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COST APPORTIONMENT THEORIES

and

APPLICATIONS TO A PROPOSED DITCH REPAIR PROJECT

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Prepared for

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

Funded by

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LEGISLATIVE COMMISSION ON MINNESOTA RESOURCES

October, 1982

Consultant's Report prepared for Natural Resources Department and funded by Legislative Comm on Mn Resources. Oct 1982

Report pursuant to 1981 Laws, ch 356-, section 31, subd 4b

McCombs - Knutson Associates, Inc.

L. Seymour Waters

DEPARTMENT OF NATURAL RESOURCES

BOX 32, CENTENNIAL OFFICE BUILDING . ST. PAUL, MINNESOTA . 55155

DNR INFORMATION (612) 296-6157

April 11, 1983

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COST APPORTIONMENT THEORIES AND APPLICATIONS TO A PROPOSED DITCH REPAIR PROJECT..consultnt McCombs-Knutson Associates, Inc. October 1982

The Honorable Fred Norton, Chairman Legislative Commission on Minnesota Resources B-46 Capitol Building St. Paul, Minnesota 55155

Dear Chairman Norton:

LCMR-FUNDED DRAINAGE PROJECT ANALYSIS

' state of INESOTA

In accordance with M.L. 1981, Chapter 356, Section 31, Subdivision 4b, the consulting firm of McCombs-Knutson Associates has completed, in cooperation with the Koochiching County Board and under contract administered by our Division of Waters, a report entitled: Cost Apportionment Theories and Applications to a Proposed Ditch Repair Project. I am transmitting copies of the report to LCMR staff for distribution.

I believe that the report will illustrate the conceptual problems faced by local ditch viewers as they try to balance various interests and arrive at a cost allocation, particularly where much of the land of the watershed receives little benefit. The consultants have explored the application of a direct benefits approach, a watershed approach, and a combined or, if you will, compromise approach.

I concur with the engineer's report that the direct benefit to state lands from the contemplated ditch repair work would be only a small proportion of the total project costs, whereas the water contributed from public lands would be a relatively high proportion. I would visualize that such a situation might be quite typical for northern Minnesota, whereas in the southern portion of the state the water contribution from benefitted state lands might also be relatively low.

State law on the assessment of Consolidated Conservation lands (M.S. 1980 \S 84A.55, Subdivision 9) reads in part as follows (emphasis added):

The commissioner...may undertake projects for the drainage of any state owned lands within any game preserve, conservation area, or other area subject to the provisions hereof so far as he shall determine that such lands will be benefitted thereby in furtherance of the purposes for which the area was established...If the commissioner shall determine...that any project for...repair...of any public ditch...undertaken by any county...will benefit such lands in furtherance of said purposes, he may...authorize the imposition of assessments...in such amounts as he shall determine...provided such assessments or contributions shall not in any case exceed the value of such benefits to state owned lands as determined by the

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Election of Waters

The Honorable Fred Norton April 11, 1983 Page Two

> commissioner...and shall be payable only out of funds appropriated and available therefor...

In the absence of more specific legislative direction, the cited statute would limit departmental participation to the direct benefits to state land. An appropriation of state funds would also be necessary as the \$85,000 appropriated for ditch repairs by M.L. 1980, Chapter 614, Section 13(a), has been fully committed.

In conclusion, I wish to thank the LCMR for making an investment in the extremely difficult and controversial subject of drainage policy. Should the legislature desire to amend its long-standing policy on direct benefits, I am certain that the LCMR-funded report will provide significant guidance in their deliberations. This department will provide all requested assistance to the legislature, and will be submitting a proposal to the 1984 session for line item review of drainage assessments which exceed a specified threshold.

Yours truly. Uluca

Joseph N. Alexander Commissioner

Enclosure

cc: Koochiching County Board
Viet Ngo
Ray Hitchcock
Larry Seymour



Reply To: 12800 Industrial Park Boulevard Plymouth, Minnesota 55441 (612) 559-3700

November 8, 1982

Mr. Dan Retka Senior Regional Hydrologist Division of Waters, Department of Natural Resources 1201 East Highway 2 Grand Rapids, MN 55744

Subject: Final Report of Cost Apportionment Theories, and Applications to a Proposed Ditch Repair Project in North West Koochiching County, Minnesota 60-6274-1

Dear Mr. Retka:

McCombs-Knutson Associates, Inc. is pleased to submit the final report with regard to the above subject for your attention.

We strongly recommend that the proposed cost apportionment theories be applied to other parts of Minnesota to determine the practicality under different drainage conditions, and under different ownerships. We also recommend that the potential application of the proposed theories in flood control projects be investigated.

The scope of this study deals primarily with the investigation of the concepts of various proposed cost apportionment theories, and their subsequent applications to a proposed ditch repair project in North West Koochiching County. For future applications, additional investigations are needed prior to implementation of any of the proposed cost apportionment theories. In the case of Koochiching County, some additional engineering study will have to be conducted to complete the required scope of work for construction.

We would be glad to work with you on expanding the scope of this study. Please call us if you wish to discuss this study or other similar work.

Yours very truly,

McCQMB8-KNUTSON ASSOCIATES, Inc.

Viet Ngo, P.E. Vice President

VN:j Enclosure

COST APPORTIONMENT THEORIES

and

APPLICATIONS TO A PROPOSED DITCH REPAIR PROJECT

Prepared for

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

Funded by

LEGISLATIVE COMMISSION ON MINNESOTA RESOURCES

October, 1982

ACKNOWLEDGEMENTS

This study, funded by the Legislative Commission on Minnesota Resources, involved the investigation of the concepts of cost apportionment related to a proposed ditch repair project in North West Koochiching County in Minnesota.

McCombs-Knutson extends its appreciation and gratitude to the following state agencies, local governments and residents for their assistances in supplying data and other information necessary for the completion of this preliminary study:

The Division of Waters of the Minnesota Department of Natural Resources, St. Paul and Grand Rapids

Land Management Information Center, Minnesota State Planning Agency, St. Paul

Minnesota Division of Forestry of the Department of Natural Resources, St. Paul

Equalization Aid Review Committee, St. Paul

Koochiching County Offices, and Local Residents of Koochiching County

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PART I OVERVIEW

I. INTRODUCTION

nature of drainage works with particular reference to The complex apportionment of the project costs prove to be an elusive problem with no standardized solution. The present regulations governing drainage works in Minnesota are described in Statutes 106 and 112. These regulations are deliberately written in general terms to allow local authorities the flexibility to administer and implement them. The lack of guidance to local government without much experience and training in the administration of drainage projects soon leads to conflicting interpretations of the regulations. A particularly serious controversy arises when the ditch system crosses land under the jurisdiction of different authorities. A representative case is when the land ownership is threefold: Federal, State and Local. Due to the flexibility of existing regulations, the interpretations of cost apportionment serious conflict of interests among different landowners. created has Therefore, the concern for an equitable method of cost apportionment of drainage projects is real. In order to implement effective drainage systems in Minnesota, it is crucial that the policies and regulations governing these projects be more defined especially with regard to the question of equitable cost apportionment.

Hence, the emphasis of this study is to develop various concepts of cost apportionments and to determine their practicality by applying these concepts to a real project.

Drainage works include repairs, maintenance, improvement and installation of new drainage systems. In this study, the concepts of cost apportionments are applied to the proposed repair work of a ditch system in North West Koochiching County, Minnesota.

This report is structured in the following manner:

. Part 1 of this report is an overview of the study.

- . Part 2 discuss the existing statutes governing drainage works, the basic procedures and theories for cost apportionment, and the proposed cost apportionment theories as presented by McCombs-Knutson.
- . Part 3 covers the application of these cost apportionment theories to the proposed ditch repair project in North West Koochiching County.

II. SUMMARY AND RECOMMENDATIONS

A. Implementation On A State Wide Basis

1. Summary

The concepts of cost apportionment as related to drainage repair of open ditches were investigated in sufficient detail. A summary of the various theories are presented in Table 1.

Conceptually, each of the theories have their limitations when applied to ditch repair work. Preliminary findings indicated that there is substantial promise in the potential application of the Combined Revised Direct Benefit and Watershed Theory. However, more investigation and testing of the Combined Theory is necessary to determine its practical application in other parts of the state and under different conditions.

