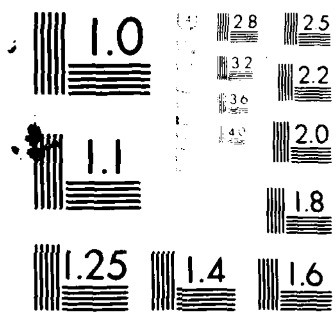
AD-A110 265 CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT F/G 13/2
GRAND FORKS - EAST GRAND FORKS URBAN WATER RESOURCES STUDY. SUM--ETC(U)
JUL 81

UNCLASSIFIED NL

1 OF 1
AD
A110265

END
DATE
FILMED
2 82
DTIC



MICROCOPY RESOLUTION TEST CHART

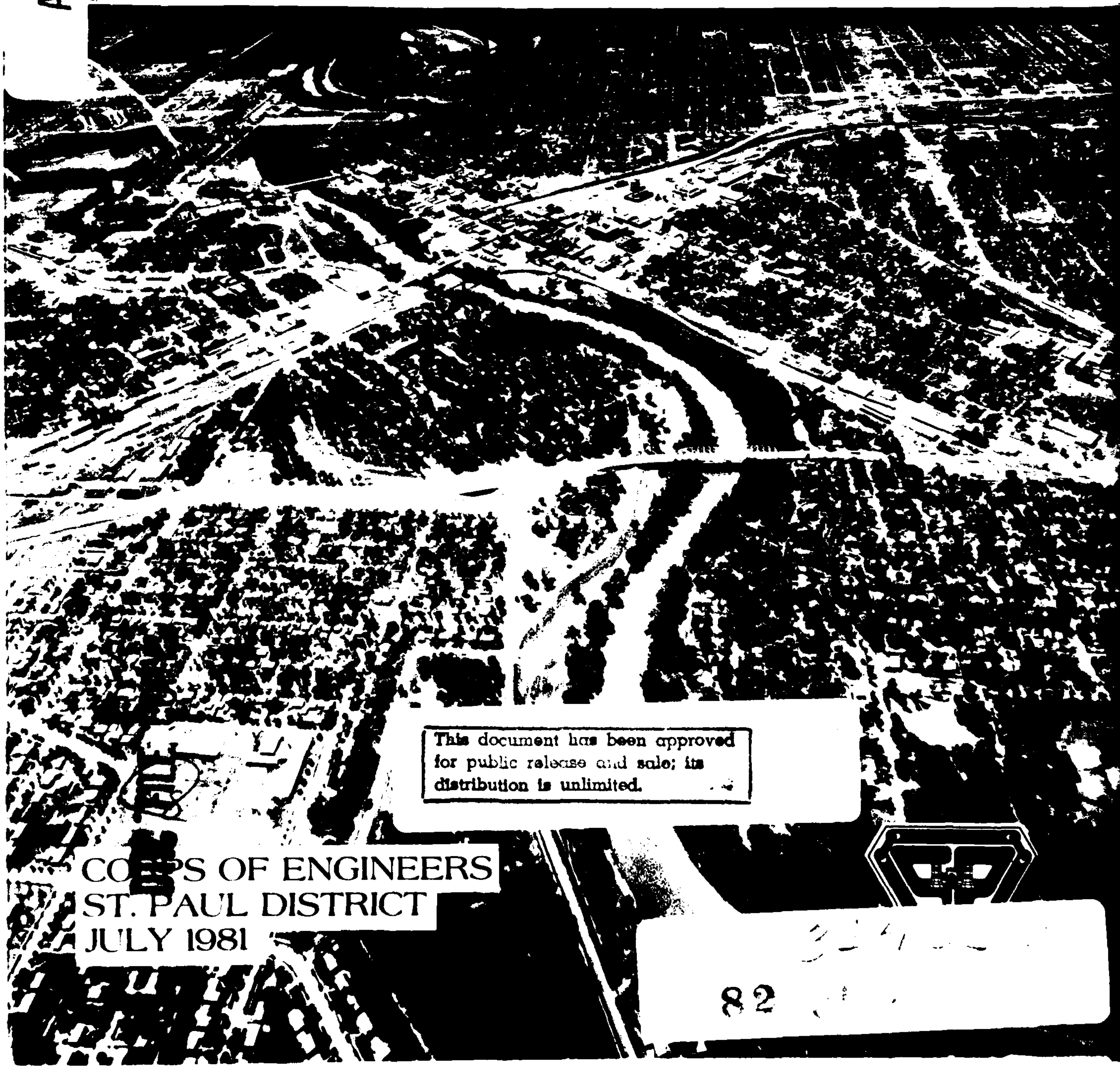
NATIONAL BUREAU OF STANDARDS

AD A111 0265

GRAND FORKS – EAST GRAND FORKS URBAN WATER RESOURCES STUDY

LEVEL II

SUMMARY REPORT



CORPS OF ENGINEERS
ST. PAUL DISTRICT
JULY 1981

82

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AD	2. GOVT ACCESSION NO. A1[illegible]	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* GRAND FORKS-EAST GRAND FORKS URBAN WATER RESOURCES STUDY; Summary Report		5. TYPE OF REPORT & PERIOD COVERED Final; 1976-1980 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Army Corps of Engineers, St. Paul District 1135 USPO and Custom House St. Paul, Minnesota		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE July 1981 13. NUMBER OF PAGES 82
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Flood control
Water resources
Water supply
Urban planning

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The goal of the Corps of Engineers Urban Study Program is to provide planning assistance to local interests in a variety of water resource areas, some not within traditional Corps areas of responsibility. The St. Paul District conducted the Grand Forks-East Grand Forks (GF/EGF) Urban Water Resources Study which was a cooperative effort amoung local, state and federal agencies. Primary attention was given to flood control, water supply and wastewater management; supporting investigations addressed recreation and energy conservation.

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

The GF/EGF urban study report consists of ten documents:
- Summary report
- Background Information Appendix
- Plan Formulation Appendix
- Water Supply Appendix
- Wastewater Management Appendix
- Flood Control and Urban Drainage Appendix
- Flood Emergency Plan for Grand Forks, North Dakota
- City of East Grand Forks, Minnesota, Civil Defense Flood Fight Plan
- Energy Conservation and Recreation Appendix/ Public Involvement Appendix
- Comments Appendix

Flood control studies showed that the East Grand Forks levee project authorized in 1953, but not constructed, still was economically feasible and recommended further study under the Corps' postauthorization program. Grand Forks flood control studies found four measures which qualified for further study and possible implementation under the Corps' Small Projects Continuing Authority. An urban drainage master plan proposed for the developing fringe areas around Grand Forks would require future developments to incorporate ponding areas to temporarilty store runoff to limit peak discharges, to those that occur under existing land conditions.

Flood emergency plans were developed jointly with both cities to improve their flood fight preparedness and effectiveness. Manuals, narrated slide programs and pamphlets were developed which covered: flood fight organizations and headquarters; responsibilities of local, state and federal agencies; pre-flood, flood fight and postflood operations; emergency evacuation plans; and citizen self-help measures.

