Ditch 2.

This proposed plan incorporates the recommendations contained in the separate engineering study and report prepared for Ditch 3 wherein the location and point of discharge of the ditch was revised substantially from existing. Under subject revision the majority of Ditch 3 drainage would be delivered through the existing but unused open ditch along the Soo Line north right-of-way and with discharge into Ditch 2 at its crossing of the Soo Line. Hydraulic analysis of flow conditions resulting from this revision indicate that the flow in Ditch 2 would be greater from the Soo Line north than would be the case if the original location and discharge of Ditch 3 into Jones Lake were retained. The increased flow in Ditch 2 north of the Soo Line would result in requiring larger culverts at four locations; First Street Northwest, Seventh Street Northwest, Interstate 694 and Long Lake Road. However, it would appear to be proper to incorporate these enlarged culverts into any Ditch 2 improvements to be constructed unless it can be definitely established that Ditch 3 will never discharge through the existing but unused open ditch at the Soo Line.

A brief discussion of the proposed plan from Long Lake southerly to Jones Lake

follows:

1. Long Lake to Pike Lake

   The open ditch must be excavated to a wider section and the grade lowered slightly. A new concrete box culvert is proposed at the crossing of Long Lake Road.

2. Pike Lake

   Temporary increased lake lands will occur immediately following high runoff to a maximum level of 869.0 under 25 year frequency storm conditions.

3. Pike Lake to Seventh Street N.W.

   The open ditch between Interstate 694 and 7th Street must be excavated to a wider section and a substantially lower grade with a new enlarged culvert installed under 694 paralleling the existing 48" culvert. The low swampy land between 694 and 7th Street will be temporarily flooded to a maximum level of 874 under 25 year frequency storm conditions. At 7th Street new triple culverts will replace the existing culverts.

4. Seventh Street N.W. to 1st Street N.W.

   The open ditch must be excavated to a wider section and a somewhat lower grade and temporary ponding will result to a maximum level of 880 under 25 year frequency storm conditions. The existing house on the south side of 7th Street and just east of the existing ditch will be flooded to about the same extent as in 1965 under 25 year frequency storm conditions. At First Street Northwest a new concrete box culvert will replace the existing culvert.

5. 1st Street N.W. to Loo Line R.R.

   At this location the existing ditch will be excavated to a wider section and a lower grade.

6. Soo Line R. R. to 8th Avenue S.W.

Due to present problems of grade, alignment and interference with existing sanitary sewers, it is proposed to construct all but the railroad fill crossing as an open cut enclosed pipe line section with the railroad portion being required to be a jacked or tunneled pipe crossing. The existing open ditch sections between the Soo Line and 8th Avenue would thus be eliminated but openings into the new pipe for local drainage would be required.

7. Jones Lake

This lake would provide temporary ponding to maximum level of 897 under 25 year storm conditions which would cause temporary backing up of Ditch 5 and the portion of existing Ditch 3 proposed to be maintained in service. However, the level of Poplar Lake would only be slightly above 897.0.

DITCH 3

We refer you to the paragraphs under Ditch 2 of this section and to the separate engineering survey and report for Ditch 3.

DITCH 5

No improvement of Ditch 5 is proposed at this time since the portion of the ditch which must be improved to meet upper watershed requirements is located within Roseville, and future land use and zoning practices in this area are not clearly established at this time. When such practices are firmly established by the Village of Roseville then a relocation and reconstruction plan for District 5 can be worked out to allow most practical use of the land, but with the incorporation of extensive temporary impounding basins and/or the continuation of natural ponds as a part of the plan to prevent overloading the existing piped portions located within and under Minnesota Highway Department bridges, pavements and interchanges. The most critical

of these is the 51" span line at Interstate 35W and County Road "D" and the 36" capped off line extending southeast to Highway Department right-of-way limits. As stated previously, the condition of the existing 24" piped portion of Ditch 5 could not be determined within the scope of this investigation. At the present time, Wilson and Langdon Lakes are utilized for ponding purposes and these must be continued in use.

In respect to the pending Roseville drainage improvement along the Minnesota Transfer right-of-way, we direct your attention to the section headed "PENDING PROPOSED MUNICIPAL DRAINAGE IMPROVEMENTS" of this report. However, it can be stated that the portion of existing Ditch 5 proposed to receive drainage from this pending improvement is an open ditch of adequate capacity and grade and in good condition.