Table l

Summary of Proposed Cost Apportionment Theories

Proposed Cost Apportionment Theories	Rationale 2	Limitations 3	Potential Applications In Drainage Projects 4		
Revised Direct Benefit	Landowners who benefit should share the cost of the drainage project.	Drainage ditches are designed to convey runoff or flow from the land. However, the runoff contribution aspect is not considered.	Limited because runoff contribution is not considered.		
Revised Watershed	Land contributing runoff should share the cost of the drainage project.	Potential benefits from the drainage project are not considered. Large land area with little benefit from the drainage projects would pay a dis- proportionate amount of the project cost. The benefit-cost ratio may be unfavorable.	Limited because potential benefits are not considered.		
Combined Revised Direct Benefit and Watershed	Landowners who benefit and/or contribute runoff should share the cost of the drainage project.	The relative value or importance of the potential benefit and run- off contribution aspects are not determined. Further studies are required to determine an equitable breakdown between the two aspects. Administrative decisions may be necessary.	Promising applica- tion in drainage projects such as ditch repairs, improvements and installation of new ditch systems. Other application may be in flood control project.		

Proposed Cost Apportionment Theories 1	Rationale 2	Limitations 3	Potential Applications In Drainage Projects 4
Cause-Effect	Land contributing runoff in excess of natural pre- drainage conditions should pay for aggra- vating the drainage problems.	Minor Change of drainage pattern and area: It is not applicable to areas where land use changes from pre-drainage to existing conditions are minimal. There is no in- centive to develop the land because any land use changes would most likely aggravate the drainage problem. Where runoff increase is marginal or practically non-existent, this theory is not applicable. Potential benefits are not considered.	Application is limited to ditch repair and im- provement. The possibility lies only in those areas where the lands are fully developed and when runoff increases can be detected. Severe limitations exist since potential benefits are not considered.
		Significant Change of drainage pattern and area: It is not applicable to drainage repair project by definition. Any drastic drainage changes would require drainage improvement. Data necessary for the analyses especially in small drain- age areas are usually non- existent. Potential benefits are not con- sidered.	Not applicable to drainage repair project. Some potential may be realized in new drainage installation or improvement projects. The analyses may be costly because of lack of reliable data for small drainage areas. Severe limitations exist because potential benefits are not considered.

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Table 1 (continued)

2. Recommendations

- Recognizing that one of Minnesota's economic base's is agriculture and 1. that agriculture is dependent to a great extent on effective drainage systems (Figure 1), it is crucial to consider drainage projects in Drainage ditch <u>repair</u> is merely one facet of the their entirety. drainage works. Other areas of drainage works include ditch improvement and installation of new ditch systems. The concepts of cost apportionment for ditch repair can easily be adapted to include ditch improvement and installation. Clear policies and regulations governing the proper functioning of drainage systems are definitely assets to Minnesota. Therefore, it is strongly recommended that further studies be carried out in other parts of Minnesota in order to determine the practicality of various cost apportionment theories related to ditch repair, improvement and installation projects.
- 2. Another potentially useful application of the cost apportionment theories is in flood control projects. An example is in lake management where the maintenance of stable lake levels will prevent flooding of valuable lake shore properties. Minnesota, a "Land of 10,000 Lakes" should definitely consider this application seriously. Additional study based on the theories with modifications, if necessary should be carried out.
- 3. Research on cost apportionment methods for drainage repair work in other states, Canada and the Netherlands showed that there are no clear policies in this subject. Therefore, it is highly possible that the State of Minnesota will set a precedent not only in the U.S. but perhaps in other parts of the world with regard to equitable cost apportionment related to drainage projects. The State of Minnesota will be in a good position to market this expertise.
- 4. The present computer data and management capabilities of the Land Management Information Center (LMIC) in the State Planning Agency and the Department of Natural Resources could be adapted to implement these theories on a state wide basis. Since most of the data necessary for cost apportionment studies are already in the computer system, the further studies and implementation of these theories are not expected to be costly. The returns from better land management would easily justify the cost.
- 5. All drainage project costs have to be assessed. The traditional viewers approach of land evaluation is time consuming and may be biased. The proposed theories are unbiased and rely on hydrologic, hydraulic and physical characteristics of the area.



Figure 1 - Areas Where Artificial Drainage is Predominant

B. Implementation in North West Koochiching County, Minnesota

1. Summary

The study areas include portions of Judicial Ditch Systems 17 and 18, and some ditches between Township 158 to 160N and Range 27 to 29W in North West Koochiching County. A location map is shown in Plate I.

The preliminary cost of the proposed ditch repair project is estimated at about \$240,700.

The preliminary estimate of potential benefits based on increase in land value and crop productivity is approximately \$262,900. No benefit-cost ratio is computed. The reason is that additional cost is required for installation of private supplementary drainage systems and for more extensive cleanout in order to realize the estimated potential benefits. This additional cost has not been included.

A summary of the preliminary assessments based on the various proposed cost apportionment theories is presented in Table 2.

Under the Revised Direct Benefit Theory, the future anticipated land use practice of the different landowners determined the outcome of the assessments. Plate IV shows the area benefitting from the proposed project.

Under the Revised Watershed Theory, the size of the drainage areas determines the outcome of the assessments. Plate V shows the drainage areas.

The Combined Revised Direct Benefit and Watershed Theory is determined assuming equal importance between the benefits derived and runoff contribution. Therefore, the assessments are based on 50% benefit and 50% surface runoff contribution. Federal and State lands are assessed mainly from the runoff contribution factor because of the negligible potential benefit.

Table 2

Summary of Preliminary Assessments

Land Ownership	Land Area	Revi Direct B Assess	Revised Re rect Benefit Wat Assessment Ass		d nt	Combined Direct Benefit & Watershed Assessment		Cause Effect Assessment	
<u> </u>	% 	\$ 	% 	\$ 5	% 6	\$ 7	% 8	\$ _9	% 10
State	78.0	9,900	4.1	182,600	75.9	96,200	40.0	In th	is specific
Private	13.0	229,200	95.2	49,600	20.6	139,400	57.9	case,	this method
Federal	9.0	1,600	0.7	8,500	3.5	5,100	2.1	is not	t applicable
Total	100.0	240,700	100.0	240,700	100.0	240,700	100.0		

Note: Assessments are in 1981 figures.

Private land is assessed mainly from the potential benefits factor. Plate VI shows the application of this theory.

Under the Cause-Effect Theory, assessments are based on increase in runoff contribution from pre-drainage to existing conditions. In the study areas, a large part of the land that drains towards the proposed ditch repair stretches is still in pre-drainage conditions. Therefore, based on this theory, substantial areas under Federal, State and even Private ownerships will not be assessed. Only those private landowners who have presently tilled their farms causing an increase in surface runoff from the pre-drainage conditions are subjected to assessments. Presently, there are only a few farms that have increased the runoff from pre-drainage conditions. These farms are identified in Plate VII. It is also evident from Plate VII that a significant length of the ditches proposed for repairs do not serve the farms that are currently contributing runoff in excess of the pre-drainage conditions. Naturally, these private landowners would only pay for those ditches that serve their lands, either directly or indirectly. Therefore, the practicality of this theory is in doubt since the rest of the landowners: Federal, State and Private (those with no land use changes) are not assessed even though the ditches proposed for cleanout will potentially serve their land. Assessing the cost of repairs for the entire proposed length of ditches to those farms that are contributing runoff in excess of predrainage conditions, even though substantial reaches of the ditches (about 50%) do not serve them, does not seem reasonable. In this specific situation, the Cause-Effect Theory is not applicable for cost apportionment.

Overall, the application of the concepts of the various cost apportionment theories have been investigated in sufficient detail in the proposed ditch repair areas. The chosen sites have poor soils, severe climate and low land values. Therefore, the investigation of the proposed theories in North West Koochiching County do not represent a typical case for future state-wide applications.

By comparing the various theories, the Combined Revised Direct Benefit and Watershed Theory is most logical and reasonable.