Regarding water supply, a low-flow study of drought flows on the Red and Red Lake Rivers found that river flow, plus storage provided by the cities' low-head dams, would satisfy 2030 demands during a 50-year drought. The uncertain future of the Garrison Diversion Project made it an unsatisfactory alternative water source. Local aquifers were unsuitable because of inadequate recharge rates. The most economical treatment and supply alternative would be for the two cities to develop a combine system in 2005. A water conservation program was proposed which could reduce demand and costs. A five-stage drought emergency plan of action was developed to cope with drought conditions more severe than the 50-year design event.

The study concluded that separate wastewater treatment facilities based on lagoon systems were the most cost-effective means of handling major point sources through 2030. However, if "zero dischage" criteria were promulgated the large land areas needed for lagoon effluent disposal could make advance mechanical treatment attractive.

Overflows from Grand Forks' combined sewers into the Red River, which is the city's drinking water source, were the most serious problems. The study's finding that the most cost-effective solution was sewer separation was accepted by the EPA and the North Dakota State Department of Health, making the city eligible for Federal financial assistance.

PREFACE

The Corps of Engineers' Urban Study Program is aimed at providing planning assistance to local interests in a variety of water resource and related land resource areas, including water supply, wastewater management, flood control, navigation, shoreline erosion, and recreation. In areas of traditional Corps responsibility (such as flood control), the Corps may implement and construct projects shown feasible in the urban study. In other areas (such as wastewater management), Corps involvement carries only through the planning stage; findings are turned over to local interests for incorporation into their broad urban comprehensive planning effort. Implementation is at the discretion of local interests in conjunction with appropriate State and Federal agencies.

The St. Paul District, Corps of Engineers, conducted the Grand Forks-East Grand Forks (GF/EGF) Urban Water Resources Study, which was a cooperative effort between local, State, and Federal agencies. The GF/EGF urban study spanned a time of transition in the Corps' urban study program. In mid-1978, directives were issued deleting the third and last stage of urban studies. At that time, the second stage of the GF/EGF urban study was nearing completion, but commitments for stage 3 studies had been made to local interests and involved State and Federal agencies. Therefore, the GF/EGF urban study was allowed to proceed to stage 3.

During the first stage, the 14-township study area was selected, broad topical problems to be addressed (water supply, wastewater management, and flood control) were identified, and a "plan of study" was developed. The plan of study outlined the general approach the study would follow. During stage 2, the topical problems were broken down into explicit problem areas. Investigators formulated a broad array of alternatives to resolve the study area's problems. The alternatives were evaluated to eliminate those which were not suitable or cost effective. The stage 3 study examined in detail those alternatives that passed the stage 2 screening. Alternatives were reassessed to determine their respective cost effectiveness and environmental/social impacts.

This particular document is 1 of ~~11~~ 10 constituting the GF/EGF urban study report:

- Summary Report
- Background Information Appendix
- Plan Formulation Appendix
- Water Supply Appendix
- Wastewater Management Appendix
- Flood Control and Urban Drainage Appendix
- Flood Emergency Plan for Grand Forks, North Dakota
- City of East Grand Forks, Minnesota, Civil Defense Flood Fight Plan
- combined { Energy Conservation and Recreation Appendix
- Public Involvement Appendix }
- Comments Appendix

This summary report provides a brief overview of the urban study, including:

- How the study was conducted.
- The study area.
- The study area's problems, needs, and concerns.
- The final alternative solutions to these problems, needs, and concerns.
- The impacts of these alternatives.
- The findings and recommendations.

It is being distributed to all individuals, agencies, organizations, and special interest groups on the urban study's mailing list and to any other persons that request copies. Because of this broad distribution, the report is brief and written in nontechnical terms to permit a layperson to read it in no more than 1 hour.

Readers desiring additional information can refer to the Plan Formulation Appendix, which addresses all the major areas of investigation (flood control, water supply, and wastewater management). Readers wishing to explore any particular topic area in even greater detail should review the appropriate technical appendix(es) listed earlier.

TABLE OF CONTENTS

TABLES

TABLES (CONT)

FIGURES

FIGURES (CONT)

SUMMARY REPORT

THE STUDY, STUDY AREA, AND REPORT

The Grand Forks-East Grand Forks Urban Water Resources Study was a cooperative Federal, State, and local planning effort aimed at developing viable solutions to water and related land resource problems, needs, and concerns in the study area for the 1980-2030 period. The study area (figure 1) encompasses 14 townships in Grand Forks County, North Dakota, and Polk County, Minnesota. Major population centers in this area are Grand Forks, North Dakota; East Grand Forks, Minnesota; and the Grand Forks Air Force Base near Emerado, North Dakota. Study area boundaries were determined by distinguishing climatic, physical, biological, and socioeconomic characteristics which yielded common water resource management problems and goals.

Federal, State, regional, and local agencies and commissions; special interest groups; and commercial and industrial representatives joined in the urban study to give the broadest possible spectrum of public involvement. Participants were organized into three units (figure 2):

- The executive group was composed of the heads of major policy and administering agencies. This group was available for critical policy and management decisions.

- The study work group was made up of the Corps of Engineers' interdisciplinary study team and the agency committee which included staff-level members of involved agencies, groups, and interests. The Corps' study team conducted the study's day-to-day business; agency committee members approved scopes of work for contracted segments of the study, participated in public involvement functions, reviewed draft reports, and acted as liaisons with their respective agencies to ensure the urban study complied with agency policies and did not duplicate ongoing work.

- The citizens committee was composed of the Grand Forks and East Grand Forks planning commissions. This committee was to assist in gathering input from the general public and disseminating information from the urban study to the citizens.