EFFECT ON OUTLET

We have carefully considered the proposed plan for the improvement of Ditch 2 together with the attendant increase in the maximum rate of discharge to Long Lake. We have determined within the scope of this report and without a detailed study of the entire Rice Creek that the effect of the construction of the proposed program of improvements will cause no additional flooding in Long Lake or on Rice Creek below Long Lake over and above those which have been experienced in the past. Our reasons for this determination follows:

1. Records indicate that the rise in levels on Long Lake lags behind heavy rainfall in the watershed by up to one week.

2. The character of the Rice Creek watershed and its vast natural storage in its lakes combined with the slight fall in Rice Creek above Long Lake tend to result in a slow passage of the resulting flood crest from the lakes downstream to Long Lake over a distance of more than 10 miles.

3. The combined watershed of Ditches 2, 3 and 5 is only about 5% of the total Rice Creek watershed above Long Lake and less than 4% of the entire Rice Creek watershed.

4. The relatively rapid fall of Rice Creek below Long Lake to the river and the relative lack of man made restrictions below Long Lake, with the exception of Locke Lake outlet which can be manually controlled, will result in rapid passage of short term high levels in Long Lake.

5. At the time of maximum levels in Long Lake the discharge downstream in Rice Creek was gauged at 606 cubic feet per second. (June, 1965)

6. The maximum high discharge rate of Ditch 2 to Long Lake is computed to be 440 c.f.s. under 25 year storm frequency conditions based on saturated development not to be anticipated for many years.

7. The discharge of surface runoff at the computed high rates will be passed through Long Lake before the flood crest from the lakes in upper Rice Creek reaches Long Lake.

8. The controlled storage and extended diversions by the St. Paul Water Department at Peltier and Centerville Lakes tend to retard and reduce in magnitude flood crests from the upper watershed and this extends the time required to reach Long Lake, thus permitting Ditch 2 flows to pass through Long Lake in advance of the Rice Creek.

ESTIMATE OF COST

The total estimated cost of improving Ditch 2 as proposed in this report is $300,255.00. This includes the cost of ditching, construction of culverts, restoration of street and highway crossings, a reasonable amount for permanent ditch easements plus an allowance for legal, engineering and contingencies. Not included is the cost of the house on the south side of 7th Street N. W., at the east side of Ditch 2, which, at the time of ultimate land development within the combined three ditch watershed, will again be subject to flooding as has occurred in the past.

This estimate of cost is based upon cost anticipated to be encountered at the present time and within the foreseeable future. Reasonable allowance is made for unforeseen conditions and anticipated increase in cost of labor and material. However, if the proposed program, particularly ditching, is not undertaken within the next several months or if ditching must be done during the rainy wet months of the year, particularly between Interstate 694 and First Street N.W. and between 8th Avenue S.W. and Jones Lake, the cost would require reappraisal at such time as it would be determined to be undertaken.

Ditching costs are based upon excavation by dragline with the waste of surplus excavated material to adjoining lands without need for hauling except between Third Street N.W. (extended) and the Soo Line R. R. A breakdown of estimated costs can be seen in Appendix A.

APPENDIX "A"

ESTIMATE OF COST

APPENDIX "A"

ESTIMATE OF COST

The following is a tabulation of estimated costs for the improvement of Ditch 2 as proposed in this report.

Ditching				
(1)	Long Lake to Pike Lake	(1450')	$ 5,400.00	
(2)	Interstate 694 to 7th St. N.W.	(1220')	4,900.00	
(3)	7th St. N.W. to 1st. St. N.W.	(3900')	22,000.00	
(4)	1st St. N.W. to Soo Line R.R.	(660')	3,500.00	
(5)	8th Ave. S.W. to Jones Lake	(460')	1,800.00	
		Total Ditching		$ 37,600.00
Culverts (including street and highway restoration)				
(1)	Long Lake Road - Concrete Box Culvert - 20'x4'	(80')	$ 17,020.00	
(2)	Interstate 694 - Culvert - 91"x58" Lo-Hed	(250')	48,580.00	
(3)	7th St. N.W. - Triple Culvert - 48"	(80')	12,320.00	
(4)	1st St. N.W - Concrete Box Culvert 12'x4'	(80')	11,920.00	
(5)	Soo Line R.R. to 8th Ave. S.W. Triple Culvert - 54"	(800')	119,650.00	
		Total Culverts		$209,490.00
Permanent Ditch Easements				14,000.00
TOTAL CONSTRUCTION COST				$261,090.00
	Plus 15% for Legal, Engineering, Contingencies			39,165.00
GRAND TOTAL COST				$300,255.00