2. Recommendations

- 1. Prior to project implementation in North West Koochiching County, it is recommended that the project feasibility be determined through more refined benefit-cost analysis. The present status of the report does not permit assessments of the proposed ditch repair costs to individual landowners.
- 2. A detailed analysis for implementation of the cost apportionment theories would require the additional cost of supplementary drainage system to be included, or a re-evaluation of the estimated potential benefits. Private supplementary drainage system is required in order to realize the estimated potential benefits. The cost for the supplementary drainage system should be considered. If supplementary drainage is not considered, the potential benefits should be re-evaluated to reflect the reduced benefits as a function of the distance from the ditches. Therefore, additional study is required prior to project implementation.
- 3. Besides the need for private supplementary drainage system, the cost of additional cleanout in the upstream ditches and towards the ditch outlets should be considered. This additional cleanout can be eliminated from consideration if the potential benefits are re-evaluated.
- 4. In order to facilitate the recommended additional study, the administrative agencies having jurisdiction over the proposed ditch repair project should decide on adopting only one theory. Hence, permitting a more thorough and detailed cost apportionment evaluation.
- 5. In order to promote the preservation of the environment, the administration having jurisidiction over the project should decide whether a water quality study should be conducted. The effect of draining the bog's water on the water quality of downstream rivers and streams may be detrimental.
- 6. Implementation of the theories would require more detailed engineering analyses and surveying. This would refine the benefit-cost estimates.

III. FUNDING SOURCE AND SCOPE OF WORK

Funding for this study was provided by the Legislative Commission on Minnesota Resources. The total fund amounts to \$35,000.

McCombs-Knutson Associates, Inc. conducted an investigation of the concepts of various cost apportionment theories related to a proposed ditch repair project in North West Koochiching County. The study areas include portions of Judicial Ditch Systems 17 and 18, and other ditches between Township 158 and 160N, and range 27 to 29W as shown in Plate I. The scope of work included data collection, field reconnaissance, ditch cross-section surveying, hydrology/ hydraulic, preliminary ditch design, economic analysis, final report and general coordination. Throughout the study period, a systematic coordination was implemented through personal meetings, written reports, phone conversations, and public presentations with the Division of Waters of the Minnesota Department of Natural Resources, especially with Mr. Dan Retka, Senior Hydrologist in Grand Rapids, Minnesota; officials and local residents of Koochiching County; and other State and Regional Government agencies in Minnesota. PART 2

COST APPORTIONMENT THEORIES

I. INTRODUCTION

The need for well defined policies and regulations governing drainage projects is outlined in Part 1. The examination of the existing regulations and the formulation of new concepts for cost apportionment are presented in this part of the report.

The drainage work under investigation is confined to drainage repairs related to open ditches. According to Minnesota Statute 106, ditch repair means restoring the ditch system or any part thereof as nearly as practicable to the same condition as when originally constructed or subsequently improved. This definition of repair is very crucial. Many of the assumptions and methodologies presented revolve around this definition. For example, under the Cause-Effect theory of Significant Change (Part 2, IV. D.2), the definition of repair renders that theory inapplicable.

The general concepts and limitations of the existing and proposed theories are discussed in Part 2 of this report.

II. EXISTING COST APPORTIONMENT PROCEDURES

The two major drainage laws and regulations are Minnesota Statutes Chapter 106 and 112.

A. Statute 106

In most counties, the determination of potential benefits and the procedures for cost apportionment of drainage works are as follows:

- 1. Governing authority having jurisdiction appoints three (3) disinterested viewers to examine all the properties affected by the project and ascertain benefits based on the potential increased value of the property due to the project.
- 2. Viewers prepare a report listing all of the lands affected, the number of acres benefited and the assessment for the benefits. The report also includes damages for land taken for the project by 40 acre tract. Assessments are related to the areas where benefits are realized.
- 3. Project is implementable if the total amount of benefits is greater than the sum of the estimated project cost plus the damages.

The regulations pertaining to ditch repair work are presented in this statute under section 106.471. Proceedings where the project affects state land used for conservation purposes are presented under section 106.672.

B. Statute 112

Under this statute, all lands contributing water within the watershed can be assessed for the drainage services. The assumption is that benefits are realized when the land can be rid of the water safely and quickly. The determination of benefits and feasibility of the project is similar to those under Statute 106. Assessments are related to some weighted factors which have not been determined.

C. Statute 84A.55

In addition to Minnesota Statutes Chapter 106 and 112, where certain classes of state land are affected by the drainage work, the responsibilities of the Commissioner of Natural Resources are defined in Minnesota Statutes Chapter 84A.55, subdivision 9. The responsibilities of the Commissioner of Natural Resources as defined under Chapter 84A.55, subdivision 9 are quoted below:

"The commissioner may make necessary investigations and surveys for and may undertake projects for the drainage of any state owned lands within any game preserve, conservation area, or other area subject to the provisions hereof so far as he shall determine that such lands will be benefited thereby in furtherance of the purposes for which the area was established, and may pay the cost thereof out of any funds appropriated and available therefor. If the commissioner shall determine after investigation that any project for the construction, repair or improvement of any public ditch or ditch system undertaken by any county or other public agency as otherwise provided by law will benefit such lands in furtherance of said purposes, he may cooperate in such project by joining in the petition therefor or consenting thereto or approving the same upon such conditions as he shall determine, and may authorize the imposition of assessments therefor upon such lands in such amounts as he shall determine, or may make lump sum contributions to the county or other public funds established for the payment of the cost of the project; provided such assessments or contributions shall not in any case exceed the value of such benefits to such state-owned lands as determined by the commissioner and specified by his written certificates or other statement filed in the proceedings, and shall be payable only out of funds appropriated and available therefor in such amounts as the commissioner may determine."

III. EXISTING COST APPORTIONMENT THEORIES

From the preceeding section, it is evident that the existing cost apportionment procedures can be grouped under two fundamental theories:

A. Direct Benefit Theory

B. Watershed Theory

A. Direct Benefit Theory

This theory is based on Statute 106. In Minnesota, most counties apply this theory with variations from one county to another. All lands that benefit from a drainage project such as ditch repair, improvement or the installation of a new ditch system are assessed. Benefits are based on increase in land values and improved crop productivity. The benefits are determined by three (3) viewers nominated by a Board of Commissioners. Every 40 acre parcel of land within the watershed is walked to determine the potential benefits.

There are a number of limitations under this theory.

- 1. It does not consider the landowner's intention to use the land. Therefore, there is no incentive to preserve wetland-wildlife habitats.
- 2. Runoff contribution causing the drainage problem is not considered.
- 3. Opinions of different viewers can have significant differences. Hence, the evaluation of potential benefits by viewers may be altered.

B. Watershed Theory

This theory is modelled loosely after Statute 112. All lands contributing runoff to the project areas can be assessed for the drainage work. It is assumed that benefits are realized when runoff can be removed from the land safely and quickly. Assessment is based on some weighted factors which have not been determined. Non-contributing areas such as lakes, depressions and other storage areas are not included in the assessment.

The limitations under this theory are as follows:

- 1. It does not consider the landowner's intention to use the land.
- 2. High grounds without drainage problems but contributing runoff are assessed. A severe limitation exists if land needing no drainage and having no additional potential benefit from the drainage work is required to pay for the project.
- 3. The assessment method has not been determined. There is no reference relating the assessment to runoff magnitude. Therefore, land with different water yields are not differentiated.

IV. PROPOSED COST APPORTIONMENT THEORIES

A review of the two existing cost apportionment theories indicates substantial deficiencies. In order to establish sound state policies related to cost apportionment of drainage projects, it is necessary to modify the existing theories and to investigate other possible theories.

McCombs-Knutson Associates, Inc. proposed the following revised versions of the two existing theories and included two other new theories. The revised versions and new theories are:

- A. Revised Direct Benefit Theory
- B. Revised Watershed Theory
- C. Combined Revised Direct Benefit and Watershed Theory
- D. Cause-Effect Theory

A. Revised Direct Benefit Theory

The rationale behind this theory is that landowners that would benefit from the proposed ditch repair project should bear the cost of the repair project by some weighted proportion of the potential benefits realized.

In essence, all lands where drainage could be improved and are served by the ditches, excluding designated wetland-wildlife areas within the drainage areas would be liable for the ditch repair cost.