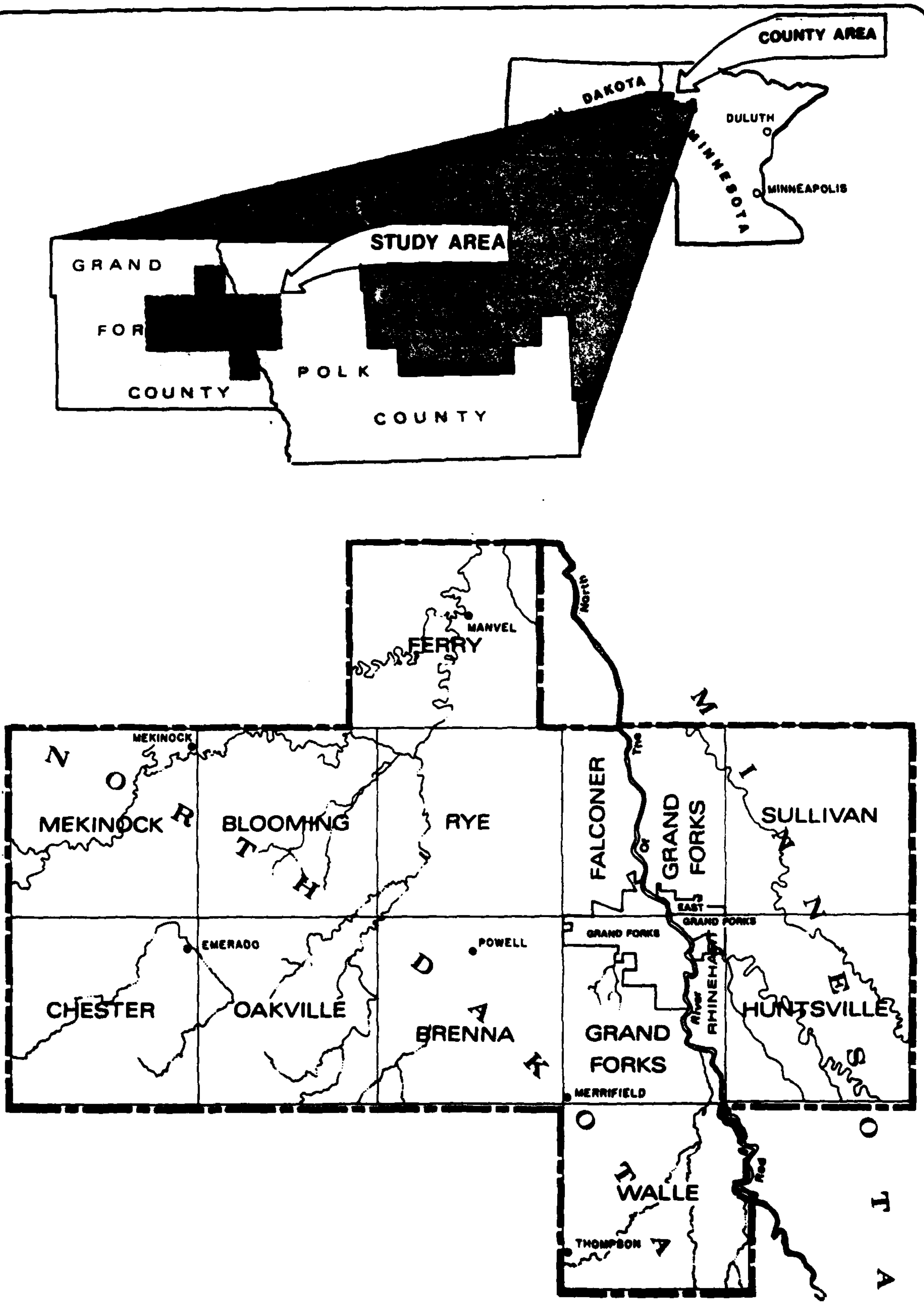


FIGURE 1 - Study Area

EXECUTIVE GROUP

Corps of Engineers	District Engineer
Environmental Protection Agency (Region VIII)	Regional Administrator
North Dakota Department of Health	Executive Officer
North Dakota State Water Commission	Engineer Secretary
Minnesota Department of Health	Commissioner
Minnesota Pollution Control Agency	Director
Minnesota Department of Natural Resources	Commissioner
City of Grand Forks	Mayor
City of East Grand Forks	Mayor

CITIZENS COMMITTEE

Grand Forks Planning Commission
East Grand Forks Planning Commission

STUDY WORK GROUP

Study Team	Early Participants	Later Participants
Chief, Urban Studies Section	Mr. David Haumersen	
Chief, General Investigations Section		Mr. Robert Northrup
Study Manager	Mr. Martin McCleery	Mr. Thomas Raster
Water Resource Engineer	Mr. Mark Phillips	
Economist		Mr. Charles Workman
Urban Planner	Mr. Clyde Hanson	Ms. Blanche Hom
Agency Committee		
Corps of Engineers		Mr. Thomas Raster
U.S. Environmental Protection Agency	Mr. James Rakers	Mr. Robert Burm
Heritage Conservation & Recreation Service		Mr. Henry Burbach
Red River Regional Planning Council		Mr. Julius Wangler
Northwest Regional Development Commission		Mr. Randy Johnson
North Dakota Departmen' of Health	Mr. Raymond Rolshoven	Mr. Francis Schwindt
North Dakota State Water Commission	Mr. Bruce Braun	Mr. Bill Hanson
North Dakota Soil Conservation Service		Mr. Lynn Bereuter
Minnesota Pollution Control Agency		Mr. Paul Davis
Minnesota Department of Natural Resources	Ms. Hedia Rieke	Mr. Gene Hollenstein
Minnesota Department of Health		Mr. Paul Johnson
Grand Forks County Planning		Mr. Al Dickie
West Polk Soil & Water Conservation District		Mr. Lee Hannah
Grand Forks Air Force Base		Mr. John Kotalik
City of Grand Forks		Mr. Robert Bushfield Mr. Frank Orthmeyer Mr. J. Keith Johnson
City of East Grand Forks		Mr. Ellis Larson Floan & Sanders Engrng Mr. Dave Mack Mr. Allen Lafave
Grand Forks-Traill Water Users, Inc.		Mr. Randal Loeslie
International Coop	Mr. J. R. Sponsler	
Grand Forks League of Women Voters	Ms. Joan Burke	Ms. Dorothy Uhrska
Grand Forks Planning Commission		Mr. Michael Polovitz
U.S. Fish & Wildlife Service		Mr. Don Simpson
Grand Forks Park Board		Mr. Dick Leker
U.S. Environmental Protection Agency	Mr. Rolland Lech	Mr. Michael Salazar
Grand Forks City Housing Authority		Mr. Royce LaGrave
Pillsbury Company	Mr. Wayne Knudson	
Institute for Ecological Studies, University of North Dakota		Dr. Paul Kannowski

STUDY ORGANIZATION

FIGURE 2

The study process consisted of three stages, each of which included four planning tasks. In figure 3, the size of the planning task boxes illustrates how the relative amount of study effort changed with each stage.

Figure 4 shows the time line for the study's three stages and the reports prepared for each stage. The primary product from stage 1 was the plan of study which laid out the urban study's scope, objectives, and process and identified the basic water resource problems that would be addressed.

In stage 2, a number of supporting investigations were conducted to provide base-line data and background information. The study area's problems, needs, and concerns were more thoroughly examined. Solutions were developed and screened to eliminate alternatives clearly lacking technical/economic feasibility or social/environmental acceptability. Seven documents were prepared - two compiling background materials (the Background Information and Recreation Appendixes), three presenting the findings and recommendations in the major areas of study (the Flood Control, Water Supply, and Wastewater Appendixes), two digesting the urban study's results to that point (the Plan Formulation Appendix and Summary Report).

Stage 3 focused on those alternatives recommended for further study. Support studies - e.g., low-flow analyses and flood emergency planning - addressed specific needs in the major areas of investigation. The alternatives were reevaluated in greater detail to identify those which were feasible, cost effective, acceptable, and implementable. Wherever appropriate, the final reports included both the stage 2 documents and stage 3 results to provide a total picture of the planning and decision-making process. The final reports include the three major appendixes and two related documents - the Flood Control, Water Supply, and Wastewater Management Appendixes and the Grand Forks and East Grand Forks flood emergency manuals. Stage 2's Background Information Appendix was largely unchanged; stage 2's recreation material was combined with the write-ups for energy conservation and public involvement into a single document to reduce the number of volumes.