APPENDIX "B"

HYDROGRAPHS AND DESIGN COMPUTATIONS

APPENDIX "B"

HYDROGRAPHS AND DESIGN COMPUTATIONS

The following impounding basins have sufficient storage capacity to contain the runoff produced by a 25 year frequency storm, from the respective local drainage areas, without sustaining damage. Therefore, outlet control structures on these impounding basins should be such as to restrict outflow until peak flows downstream have passed.

BASIN	DRAINAGE AREA (ACRES)	VOLUME OF RUNOFF (25 YEAR STORM) (Ac.-Ft.)	AVAILABLE STORAGE (Ac.- Ft.)
Langdon Lake	234	47	50
Wilson Lake	73	15	25
Silver Lake	707	141	201
St. Anthony Pond	207	21	30(+)

The following hydrographs and design computations are for impounding basins where storage is limited and outlet capacity must be sufficient to prevent damage due to excessive ponding.

FULHAM POND

$Q_o = Q_I \cdot [1.25 - (1.5 \times \frac{V_s}{V_r} + .06)^{\frac{1}{2}}]$

Area = 365 Ac.; T = 2 Hr.; c = 0.53

$Vr = \frac{2.40}{12} \times 365 = 73$ Ac.-Ft.

Vs = 31.5 Ac.-Ft.

Qi = 0.53 x 1.20 x 365 = 232 cfs

$Qo = 232\ [1.25 - (1.5 \times \frac{31.5}{73.0} + 0.06)^{\frac{1}{2}}] = 95$ cfs

$t = 24.2 \times \frac{73.0}{232} = 7.8$ Hrs.

(see hydrograph No. 1)

MTR POND

Area = 606 Ac.; T = 3.0 Hr.; c = 0.52

Local: $Vr = \frac{2.4}{12} \times 606 = 121$ Ac.-Ft.

Qi = 0.52 x 0.85 x 606 = 268 cfs

$t = 24.2 \times \frac{121}{268} = 10.5$ Hrs.

Total: Vr = 194 Ac.-Ft.

Vs = 32 Ac.-Ft.

Qi = 364 cfs

$Qo = 364[1.25 - (1.5 \times \frac{32}{194} + 0.06)^{\frac{1}{2}}] = 252$ cfs (trial)

Graphical Refinement: Vs = 32 Ac.-Ft. REQ Qo = 252 cfs

Qo = 252 cfs

(see hydrograph No. 1)

35 W POND

Area: 356 Ac.; T = 2 Hrs.; c = 0.52

$Vr = \frac{2.4}{12} \times 356 = 71$ Ac.-Ft.

Vs = 51 Ac.-Ft.

Qi = 0.52 x 1.20 x 356 = 221 cfs

$Qo = 221[1.25 - (1.5 \times \frac{52}{71} + 0.06)^{\frac{1}{2}}] = 38$ cfs

$t = 24.2 \times \frac{71}{221} = 7.8$ Hrs.

(see hydrograph No. 2)

POPLAR LAKE

1. Based on present Ditch 3 alignment

Area: 400 Ac.; T = 2 Hrs.; c = 0.50

$Vr = \frac{2.40}{12} \times 400 = 80$ Ac.-Ft.

Vs = 61 Ac.-Ft.

Qi = 0.50 (1.20) 400 = 240 cfs

$Qo = 240[1.25 - (1.5 \times \frac{61}{80} + 0.06)^{\frac{1}{2}}] = 38$ cfs

$t = 24.2 \times \frac{80}{240} = 8.1$ Hr.

(see hydrograph No. 2)

2. Based on proposed Ditch 3 alignment

Area: 53 Ac.