The revised aspects of the theory are as follows:

- 1. It assumes that all landowners interested in the ditch repair project would utilize their land to maximum productivity. The maximum productivity is based on future anticipated land use practice and the supportive capability of the soils.
- 2. Designated wetland-wildlife areas are excluded under this revised version. This would provide for the preservation of wetland-wildlife areas.

- 3. This revised theory is based on scientific and engineering data instead of the traditional viewers approach. Hydrologic, hydraulic and physical characteristics are considered.
- 4. A weighting system based on the percentage of potential benefits derived is used to determine the assessments.

The main limitation is that the runoff contribution from the land is not considered. Drainage works are designed to convey flow. Therefore, land contributing runoff should also be considered when determining the ditch repair assessments.

B. Revised Watershed Theory

The rationale behind this theory is that land contributing surface and sub-surface runoff causing the drainage problem should bear the cost of the ditch repair.

The revised aspects of this theory are as follows:

- 1. It assumes that all landowners are interested in improving the productivity of their land if economic analyses prove its feasibility.
- 2. Designated wetland-wildlife areas are excluded. This would provide for the preservation of wetland-wildlife areas.
- 3. The assessments are related to the runoff magnitude. Therefore all lands contributing to the drainage problem are assessed, regardless of potential benefits.
- 4. A weighting system based on the percentage of runoff from each land area is used to determine the assessments.

A major limitation is that the potential benefits are not considered. Large areas with little benefit are liable to be severely assessed.

C. Combined Revised Direct Benefit and Watershed Theory

Even with the revisions to the two existing theories, limitations are inevitable by nature of their definitions. The omissions of either the potential benefit or runoff contribution aspects of the drainage work are serious flaws. Therefore, by combining the Revised Direct Benefit and Watershed theories, the limitations imposed by their definitions are eliminated.

The rationale behind this theory is that land benefitting from the ditch repair works and contributing runoff to the ditch should pay for the ditch repair cost.

The only limitation is that the relative level of importance between the potential benefit and runoff contribution factors is not clearly defined. However, this is only a minor limitation because the level of importance can always be set by the administrative agencies having jurisdiction over the drainage projects.

D. Cause-Effect Theory

Another theory that McCombs-Knutson has formulated after consultation with the Department of Natural Resources is the Cause-Effect theory. The two scenarios under this theory are as follows:

- 1. Minor Change
- 2. Significant Change
- 1. <u>Minor Change</u>: When the drainage area and pattern remain practically unchanged between the pre-drainage and existing conditions, the drainage area is classified as Minor Change. Under this classification, the increase in runoff contribution between the pre-drainage and existing conditions is used to determine the assessments.

The rationale behind this theory is that land naturally contributing runoff should not have to pay for the ditch repair cost. Land use

changes resulting in the alteration of the natural runoff by aggravating the drainage problem should pay for the changes in runoff incurred.

An obvious limitation of this theory is evident in areas where the land use changes are limited. The assessments would be borne by those few residents who have already tilled their land.

The other major limitation is that there is no incentive to develop the land because any landowners changing their land use are probably aggravating 'the drainage problem and would be subjected to assessments. This will not be a limitation if a benefit-cost ratio is favorable for project implementation.

Another possible limitation arises when there is no increase in runoff or marginal increase in runoff is encountered. This scenario is possible if land management is practiced. In this case, the theory is not applicable.

Potential benefits due to improved drainage of the land are not considered. Land area with marginal or no increase in benefit but contributing excessive runoff will be penalized severely.

2. <u>Significant Change</u>: When the drainage areas and patterns are drastically altered between the pre-drainage and existing conditions, the drainage area is classified as Significant Change. This would occur if the drainage area changes in size, and the drainage patterns such as the flow direction and magnitude are altered drastically. The increase in water yield and peak flows should be considered as the criteria for assessments. Figure 2 shows the concepts of increase in water yield and peak flow consideration.

The rational is similar to that under Minor Change except that the drainage area and pattern have changed significantly.

The major limitation in this theory is that it is certainly not suitable for application in drainage repair work. The reason is that any drastic change in drainage area or pattern will require a drainage improvement work instead of repair work. It is not possible to restore the ditch system to its original condition when the flow has changed, presumably drastically increased.

Potential benefits due to the restored drainage conditions are not considered. Land areas with no increase or marginal increase in benefit but contributing excessive increase in water yields or peak flow will be severely penalized.



A. SIMPLIFIED CONCEPT OF WATER YIELD



B. SIMPLIFIED CONCEPT OF CONTRIBUTION TO PEAK FLOW

Figure 2 - Concepts of Cause-Effect Theory

PART 3

APPLICATION OF COST APPORTIONMENT THEORIES

to

PROPOSED DITCH REPAIR PROJECT

in

NORTH WEST KOOCHICHING COUNTY, MINNESOTA
I. INTRODUCTION

A. Background

The cost apportionment theories formulated in Part 2 of this report are applied to some of the ditches proposed for repair in North West Koochiching County. The study areas include portions of Judicial Ditch (J.D.) systems 17 and 18, and some ditches between township 158 and 160N, and range 27 to 29W. A location map is shown in Plate I.

In the study areas, there are three different land ownerships: Federal, State and Private. There are conflicting viewpoints between the different landowners with regard to the burden of the proposed project costs.

1. Federal and State Viewpoints

The Federal and State have not indicated any interest in the proposed ditch repair project. The potential benefits perceived by the Federal and State landowners are negligible because their lands are not intended for agricultural use, i.e. woodlands. According to the State, the potential benefits based on improved wood productivity is insignificant and, therefore, the project is not justifiable.

2. Private Viewpoints

The private landowners petitioned for the repairs of the ditches with the intention of improving the drainage of their lands. Since the ditches proposed for repairs would drain Federal and State lands as well, the private landowners contend that the Federal and State landowners should share the cost of the proposed ditch repairs. Furthermore, the private landowners believe that the drainage of their lands is seriously inhibited due to the uncontrolled runoff from adjacent Federal and State lands. Hence, damaging their lands.

Some of the ditches are obstructed by beaver dams, brush and even trees. According to the local government, it is the responsibility of the State government to clean out the ditches where beaver dams have obstructed the flow. The reason is that the beavers are protected by the State. Hence, the State should pay for the cleanout and maintenance of those ditches.

B. Objectives

The objectives of this study are as follows:

- 1. To investigate the possibility of applying the concepts of the proposed cost apportionment theories to the ditches proposed for repair in North West Koochiching County.
- 2. To assist the State of Minnesota in decision making and implementation of the proposed cost apportionment theories or theory.

The results presented are preliminary and are based heavily on the assumptions underlying the theories. All monetary figures are presented in 1981 dollars.

II. SITE CHARACTERISTICS

A. Physical

The topography of the study area is extemely flat with land slope generally less than 0.1%. Approximately 90 to 95% of the study areas are covered with bogs, swamps and forest. The remainder of the area is farmed. Organic soil comprises approximately 85 to 90% of the areas. The Washkish, Mooselake and Greenwood soil series belong under the organic soil category. Inorganic soil of the Indus, Chilgren and Spooner series covers the other 10 to 15% of the study areas. The drainage areas range from 0.7 to 13 square miles in size. The total drainage area is about 34.0 square mile. In the organic soil, the groundwater table is normally 0 to 3 feet deep. In the inorganic soil, the groundwater table is about 6 to 10 feet deep. The ditches investigated are in poor drainage conditions. The ditches are filled in, obstructed by brush, trees and beaver dams. The outlets of the ditches are severely restricted and the flow in the ditches has altered direction. The land is in a very poor state of drainage.

B. Climatological

The average normal precipitation (1941-1970) is about 24 inches. The annual normal snowfall (1931-1960) is about 60 inches. Approximately half of the precipitation occurs in the summer months. The 10-year 24-hour rainfall, is estimated at about 3.47 inches. The 10-year 24-hour rainfall is used to determine the surface runoff magnitude associated with the Revised Watershed Theory.

The study area has a typical continental climate with wide extremes in temperature from summer to winter. The summer is warm during the days and cool during the nights. The warmest temperature in July averages about 81° F. The proximity of Lake of the Woods slightly lowers the summer temperatures. Fall frost occurs around September 11. The average normal winter temperature (1941-1970) range from 2 to 10° F. The growing season is short, generally lasting about 90 to 100 days. The short growing season and poor soil impose severe limitations on crop productivity.