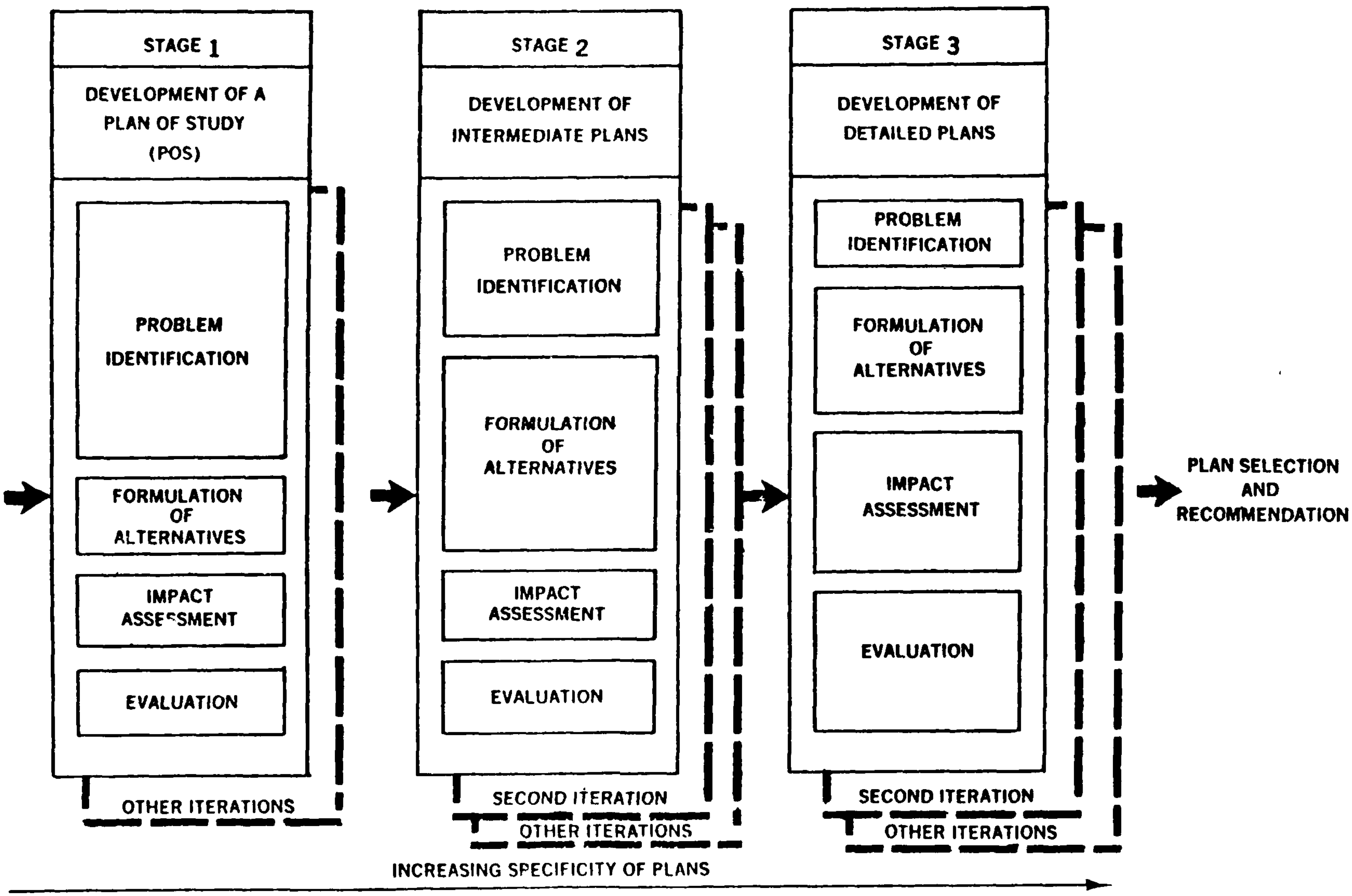


FIGURE 3 General Relationship of Plan Development Stages and Functional Planning Tasks.