$Vr = \frac{2.4}{12} \times 53 = 11$ Ac.-Ft.

Vs = 61 Ac.-Ft.

Vs is greater than Vr therefore total storm can be stored and delivered after peak flows downstream have passed

JONES LAKE

Area = 691 Ac.; T = 3 Hrs.; c = 0.48

1. Based on present Ditch 3 alignment

Local:

$Vr = \frac{2.4}{12} \times 691 = 138$ Ac.-Ft.

$Qi = 0.48 \times 0.85 \times 691 = 282$ cfs

$t = 24.2 \times \frac{138}{282} = 11.9$ Hrs.

Total:

Vr = 483 Ac.-Ft.

Vs = 104 Ac.-Ft.

Qi = 610 cfs

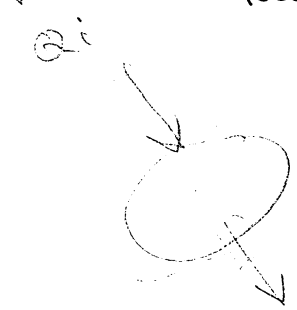
before alignment - not now.

$Qo = 610[1.25 - (1.5 \times \frac{104}{483} + 0.06)^{\frac{1}{2}}] = 384$ cfs (trial outflow)

Graphical Refinement: Vs = 104 Ac.-Ft. REQ Qo = 365 cfs

Adjusted Qo = 365 cfs

(see hydrograph No. 2)



2. Based on proposed Ditch 3 alignment

Vr = 483 - 80 = 403 Ac.-Ft.

Vs = 104 Ac.-Ft.

Qi = 575 cfs

$Qo = 575[1.25 - (1.5 \times \frac{104}{403} + 0.06)^{\frac{1}{2}}] = 362$ cfs (trial outflow)

Graphical Refinement: Vs = 104 Ac.-Ft. REQ Qo = 320 cfs

Adjusted Qo = 320 cfs

(see hydrograph No. 3)

this is now

COMPUTATION OF PEAK FLOW FOR CULVERT AT 1ST STREET NW

BASED ON PROPOSED DITCH 3 ALIGNMENT

Q = Ditch 3 flow + Jones Lake outflow (see hydrograph No. 3)

For T = 2 Hr.

Q = 0.47 x 1.2 x 347 + 215 = 411 cfs

For T = 3 Hr.

Q = 0.47 x 0.85 x 347 + 320 = 455 cfs

USE: Q = 455 cfs

7TH STREET POND

1. Based on present Ditch 3 alignment

Area = 622 Ac.; T = 2 Hrs.; c = 0.37

Local:

$Vr = \frac{2.4}{12} \times 622 = 124$ Ac.-Ft.

Qi = 0.37 x 1.20 x 622 = 276 cfs

$t = 24.2 \times \frac{124}{276} = 10.9$ Hrs.

Total:

Vr = 607 Ac.-Ft.

Vs = 77 Ac.-Ft.

Qi = 610 cfs

$Qo = 610[1.25 - (1.5 \times \frac{77}{607} + 0.06)^{\frac{1}{2}}] = 456$ cfs (trial outflow)

Graphical Refinement: Vs = 77 Ac.-Ft. REQ Qo = 435 cfs

Adjusted Qo = 435 cfs

(see hydrograph No. 4)

2. Based on proposed Ditch 3 alignment

Area = 969 Ac.; T = 3 Hrs.; c = 0.41

Local:

$Vr = \frac{2.4}{12} \times 969 = 194$ Ac.-Ft.

$Qi = 0.41 \times 0.85 \times 969 = 338$ cfs

$t = 24.2 \times \frac{194}{338} = 13.9$ Hrs.

Total:

Vr = 597 Ac.-Ft.

Vs = 77 Ac.-Ft.

Qi = 660 cfs

$Qo = 660[1.25 - (1.5 \times \frac{77}{597} + 0.06)^{\frac{1}{2}}] = 498$ cfs (trial outflow)

Graphical Refinement: Vs = 77 Ac.-Ft. REQ Qo = 460 cfs

Adjusted Qo - 460 cfs

(see hydrograph No. 5)

694 POND

Area = 124 Ac.; T = 1.0 Hr.; c = 0.33

Local:

$Vr = \frac{2.4}{12} \times 124 = 25$ Ac.-Ft.