A. Drainage Areas

Lands draining naturally towards the respective ditch stretches proposed for repair are delineated. The delineation of the drainage areas were based on U.S. Geological Survey topographic maps supplemented by field reconnaisannce and interviews with local residents. The drainage areas are labelled A to G in Plates I to VII. The size of the drainage areas vary from 0.7 (A) to 13 (G) square miles. Within the drainage areas C, D and G, sub-drainage areas were delineated representing lands served directly by the proposed ditch repair stretches. The flat topography of the land results in difficulty of determining the exact drainage boundaries. Therefore the delineation is approximate.

B. Land Ownerships

There are three landowners within the study areas. The September 1980, Minnesota DNR landownership record indicates that the land belongs to the Federal government, State government and Private owners. Since the emphasis of this study is to investigate the concepts of cost apportionment rather than the actual implementation, the results are therefore presented under the three landownerships. Further breakdown of the Private landownership to individuals is not necessary at this stage. In the study areas, approximately 78% (26.7 square miles) is State land, 13% (4.3 square miles) is Private land and 9% (3.1 square miles) is Federal land. There is about 170 acres of Indian Reservation land within the Federal land. The Indian Reservation land is excluded from all analyses based on administration viewpoint (DNR). The different landownerships are shown in Plate I.

C. Soil Types

The soil types in the study areas are classified under two broad categories: organic and inorganic soil. The organic soil includes soil of the Washkish, Mooselake and Greenwood series. The Washkish, Mooselake and Greenwood series consist of very poorly drained soils formed in organic peat.

The color of the surface is brown to black with dark reddish brown underneath the surface. The inorganic soil includes soil of the Indus, Chilgren and Spooner series. The inorganic soil series consists of very poorly drained soil composed of mucky silt loam, clayey soils or clayey loam. Approximately 90 to 95% of the study is composed of organic soil while only 10 to 15% is inorganic in nature. The soil types are shown in Plate II. The soil delineations are provided by the Soil Conservation Service at Grand Rapids, Minnesota.

D. Land Uses and Values

The Koochiching County assessor's office currently uses five broad land use classifications for ditch assessments. The land use classifications and land values are shown in Table 3.

Table 3

Land Use and Land Value Classifications

Land Use

Land Values (1981 dollars)

1.	Tillable Land	\$300/acre
2.	Pasture Land	170/acre
3.	Woods	90/acre
4.	Wasteland	65/acre
5.	Recreational Land	90/acre

In the study areas, the recreational land use is not applicable and is therefore omitted from any analysis. Plate III shows the existing agricultural land use.

IV. RESEARCH AND ORIGINAL DATA

A. Sources

The information regarding the original ditch plans and assessments is supplied by the county recorder's office and the Minnesota Department of Natural Resources.

B. Ditch Plans

Original ditch plans for J.D. 17 and 18, dated 1912 and 1914 are available from the County Assessor's Office. However, the information is incomplete. There is no reference datum or cross-section geometry recorded. Review of the original ditch plans from different sources indicated variation in terms of flow directions and ditch locations. No information is available for portions of other ditches proposed for repairs that are not part of J.D. 17 and 18. The cost of original construction of the ditches under investigation is not available.

C. Viewers Assessments

The 1912 viewers assessment data for the study areas were plotted using the Land Management Information Center (LMIC) computer with the assistance of the LMIC staff. Even though the assessment data is not complete, a clear pattern of assessment is evident as shown in Figure 3. There is no information of the actual assessment procedures. However, judging from the assessment plot, land further away was assessed less than those adjacent to the ditches. There is no evidence that the soil types and the hydrology are taken into consideration.





V. DITCH REPAIR

A. Definition And Procedures

According to Minnesota Statute Chapter 106.471, ditch repair means restoring the ditch system or any part thereof as nearly as practicable to the same condition as when originally constructed or subsequently improved. Normally, in ditch repair work, there is no awarding of damages for the land through which the ditch flows since the damages incurred by the original ditch construction would presumably been paid off to the original property owners. Damages may be awarded if the ditch repair work include taking of property not contemplated and included in the original proceeding for the establishment of the ditch.

Under Minnesota Statute Chapter 106.471, sub-division 2b, the annual ditch repair or maintenance cost for one ditch system for one year should not exceed \$20,000.00 or 20% of the original construction cost of the ditch system. The limitation of \$20,000.00 or 20% of original construction cost applys to ditch repair or maintenance work that can be conducted without advertising for bids or entering into contracts. However, in any year, it is possible through petitions or a ditch maintenance fund, for the ditch repair or maintenance cost to exceed \$20,000.00 or 20% of the ditch system original construction cost.

Minnesota Statutes Chapter 106 sets forth the procedures for implementation of proposed ditch repair projects. The county board or joint county ditch authority (where a ditch system crosses two or more counties) is responsible for maintaining public drainage systems. If it is apparent to the ditch authority, or if a petition of 26% of the landowners indicate a need for repair, the ditch authority may appoint an engineer to report on the necessary repairs. Upon completion of the report, the county board shall hold a hearing on the engineer's report.

In the event that benefits originally determined no longer reflect present land values or appear to be invalid, viewers should be appointed to redetermine benefits and damages, if any. In the case where assessment of certain classes of state owned land are involved, the responsibilities of the Commissioner of Natural Resources as defined in Minnesota Statutes Chapter 84A.55 and Chapter 106.672 should be considered.

The viewers then file a viewer's report with the county clerk or auditor. At this time, a final hearing date is established. Upon completion of the final hearing, the county board or joint ditch authority will continue or dismiss the proceedings. In the event that the viewer's and engineer's final reports are approved, bidding procedures may be initiated for repair cost exceeding \$20,000 in one year or 20% of the original construction cost of the ditch system. No bids or entering into contracts are required for repair cost in amount less than \$20,000 in one year or 20% of the original construction cost of the ditch system. Once contracts for construction are awarded, the proposed ditch repairs may begin. For projects that cost less than \$20,000 a year, the ditch authority may award the job for construction without entering into bids or contracts, and the proposed ditch repairs may begin.

General procedures for ditch repairs outlined above apply under Minnesota Statutes chapter 106. In the specific proposed ditch repair project in Northwest Koochiching county, depending on the cost apportionment theories selected for implementation, variations to the existing procedures under Chapter 106 can be expected.

B. Cross-section Geometry

The original ditch plans from 1914 do not have any cross-section of the ditches plotted or recorded. The cross-section geometry of the ditches such as side slope, bottom and top width are estimated. The size and location of the culverts and the existing ditch conditions provided an approximation of the

original ditch cross-section geometry. The side slope is assumed a 2:1 (horizontal:vertical) ratio. The bottom width is approximated from the size and location of the culverts. Caution was exercised because some culverts were presumably placed in at a later date when the original culverts were filled in. Typical ditch cross-sections are plotted in Figure 4 to 10. The cross-sections for earthwork computations are located at 500 feet. At each location, cross-sections are surveyed 300 feet across. The vegetation is most-ly dense brush and trees at the banks of these cross-sections.

C. Ditch Grades

The ditch grades were obtained from the original ditch plans (1914) with some modifications where the locations of culverts indicate different grades are necessary for flow conveyance. The flow directions are assumed as those shown on the 1914 ditch plans for those ditches that were part of J.D. 17 and 18. For those ditches investigated but not part of J.D. 17 and 18, the flow directions indicating drainage of the land towards the closest natural outlet, the flow directions showing potential hydraulic capacities and a consistent overall effective drainage of the land are assumed. Typical ditch grades are shown in Figure 4 to 10.

D. Structures

All culverts are assumed to require replacement. The culverts will be replaced by corrugated metal pipes ranging from 36 to 54 inches in diameter and various lengths. In the field, existing culverts that have sufficient flow capacities, located at the right grade or depth and in good structural conditions will not be replaced. Appurtenance associated with the proper functioning of the culverts such as aprons and connections are required. The cost of the structures including installation are included in the cost estimate.