GRAND FORKS - EAST GRAND FORKS URBAN WATER RESOURCES STUDY

SCHEDULE OF DOCUMENTS

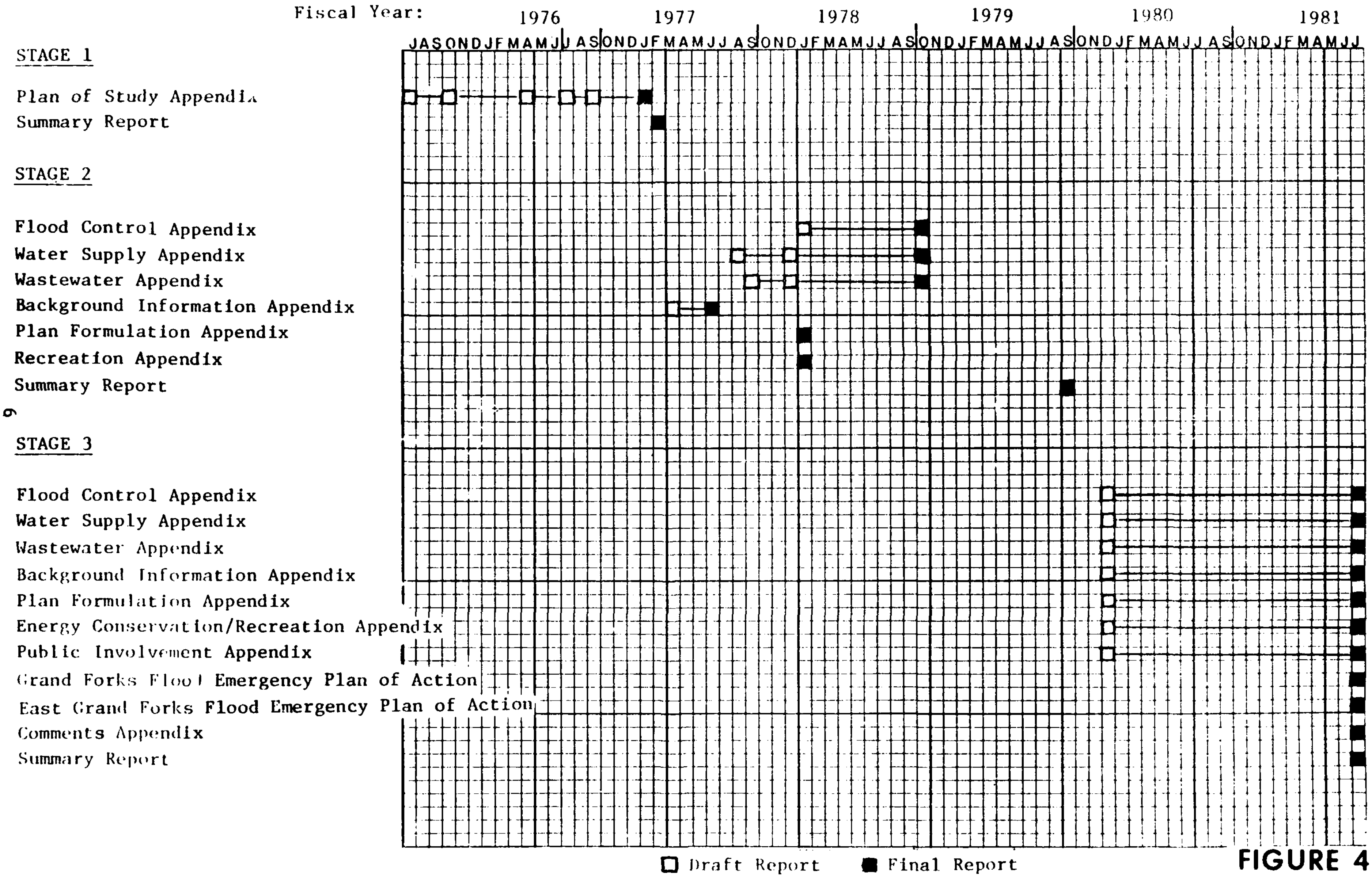


FIGURE 4

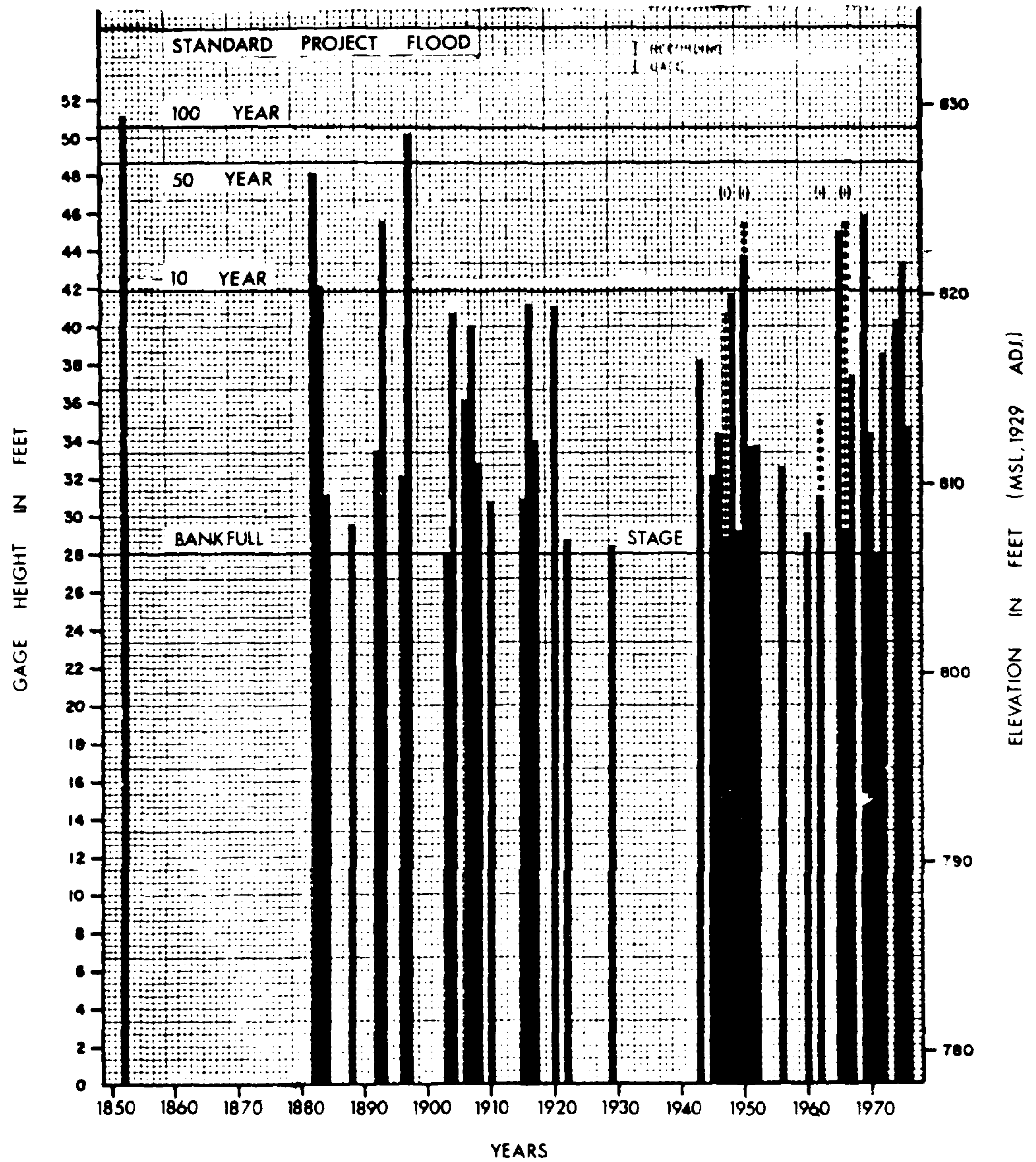
A Comments Appendix presents the Corps' responses - including changes in study focus and report modifications - to review comments from outside agencies and groups. The Summary Report and Plan Formulation Appendix digest the urban study's major investigations. The Summary Report was written in a brief, nontechnical format; the Plan Formulation Appendix includes more detail for readers seeking additional information.

FLOOD CONTROL

FLOOD THREAT

Within the study area, only Grand Forks and East Grand Forks were identified as having serious flooding problems. Figure 5 shows the relationship of past Red River of the North floods to the bank-full stage and different frequency events. The 1979 "Flood of the Century" was approximately a 70-year event (a flood which would recur about once every 70 years on the average over a period of many years). This flood has about a 1.4-percent chance of being equaled or exceeded in any one year.[1] Table 1 lists the Red River's 10 largest discharges and corresponding peak stages recorded at Grand Forks. Figure 5 and table 1 illustrate the frequency of significant (say 10-year or larger) floods between 1897 and 1950 and the recent upsurge in the frequency of larger floods.

[1] The Corps of Engineers recently reanalyzed the flood frequencies of the Red River. However, unless otherwise noted, the frequencies in this report are based on the "old" frequency-discharge relationship administratively agreed to by several Federal and State agencies in June 1971.



RED RIVER OF THE NORTH

(1) VARIATION IN SHADING ON THE BAR GRAPH INDICATES MORE THAN ONE FLOOD DURING THE YEAR

(2) U.S.G.S. GAGE ON LEFT BANK 500 FEET DOWNSTREAM FROM DAM AT RIVERSIDE PARK IN GRAND FORKS AT MILE 295.7. GAGE ZERO, ELEVATION 778.35.