$Qi = 0.33 \times 1.9 \times 124 = 78$ cfs

$t = 24.2 \times \frac{25}{78} = 7.8$ Hrs.

Total:

1. Based on present Ditch 3 alignment

$Vr = 632$ Ac.-Ft.

$Vs = 22$ Ac.-Ft.

$Qi = 490$ cfs

$Qo = 490[1.25 - (1.5 \times \frac{22}{632} + 0.06)^{\frac{1}{2}}] = 450$ cfs (trial outflow)

Graphical Refinement: Vs = 22 Ac.-Ft. REQ Qo = 442 cfs

Adjusted Qo = 442 cfs

(see hydrograph No. 6)

2. Based on proposed Ditch 3 alignment

$Vr = 622$ Ac.-Ft.

$Vs = 22$ Ac.-Ft.

$Qi = 515$ cfs

$Qo = 515[1.25 - (1.5 \times \frac{22}{622} + 0.06)^{\frac{1}{2}}] = 475$ cfs (trial outflow)

Graphical Refinement: Vs = 22 Ac.-Ft. REQ Qo = 468 cfs

Adjusted Qo = 468 cfs

(see hydrograph No. 7)

PIKE LAKE

Area = 509 Ac. (includes Forrest Dale Pond area); T = 2 Hr.; c = 0.32

Local:

$Vr = \frac{2.4}{12} \times 509 = 102$ Ac.-Ft.

$Qi = 0.32 \times 1.2 \times 509 = 195$ cfs

$t = 24.2 \times \frac{102}{195} = 12.7$ Hrs.

Total:

1. Based on present Ditch 3 alignment

   Vr = 734 Ac.-Ft.

   Vs = 117 Ac.-Ft.

   Qi = 617 cfs

   $Qo = 617[1.25 - (1.5 \times \frac{117}{734} + 0.06)^{\frac{1}{2}}] = 432$ cfs (trial outflow)

   Graphical Refinement: Vs = 117 Ac.-Ft. REQ Qo = 410 cfs

   Adjusted Qo = 410 cfs

   (see hydrograph No. 8)

2. Based on proposed Ditch 3 alignment

   Vr = 724 Ac.-Ft.

   Vs = 117 Ac.-Ft.

   Qi = 645 cfs

   $Qo = 645[1.25 - (1.5 \times \frac{117}{724} + 0.06)^{\frac{1}{2}}] = 450$ cfs (trial outflow)

   Graphical Refinement: Vs = 117 Ac.-Ft. REQ Qo = 440 cfs

   Adjusted Qo = 440 cfs

   (see hydrograph No. 9)

APPENDIX "C"

LONG LAKE LEVEL RECORDS

Precipitation This Year 25.74

Normal Precipitation 24.71

Cum. Excess-Deficiency -36.80
(Since 1924)