E. Miscellaneous

The proposal for this study requires a total of about 14 miles of ditches to be investigated. However, the ditch in the northern end of Section 25 in drainage sub-area Dl does not serve any private land and the ditch indicated as flowing towards the northwest direction into McCloud Creek in drainage area F cannot be located in the field or original plans. These ditches totaling about 2.5 miles were excluded from further analysis. Hence, approximately 11.5 miles of ditches were investigated in this study.

Approximately 108,000 cubic yard of material is required to be excavated. Right-of-way of approximately 27 to 34 feet from the center line of the ditches is required. The banks of the ditches and about 16.5 feet of right-of-way on each side of the ditches are required to be seeded. Clearing and grubbing is required where dense trees or brush hinders the ditch repair works.

Aerial bluelines of the area taken in 1978 were also used to determine the vegetation cover and land use. The bluelines were taken by the Minnesota Department of Transportation.





Elevation (feet)



Figure 5 - Typical Ditch Cross-sections and Grade in Drainage Area B







Figure 7 - Typical Ditch Cross-sections and Grade in Drainage Area D





Figure 8 - Typical Ditch Cross-sections and Grade in Drainage Area E



Figure 9 - Typical Ditch Cross-sections and Grade in Drainage Area F



Figure 10 - Typical Ditch Cross-sections and Grade in Drainage Area G

Elevation (feet)

VI. PRELIMINARY COST ESTIMATES

A. Repair Costs

The preliminary repair costs include excavation, clearing and grubbing, seeding, structures, contingencies (15%), engineering and administration costs. A preliminary cost estimate for about 11.5 miles of the ditches are shown in Table 4 below. All monetary figures used in this report are based on 1981 dollars.

Table 4

Preliminary Cost Estimates

Α.	Repair Costs:	Excavation Cost @ \$1.25/cubic yard	\$135,250
		Cleanup and Grubbing @ \$500/acre	17,000
		Seeding @ \$150/acre	3,600
		Structures	26,050
		Contingencies (15%)	27,350
		Engineering and Administration	31,450
	Total	• • • • • • • • • • • • • • • • • • • •	\$240,700
в.	Annual Mainte	nance Cost	Varies
С.	Annual assess	ment revisions	Varies

B. Maintenance Cost

As mentioned in Section V.A., under Minnesota Statute Chapter 106.471, sub-division 2b, the annual ditch repair or maintenance cost for one ditch system for one year should not exceed \$20,000.00 or 20% of the original construction cost of the ditch system. The limitation of \$20,000.00 or 20% of original construction cost applys to ditch reapir or maintenance work that can be conducted without advertising for bids or entering into contracts. However, in any year, it is possible through petitions or a ditch maintenance fund, for the ditch repair or maintenance cost to exceed \$20,000.00 or 20% of the ditch system original construction cost.

It is not possible to estimate the annual ditch maintenance cost after completion of the proposed ditch repairs because it varies with the actual maintenance being carried out. In the first few years after the ditch repairs, maintenance cost presumable will be minimal. However, a need for regular ditch maintenance is required for the proper functioning of the ditches. Regular maintenance such as mowing or spraying the banks to keep brush and trees from growing is advisable.

C. Proposed Assessment Revision Cost

In order to provide a check of the estimated potential benefits with actual field conditions, and to reflect changes in land use, new landownerships, land values and crop productivities, it is proposed that the assessment be revised when necessary. This proposed assessment revision should be conducted annually or periodically depending on the extent of changes. Therefore, this cost cannot be estimated since it is a variable cost. It is proposed that the assessment revisions be carried out only in those drainage areas that are affected by the land use change. It is suggested that the proposed assessment revisions be made either to the remaining unpaid portion of the assessment or a redistribution of the entire initial assessment. Depending on the schedule of payments, both the proposed assessment revision should be associated to the cost apportionment theory applied to the areas.

Therefore the total cost of the proposed ditch repair project is estimated at about \$240,700. Annual maintenance and proposed assessment revision costs are variables, and cannot be determined at this point.

VII. PRELIMINARY BENEFIT ESTIMATES

A. Potential Agricultural Benefits

In the study areas, the drainage of the land is assumed to provide for improved agricultural land use. The potential benefits that could be realized from the proposed ditch repair project include increase in land value, and crop productivity. The estimate of potential benefits is based on the future anticipated land use practices and productive capability of the soil.

B. Federal and State Land

In the study areas, the future anticipated land use practices of the Federal and State governments remain unchanged from the present condition. Therefore, any benefit that could be realized from the proposed ditch repair project would only be associated with the conversion of wasteland to woodland. Since the Federal and State governments have not indicated a desire to change their current land use practices, it is reasonable to assume that no supplementary drainage system will be installed. Any changes with respect to the assumed land use practices will require a re-evaluation of the potential benefits as presented in this report.

Research on timber improvement in drained peat soils showed that benefits are realized only within about 100 feet from the centerline of the ditch (Reference 2). With the right-of-way taken into consideration, only about 70 feet wide strip of land adjacent to the ditches would benefit. Therefore, the approximate Federal and State land areas benefitting are 12 and 90 acres respectively. The increase in land value from wasteland to woodland is about a mere \$25 per acre. The total increase in land value for Federal and State lands are approximately \$300 and \$2200 respectively.

Increase in crop productivity is based on improved timber productivity. In the study areas, the timber is assumed to be used for pulp wood. According to the Minnesota Division of Forestry of the Department of Natural Resources, pulp wood from Black Spruce trees in the area would most likely provide the best

returns. It is estimated that the price of Black Spruce pulp is about \$19.50 per cord (1981 dollars). However, the long crop rotation of 90 years for Black Spruce and the small acreage of improved timber productivity resulted in a negligible benefit. Therefore, no benefits is shown in Table 4 for Federal and State lands.

C. Private Land

The future anticipated land use for private land is based on the assumption that all non-productive or less productive land would be converted to the maximum possible agricultural productivity depending on the soil supportive In order to realize the maximum potential benefits, supplementary capability. drainage system is required. It is assumed that the supplementary drainage system is designed such that the water table will be sufficiently lowered to permit crops of maximum value to be cultivated over the entire private land. This assumption implies that uniform benefit is attained over the entire private land without regard to the distance from the project sites. In order to realize the estimated potential benefits, a more extensive cleanout of the ditches for the upstream outlet stretches is required. and Without supplementary drainage and additional cleanout, the potential benefit has to be re-evaluated. It is also assumed that organic soil supports pasture land while inorganic soil supports tillable land. It is necessary to make the preceeding assumption in order to relate to the land use classifications (Section IV) and because other factors such as the severity of the climate and distance to potential markets are not considered.

Based on the assumptions in the preceeding paragraph, the entire private land would benefit except those lands presently tilled or requiring no drainage. The total drainage land area that would benefit is estimated at about 1700 acres. The resulting increase in land value is approximately \$198,600.

The annual crop productivity for private land is assumed to be the average cash rent paid for tillable (\$8.88 per acre) and pasture land (\$3.91 per acre). The average cash rent figures in 1981 dollars are obtained from the

Minnesota Equalization Aid Review Committee (EARC). The land rent represents more accurately the actual crop productivity of the land because rent charged is directly based on expected return in harvested crops and not on speculative value or other externalities. The present worth due to the improved annual crop productivity is estimated at about \$61,800.

D. Miscellaneous

A summary of the preliminary estimate of potential benefits is shown in Table 5. The total project cost necessary to realize the estimated potential benefits cannot be determined at this point. Therefore, it is not appropriate to compute a benefit-cost ratio for the proposed ditch repair project. A more refined benefit-cost ratio requires detailed analyses either to re-evaluate potential benefits or re-evaluate the total project costs. The vast areas of Federal and State land, limited acreage of private land, severe climate for crops and market availability for the crops would presumably lower the benefits. The additional cost for private supplementary drainage system and more extensive cleanout would increase the cost dramatically.

Table 5

Land Ownership <u>1</u>	Land Area % 2	Increase In Land Value 1981 \$ 3	Present Worth of Annual Increase in Crop Productivity 1981 \$ 4
State* Private Federal*	78.0 13.0 <u>9.0</u>	2,200 198,600 300	-0- 61,800 -0-
Subtotal Total		201,100	61,800 262,900

Preliminary Potential Benefit Estimates

Note: The increase in crop productivity is computed at 12% interest rate over an infinite period of years.