URBAN WATER RESOURCES STUDY

GRAND FORKS, NORTH DAKOTA

FIGURE 5

FLOODS ABOVE BANKFULL STAGE

ST. PAUL DISTRICT CORPS OF ENGINEERS

Table 1 - 10 largest flood discharges,
Red River of the North at Grand Forks, North Dakota

Order of magnitude	Date of crest	Gage heights (feet)(1) Stage	Elevation	Estimated peak discharge (cfs)
1	10 April 1897	49.3	827.65	85,000
2	26 April 1979	49.81	827.16	82,000
3	18 April 1882	46.3	824.65	75,000
4	4 April 1966	45.55	823.90	55,000
5	11 April 1978	45.73	824.08	54,200
6	12 May 1950	45.5	823.85	54,000
7	16 April 1969	45.69	824.04	53,500
8	24 April 1893	43.8	822.15	53,300
9	17 April 1965	44.92	823.27	52,000
10	24 April 1975	43.27	821.62	45,000

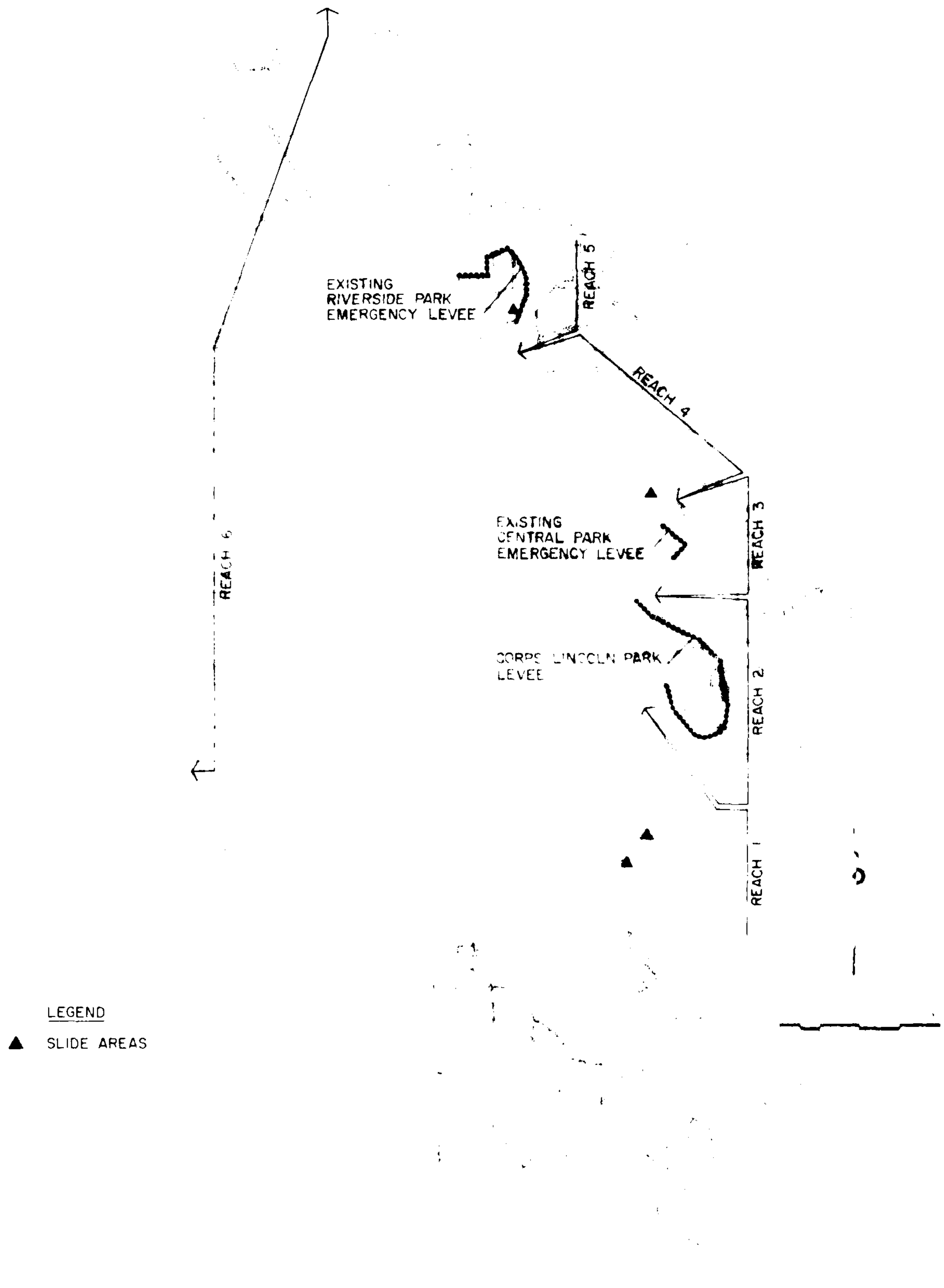
(1) Gage zero = 778.35 (1929 adjustment).

PROBLEMS, NEEDS, AND CONCERNS

The 100-year floodplains of the three major flood sources - the Red River, Red Lake River, and English Coulee - cover a large share of the urban area (figure 6). Although the highest recorded flood occurred in 1897, the frequency of recent floods has greatly concerned local interests.

Emergency flood barriers constructed during recent flood emergencies supplement the protection provided by the Lincoln Park levee/floodwall, a Corps-built permanent structure which protects a neighborhood in Grand Forks (figure 6). These flood barriers do not provide an adequate degree of protection and are susceptible to subsidence problems.

The Lincoln Park levee/floodwall was completed in 1958. It provides only about a 30-year level of protection with 3 feet of freeboard (levee height above the design water level to provide a factor of safety), and soil creep has caused subsidence over the years. Emergency levees protect Grand Forks' Riverside Park and Central Park neighborhoods and East Grand Forks' downtown business district and adjacent residential areas. These levees were constructed during the 1965, 1966, 1969, 1971, and 1975 flood emergencies and have been retained and improved by the cities.



100-YEAR FLOODPLAIN/EXISTING FLOOD BARRIERS/STUDY REACHES

FIGURE 6

The emergency levees give residents a false sense of security; the visible physical barrier and success to date in preventing major flooding have built local confidence in the existing flood barriers and created a false impression that adequate protection is available or could be developed in a future flood emergency. However, the Corps views emergency levees only as a means of reducing flood damage during the event for which they were constructed. These levees were built quickly to protect against imminent danger; they do not meet Corps criteria for design and construction. Furthermore, the unstable foundation materials beneath the emergency levees have been responsible for severe slides and subsidence of portions of these levees. The emergency levee systems also lack proper interior drainage, which contributes to damages from sewer backups, excessive ponding levels behind levees, etc.

Some areas of the cities totally lack protection. For instance, before 1979, the recognized flood threat to developments along English Coulee was from Red River backwater which can affect the lower reach of the coulee. During the 1979 flood, however, excessive runoff down the coulee caused flood stages along much of the coulee, some surpassing 100-year levels shown in the Grand Forks 1977 Flood Insurance Study. Flood fighters gearing up to face the Red River assault were unprepared to handle the coulee's challenge. The result - more flood damages in Grand Forks from coulee flooding than from Red River flooding.

Protection is also lacking in newly developing areas of East Grand Forks north and south of the downtown district. These areas require an incredible commitment of manpower and resources to protect in an emergency. During the 1979 flood, "Minnesota Point," separated from the downtown area by the Red Lake River, was totally cut off by floodwaters and was accessible only by boat or helicopter. The residents and flood fighters dubbed their refuge "Isle de Sandbag," reflecting the millions of sandbags used to save the community from being totally inundated.