Area in Acres at Normal Elevation 186.7

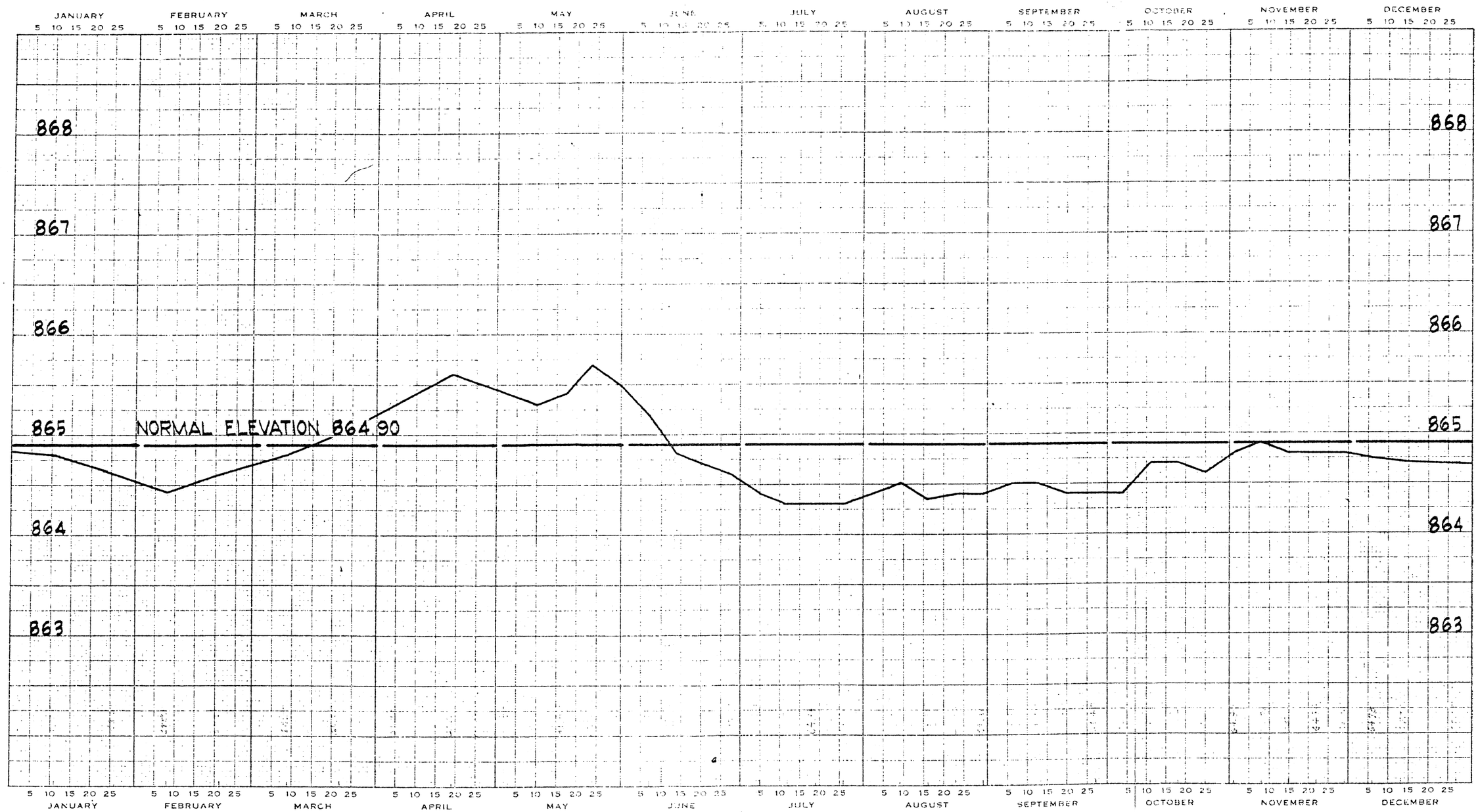
Gallons Equiv. to One Foot on Lake 60,840,000

Ratio: Watershed to Lake Area 78.5 TO 1

Lake LONG Year 1981

OFFICE OF
RAMSEY COUNTY ENGINEER

Sheet No.



Month	K. W. Demand	K. W. Consumed	Total Cost
JAN.			
FEB.			
MAR.			
APR.			
MAY			
JUNE			
JULY			
AUG.			
SEPT.			
OCT.			
NOV.			
DEC.			
TOTAL			

PUMP NO.

Month	K. W. Demand	K. W. Consumed	Total Cost
JAN.			
FEB.			
MAR.			
APR.			
MAY			
JUNE			
JULY			
AUG.			
SEPT.			
OCT.			
NOV.			
DEC.			
TOTAL			

PUMP NO.

Month	K. W. Demand	K. W. Consumed	Total Cost
JAN.			
FEB.			
MAR.			
APR.			
MAY			
JUNE			
JULY			
AUG.			
SEPT.			
OCT.			
NOV.			
DEC.			
TOTAL			

Pumping Costs This Year

Mil. Gals. Pumped This Year

Equiv. on Lake in Ft. This Year

K. W. H. Consumed This Year

Av. Costs Per K. W. H. This Year

Av. Costs Per M. G. Pumped This Year

Cum. Pumping Cost

Cum. M. G. Pumped

Cum. Equiv. on Lake in Ft.

Cum. K. W. H.

Cum. Av. Cost Per K. W. H.

Cum. Av. Costs Per M. G. Pumped