* Increase in land value is based on the change from wasteland to woodland for about a distance of 100 feet from the center line of the ditch. There is no value in terms of woodland crop productivity because of the long crop rotation (90 years for Black Spruce) period and marginal improvement in land area.

A. Rationale

The rationale behind this theory is that landowners that would benefit from the proposed ditch repair project should bear the cost of the repair project by some weighted proportion of the potential benefits realized.

B. Assumptions

In general, all lands that can be drained and are served by the ditches, excluding designated wetland-wildlife habitat within the drainage areas can benefit from the ditch repair works.

Benefit is assumed to occur when the lands are drained from a 10-year 24-hour rainfall (about 3.47 inches) within a 24-hour duration, and the drawdown of the water table is sufficient to permit improved crop production. As discussed under Section VII, uniform benefits are assumed based on soil types and future anticipated land use practices. Potential benefits are derived from increase in land value and crop productivity.

C. Methodology

Drainage areas and sub-areas served by the ditches proposed for repair are delineated. The cost of ditch repair is assessed only to the areas served directly or indirectly by the ditch. It is possible that several sub-drainage areas are assessed for the cost of one ditch repair. In the study areas, the cost of repairing the ditch in sub-area C3 is shared by the entire drainage area: C1, C2 and C3. The sub-areas C1 and C2 are indirectly served while the sub-area C3 is directly served by the ditch in C3. The same principle is applied to drainage area G. In drainage sub-area D3, the cost of the ditch repair is shared by sub-areas D1 and D3 but not D2 since D2 is not served by the ditch. Similarly, the cost of ditch repair in D2 is shared by D1 and D2 but not D3.

The assessments for the proposed ditch repairs are divided according to the percentage of potential benefits derived. The assessments are divided under Federal, State and Private landowners. Within each drainage or sub-drainage area, the ratio of potential benefit of one landowner to the total potential benefit multiplied by the estimated ditch repair cost results in the assessment for that landowner. From the preceeding paragraph, sub-area Cl is assessed for the ditch repair cost in Cl and partially for the ditch in C3. The landowners in Cl are assessed for the ditch in C3 by the ratio of potential benefits in Cl to the potential benefits in the entire drainage area C multiplied by the ditch repair cost of C3. However in drainage area D, a different situation is The ditches in sub-areas D2 and D3 both serve sub-area D1. The encountered. cross-section geometry and grade of the ditches in sub-areas D2 and D3 in the repaired conditions are similar in magnitude. Therefore, it is assumed that flow from the ditch in Dl is divided equally in magnitude to the ditches in D2 and D3. In reality, it is difficult to determine the flow distribution without field measurements. Therefore, the potential benefits from Dl is halved and the assessment analysis similar to drainage area C is conducted.

D. Preliminary Assessment Results

Based on the assumptions and methodology outlined above, the preliminary assessment results based on the Revised Direct Benefit theory is presented in Table 6 below. Plate IV shows the areas with potential benefits.

Table 6

Preliminary Revised Direct Benefit Assessments

Land Ownership 1	Land Area % 2	Repair Assessment 1981 \$ 3	Assessment % 4
State Private Federal	78.0 13.0 9.0	9,900 229,200 1,600	4.1 95.2 0.7
Total	100.0	240,700	100.0

E. Limitations

A major limitation of the Revised Direct Benefit Theory is that no consideration is placed for the source of the drainage problem. The runoff contribution from the land is not taken into account. Drainage of scattered portions of land especially those lands located at the runoff receiving end of the drainage area would not be effective unless the land where runoff occurs is also managed.

Another major limitation is the future anticipated land use practices of the various landowners. In this specific situation, the Federal and State landowners have no intention to improve their respective lands by installing supplementary drainage system, the potential benefit estimated is substantially lower as compared to the private land with supplementary drainage system. Inherent in this difference in land use planning, the downstream landowners are ultimately assessed a greater amount for the ditch repairs.

Other limitations include the assumptions used to estimate the potential benefits on private land. Without private supplementary drainage, the potential benefits would be drastically reduced. Market availability for the crops and the severity of the climate are not considered.

IX. REVISED WATERSHED THEORY

A. Rationale

The rationale behind this theory is that land contributing surface and sub-surface runoff causing the drainage problem should bear the cost of the ditch repair.

B. Assumptions

In general, all lands except designated wetland-wildlife habitat, contributing surface and sub-surface runoff to the drainage ditches are assessed. The assessment is based on the percentage of surface volume runoff (acre-feet). Sub-surface runoff cannot be determined without more detail analysis. It is assumed that the water table is sufficiently lowered to permit crop production by appropriate design of supplementary drainage system.

The drainage ditches proposed for repairs are assumed to be designed for a 5 to 10 year runoff because of the available hydraulic capacity of the ditches in their restored state. Therefore, the 10-year 24-hour rainfall of about 3.47 inches is used to generate the surface runoff. The Soil Conservation Service curve number method is used to determine the surface runoff. It is evident that spring runoff is related to the size of the drainage areas. All the rainfall would runoff in the spring. In the summer, surface runoff is computed by considering the different soil types, vegetation cover and existing land use practices. The average volume runoff from spring and summer conditions is used for assessment analysis.

Another major assumption is that all the surface runoff within a drainage area or sub-area would flow towards the ditches proposed for repair. The very poor drainage condition of the ditches may render the preceeding assumption invalid unless additional cleanout to ensure flowing condition in the ditches is carried out. It is suggested that obstructions to the flow due to beaver

dams, brush and other materials be removed without necessarily conducting a complete repair of the ditches.

C. Methodology

The drainage and sub-drainage areas are delineated. Indian reservation and designated wetland-wildlife habitat are excluded from the analysis. Within the study areas, there is no designated wetland-wildlife area. The assessment is based on the percentage of surface runoff contribution from the various landowners. Once the average surface runoff is computed, the assessment procedures are similar to those outlined under the Revised Direct Benefit Theory.

D. Preliminary Assessment Results

The preliminary assessment results are presented in Table 7 below.

Table 7

Preliminary Revised Watershed Assessments

Land Ownership 1	Land Area % 2	Repair Assessment 1981 \$ 3	Assessment % 4
State Private Federal	78.0 13.0 9.0	182,600 49,600 8,500	75.9 20.6 <u>3.5</u>
Total	100.0	240,700	100.0

As expected, the assessments are closely related to the drainage areas. Plate V shows the drainage and sub-drainage areas contributing surface runoff to the proposed ditch repair sites.

E. Limitations

The major limitation is that the potential benefits derived from the improved drainage are not considered. A serious difficulty is apparent when a land with little potential benefit is assessed substantially based on the runoff contribution. Those lands with little benefit may not be able to justify their share of the ditch repair cost.

Due to the flat topography, the drainage area delineation is only approximate. However, any changes in drainage areas can be accounted for during the proposed assessment revision.

X. COMBINED REVISED DIRECT BENEFIT AND WATERSHED THEORY

A. Rationale

The rationale behind this theory is that the land benefitting from the ditch repair works and contributing runoff to the ditch should pay for the ditch repair cost.

B. Assumptions

The assumptions under the Revised Direct Benefit and Watershed theories would apply. The main assumption specific to this study is that the benefits and runoff contribution factors are given equal level of importance.

C. Methodology

The potential benefits and average surface runoff are computed separately under the Revised Direct Benefit and Watershed theories respectively. The percentages of potential benefit and runoff contribution are added and the average percentage computed. This would imply that the assessment is a function of 50% potential benefit and 50% runoff contribution except in areas where no benefit is realized from the ditch repairs. Where no potential no benefit if apparent, assessment is based on runoff contribution alone. The average percentage computed from the various landowners is multiplied with the ditch repair cost to obtain the respective assessments. Alternatively, half of the ditch repair cost can be assigned to the assessment method based on potential benefit and the other half assigned to the runoff contribution method. The assessment is the sum of the two halves.

D. Preliminary Assessment Results

The preliminary assessment results based on this theory is presented in Table 8 below. Plate VI shows the different assessments under this theory.