EAST GRAND FORKS STUDIES

A 1953 report prepared by the Corps of Engineers recommended construction of a levee. It wasn't until 1975, however, that East Grand Forks provided the necessary assurances of local cooperation. The urban study provided a means whereby a preliminary reassessment could be made of the economic feasibility of the authorized plan and other flood protection measures that might be appropriate in light of changed conditions.

Five plans were examined in stage 2 of the urban study (figures 7 and 8). The authorized plan (plan A) follows the alignment of the existing emergency levee. This plan would protect to the 62-year level by raising and widening 7,600 feet of the emergency levee and replacing part of the levee with a 1,500-foot concrete floodwall. Because plan A's alignment crosses areas subject to foundation stability problems, plans B and C were developed. Plan B would realign the levee/floodwall, but retain the same degree of protection. Plan C would raise the level of protection of the realigned levee/floodwall to the 100-year level. Plan D would provide 100-year protection to the newly developing area north of the authorized project. Plan E would provide 100-year protection to the Minnesota Point area.

As shown in table 2, under the 3 1/4-percent interest rate prevailing when plan A was originally authorized, plans A and C would be economically feasible (the benefit-cost ratio would equal or exceed 1.0). Under the 6 5/8-percent interest rate prevailing during the stage 2 studies, none of the plans would be economically justifiable.

In terms of environmental and social impacts, plan A would require removing up to 50 trees resulting in loss of wildlife habitat. Plans B and C would require removal of 23 residences and relocation of the occupants. Plans D and E would have no significant adverse impacts.

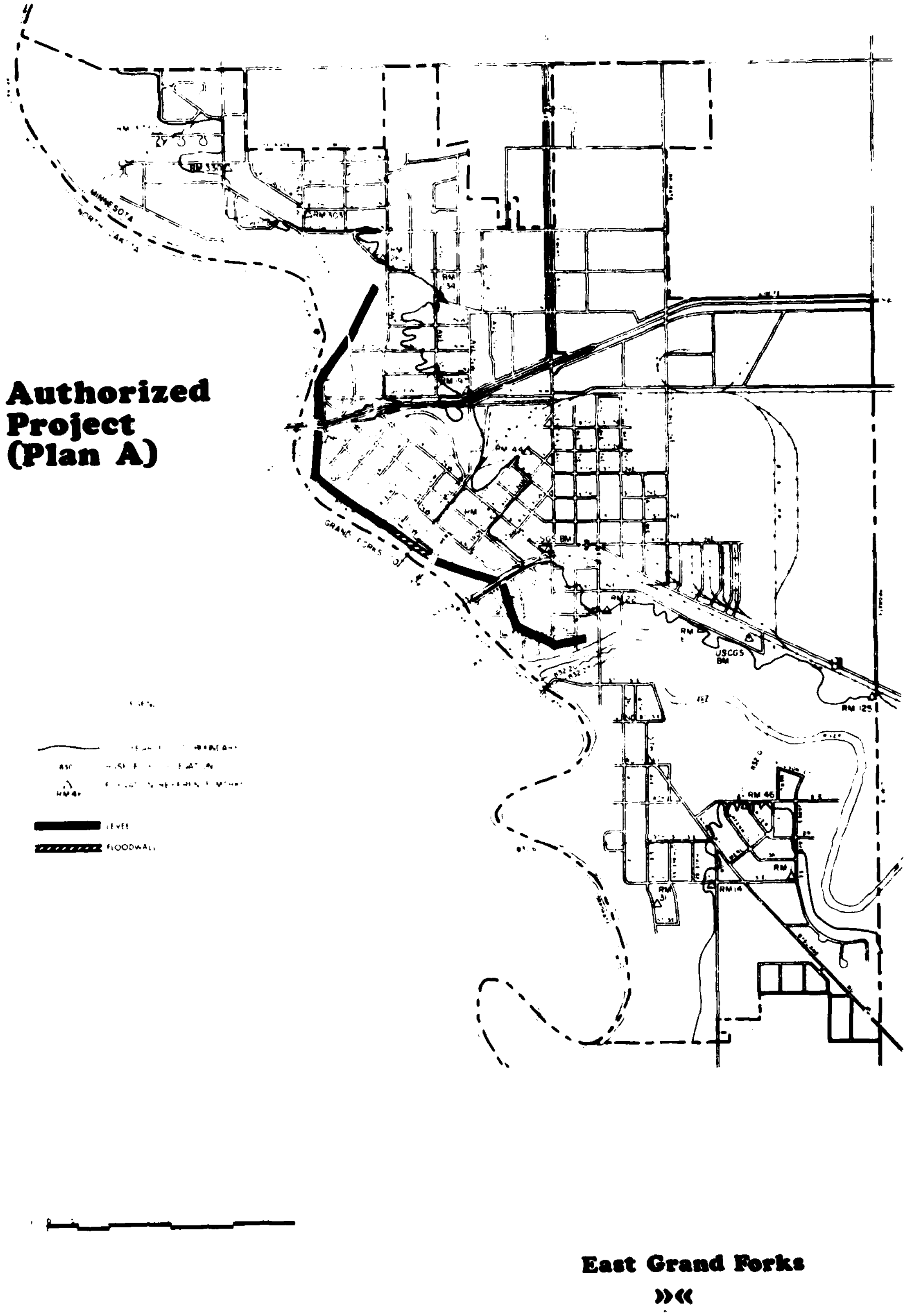
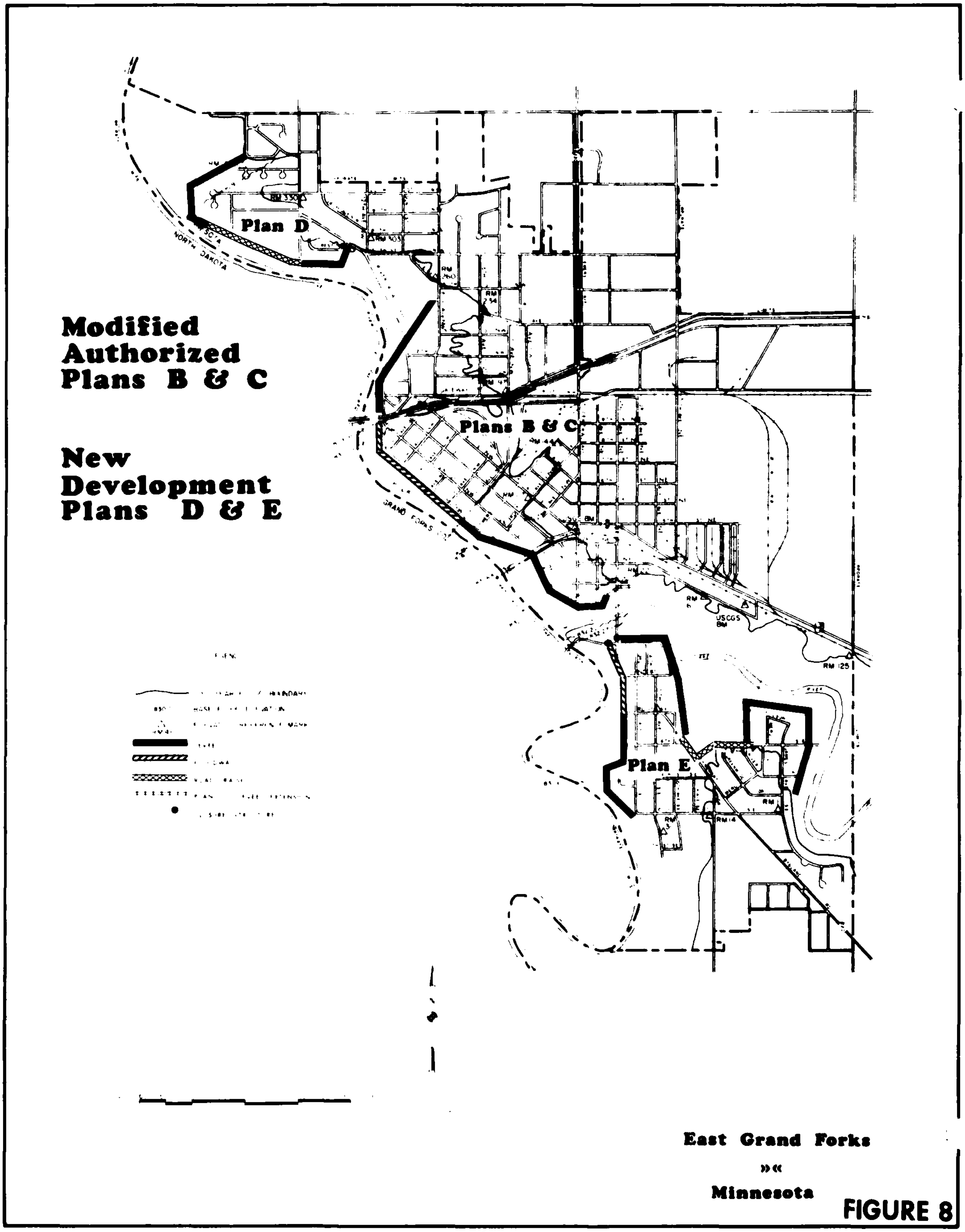