Table 8

Land Ownership l	Land Area % 2	Repair Assessment 1981 \$ 3	Assessment % 4
State Private Federal	78.0 13.0 9.0	96,200 139,400 5,100	40.0 57.9 2.1
Total	100.0	240,700	100.0

Preliminary Combined Revised Direct Benefit and Watershed Assessments

Even though the State land represents 78% of the study areas, the assessment under this theory is about 40% because of the negligible potential benefits.

E. Limitations

The limitations imposed by the Revised Direct Benefit and Watershed theories would apply. The equal weighting placed on potential benefit and runoff contribution is arbitrarily set without regard to the magnitude of each factor and relative importance. Additional studies in other parts of Minnesota and under different drainage conditions would enable a refined weighting implementable on a State-wide basis. Hence, this limitation can be eliminated with additional studies.

XI. CAUSE-EFFECT THEORY

A. Rationale

The rationale behind this theory is that land naturally contributing runoff should not have to pay for the ditch repair cost. Land use changes resulting in the alteration of the natural runoff by aggravating the drainage problem should pay for the changes in runoff incurred.

B. Assumptions

It is assumed that the physical, climatological, and vegetation characteristics within the study areas for the pre-drainage and existing conditions remain practically unchanged. The ditches under investigation are short and the topography of the land is flat. Therefore, the size of the areas draining into the respective ditches under investigation is unlikely to change from pre-drainage to existing conditions. Hence, the analysis under this theory is carried out under the classification of Minor Change instead of Significant Change as outlined earlier. Pre-drainage conditions are assumed to comprise of bogs, woods, brush, and swamps.

C. Methodology

The assessment methodology is based on the increase in surface runoff contribution between the existing and pre-drainage conditions. The average runoff for spring and summer conditions is computed for pre-drainage and existing conditions. To facilitate the computations, only those areas with land use practice that differ from the pre-drainage conditions are analyzed. Assessment is a function of the percentage increase in runoff contribution from the various land. Since the study areas are classified under Minor Changes, no computer simulation of the hydrology or hydraulics is necessary. Under Significant Changes, computer simulation would be necessary.

D. Preliminary Assessment Results

In this specific situation, the Cause-Effect Theory is not applicable. An explanation for its inapplicability with respect to cost apportionment of ditch repair work in the study areas is presented in the limitation section. No assessments are made under this theory.

E. Limitations

A clear limitation of this theory is evident in areas where the pre-drainage and existing conditions are practically unchanged. Therefore, there is only limited land use changes. Hence, increase in runoff from pre-drainage to existing conditions is minimal.

In the study areas, a large part of the land that drains towards the proposed ditch repair stretches is still in pre-drainage conditions. Therefore, based on this theory, substantial areas under Federal, State and even Private ownerships will not be assessed. Only those private landowners who have presently tilled their farms causing an increase in surface runoff from the pre-drainage conditions are subjected to assessments. Presently, there are only a few farms that have increased the runoff from pre-drainage conditions. These farms are identified in Plate VII. It is also evident from Plate VII that a significant length of the ditches proposed for repairs do not serve the farms that are currently contributing runoff in excess of the pre-drainage conditions. Naturally, these private landowners would only pay for those ditches that serve their lands, either directly or indirectly. Therefore, the practicality of this theory is in doubt since the rest of the landowners: Federal, State, and Private (those with no land use changes) are not assessed even though the ditches proposed for cleanout will potentially - serve their land. Assessing the cost of repairs for the entire proposed length of ditches to those farms that are contributing runoff in excess of pre-drainage conditions even though substantial reaches of the ditches (about 50%) do not serve them is unreasonable. In this specific situaion, the Cause-Effect Theory is not applicable for cost apportionment.

This theory results in no incentive to develop the land because any landowners aggravating the drainage problem by land use changes would be subjected to assessments. This will not be a limitation if a benefit-cost ratio is favorable for project implementation.

The five land use classifications (Section III.D) is too broad under this theory. Presently tilled farms have no increase in benefits from the ditch repairs. Minimal increase in benefits cannot be detected. Finally, potential benefits are not considered.

XII. PROVISION FOR WETLAND-WILDLIFE HABITAT

Wetlands represent natural storage reservoirs. Therefore, wetland with its capability of retarding runoff can prevent excessive flooding in downstream areas. Wetlands also provide for wildlife habitat. The draining of wetland-wildlife areas may have environmental consequences especially when the soil is acidic in nature. Therefore, provision for the preservation of all designated wetland-wildlife areas should be made.

However, in the study areas, there are no wetland or wildlife areas officially designated. Recognizing the need to preserve wetland-wildlife areas, all designated wetland-wildlife areas, if any, are excluded from the analyses. It is suggested that the administrative agencies should decide on whether a water quality study should be conducted prior to implementation of the proposed ditch repairs. The draining of the bog's water which is acidic in nature may affect the water quality of downstream rivers if sufficient quantity is discharged.

XIII. LAND AND OTHER RESOURCES MANAGEMENT

The present land use and water management in the study areas in Northwest Koochiching County require substantial improvement. A systematic data collection and a more in-depth investigation of the land use and water problems would allow for improved management of those resources. It is proposed that the existing annual tax assessments should be refined to reflect changes in the land use.
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	APPENDIX	
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Federal Land

State Land

Private Land

Indian Reservation

Drainage Boundary

Sub-Drainage Boundary

Drainage Areas

Sub-Drainage Areas

Ditches Investigated

Original Flow Direction

Plate I LOCATION MAP

PRELIMINARY INVESTIGATION OF PROPOSED DITCH REPAIR PROJECT IN NORTH-WEST KOOCHICHING COUNTY, MINNESOTA

McCombs-Knutson Associates, Inc.



LEGEND

	Ditches Investigated
OPEN	Organic Soil
	Inorganic Soil

Plate II SOIL TYPES

PRELIMINARY INVESTIGATION OF PROPOSED DITCH REPAIR PROJECT IN NORTH-WEST KOOCHICHING COUNTY, MINNESOTA

McCombs-Knutson Associates, Inc.





	Ditches Investigated
	Farms
	Inorganic Soil
OPEN	Organic Soil

Plate III EXISTING AGRICULTURAL LAND USE

PRELIMINARY INVESTIGATION OF PROPOSED DITCH REPAIR PROJECT IN NORTH-WEST KOOCHICHING COUNTY, MINNESOTA

McCombs-Knutson Associates, Inc.



LEGEND

Ditches Investigated

DRAINED CONDITIONS

Federal and State Land Potential Wood Production (100 ft. from ditch centerline)

Private Land Potential Tillable Land Potential Pasture Land

Potential Pasture

No Benefits

OPEN

Tilled Farms, High Grounds, and Indian Reservations Federial and State Land Not Adjacent to Ditch Repair Work

Plate IV REVISED DIRECT BENEFIT THEORY

PRELIMINARY INVESTIGATION OF PROPOSED DITCH REPAIR PROJECT IN NORTH-WEST KOOCHICHING COUNTY, MINNESOTA

McCombs-Knutson Associates, Inc.



LEGEND

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Ditches Investigated

Runoff Contributing Areas

Plate V REVISED WATERSHED THEORY

PRELIMINARY INVESTIGATION OF PROPOSED DITCH REPAIR PROJECT IN NORTH-WEST KOOCHICHING COUNTY, MINNESOTA

McCombs-Knutson Associates, Inc.



LEGEND

Ditches Investigated

Assessment Based on 50% Benefit and 50% Runoff Contribution

Assessment Based on Runoff Contribution

OPEN

No Assessment

Plate VI COMBINED REVISED DIRECT BENEFIT AND WATERSHED THEORY

PRELIMINARY INVESTIGATION OF PROPOSED DITCH REPAIR PROJECT IN NORTH-WEST KOOCHICHING COUNTY, MINNESOTA

McCombs-Knutson Associates, Inc.



LEGEND

Areas contributing runoff in excess of natural conditions: Tilled Farms

OPEN Areas assumed in natural conditions: Bogs and Woods

Ditches Investigated

Plate VII CAUSE-EFFECT THEORY

PRELIMINARY INVESTIGATION OF PROPOSED DITCH REPAIR PROJECT IN NORTH-WEST KOOCHICHING COUNTY, MINNESOTA

McCombs-Knutson Associates, Inc.