Authorized
Project
(Plan A)
MINNESOTA
NORTH DAKOTA
GRAND FORKS
USCGS BM
RM 125
RM 46
RM 14
LEVEE
FLOODWALL
East Grand Forks
Minnesota

FIGURE 7



Modified
Authorized
Plans B & C

New
Development
Plans D & E

Plan D
Plans B & C
Plan E
NORTH DAKOTA
GRAND FORKS
USCGS BM
RM 125
RM 14

East Grand Forks
Minnesota

FIGURE 8

Table 2 - Comparison of costs and benefits, East Grand Forks flood barrier alternatives

Item	Plan A Authorized Plan		Plan B Modified Authorized Plan		Plan C Modified Authorized Plan w/1-Percent Protection		New Development Plan D	New Development Plan E
	3 1/4%	6 5/8%	3 1/4%	6 5/8%	3 1/4%	6 5/8%	6 5/8%	6 5/8%
First costs								
Federal	$7,047,000	$7,243,400	$8,026,000	$8,226,000	$8,400,500	$8,610,200	$1,300,000	$5,766,000
Non-Federal	494,600	510,700	2,289,000	2,340,000	2,350,600	2,408,700	395,000	398,000
Total	7,541,600	7,754,100	10,315,000	10,566,000	10,751,100	11,018,900	1,695,000	6,164,000
Average annual costs								
Federal	238,800	480,100	271,900	545,900	284,600	571,500	86,200	382,600
Non-Federal	31,800	49,900	91,600	170,300	94,300	175,500	31,000	39,200
Total	270,600	530,000	363,500	716,200	378,900	747,000	117,200	421,800
Average annual benefits (1)	316,000	316,000	316,000	316,000	422,000	422,000	29,000	122,000
Benefit-cost ratio	1.2	0.6	0.9	0.4	1.1	0.6	0.2	0.3

(1) Average annual benefits do not consider local employment and future damage growth. By adding local employment and future benefits attributable to the reduction of damage to future growth, it is possible that a marginally infeasible project might prove to be economically feasible.

As a result of the investigation conducted under the urban study, it was recommended that postauthorization studies proceed - with particular attention to plan C which appears to be preferable on the basis of current Corps design criteria and questionable soil stability along the authorized alignment. The recommended postauthorization studies are being conducted independently of the urban study under the appropriate Corps authority.

The unquestioned seriousness of the flood threat to East Grand Forks and uncertain prospects for permanent flood protection indicated a definite need for maintaining and improving the city's flood fighting capability. Accordingly, in stage 3 of the urban study, the Corps contracted with the city's Civil Defense Director and the consulting firm which serves as city engineers to prepare a flood emergency plan of action. The authors drew on experience gained by themselves and other flood fight leaders during the 1978 and 1979 floods to prepare a flood fight manual (entitled City of East Grand Forks, Minnesota, Civil Defense Flood Fight Plan, published as a separate urban study document). This manual addresses:

- Flood fight organization - responsibilities of 23 units handling various duties from food services to dike patrol to sandbag filling.

- Flood emergency center - location, equipment, communications.

- Cooperating organizations - responsibilities, functions, and resources of city, county, regional, State, and Federal agencies involved in flood fighting and postflood assistance.

- Preflood preparations - public information on flood insurance and self-help measures; inventorying and stockpiling equipment and materials.

- Flood fight activities - mobilizing volunteers, capping sewer outfalls, ensuring municipal services, effecting emergency evacuations.

- Postflood activities - cleanup, damage estimates, disaster assistance applications.

The Corps also sponsored development of pamphlets and a narrated slide program describing the community's flood fight plan and self-help measures that could be adopted by residents.

GRAND FORKS STUDIES

General

In stage 2, Grand Forks' flood-related studies were divided into two investigations - one addressing major flooding from the Red River, the other addressing relatively minor urban drainage problems, particularly along English Coulee. The serious damages caused by the coulee in 1979 elevated urban drainage into a major flood control issue. Therefore, during stage 3, distinctions between the two investigations began to blur.

Flood Control Investigation

The city was divided into six reaches (figure 6) - five along the Red River and one covering part of English Coulee. In stage 2, six non-structural plans (F through K) and four structural plans (L through O) were considered:

- Plan F - Flood forecasting and warning services to provide advisories regarding peak stages and dates.
- Plan G - Floodplain regulations to manage flood-prone areas. The city already has a floodplain zoning ordinance and flood proofing code.
- Plan H - Flood insurance. The city is already in the Federal flood insurance program, and insurance is available to residents.
- Plan I - Permanent evacuation of over 2,600 flood-prone structures in the 100-year floodplain.
- Plan J - Flood proofing about 2,400 suitable structures in the 100-year floodplain.
- Plan K - Emergency flood fighting and relief activities.

- Plan L - Flood barriers for Reaches 1-5 (flood barriers were considered impractical for Reach 6).
- Plan M - A 13.7-mile diversion channel around the west side of the city to carry flows exceeding the Red River's bank-full capacity.
- Plan N - Reservoir storage of Red Lake, Wild Rice, and Sheyenne River floodwaters to reduce peak stages in the study area.
- Plan O - Modification of the Red River channel to increase its flow capacity.

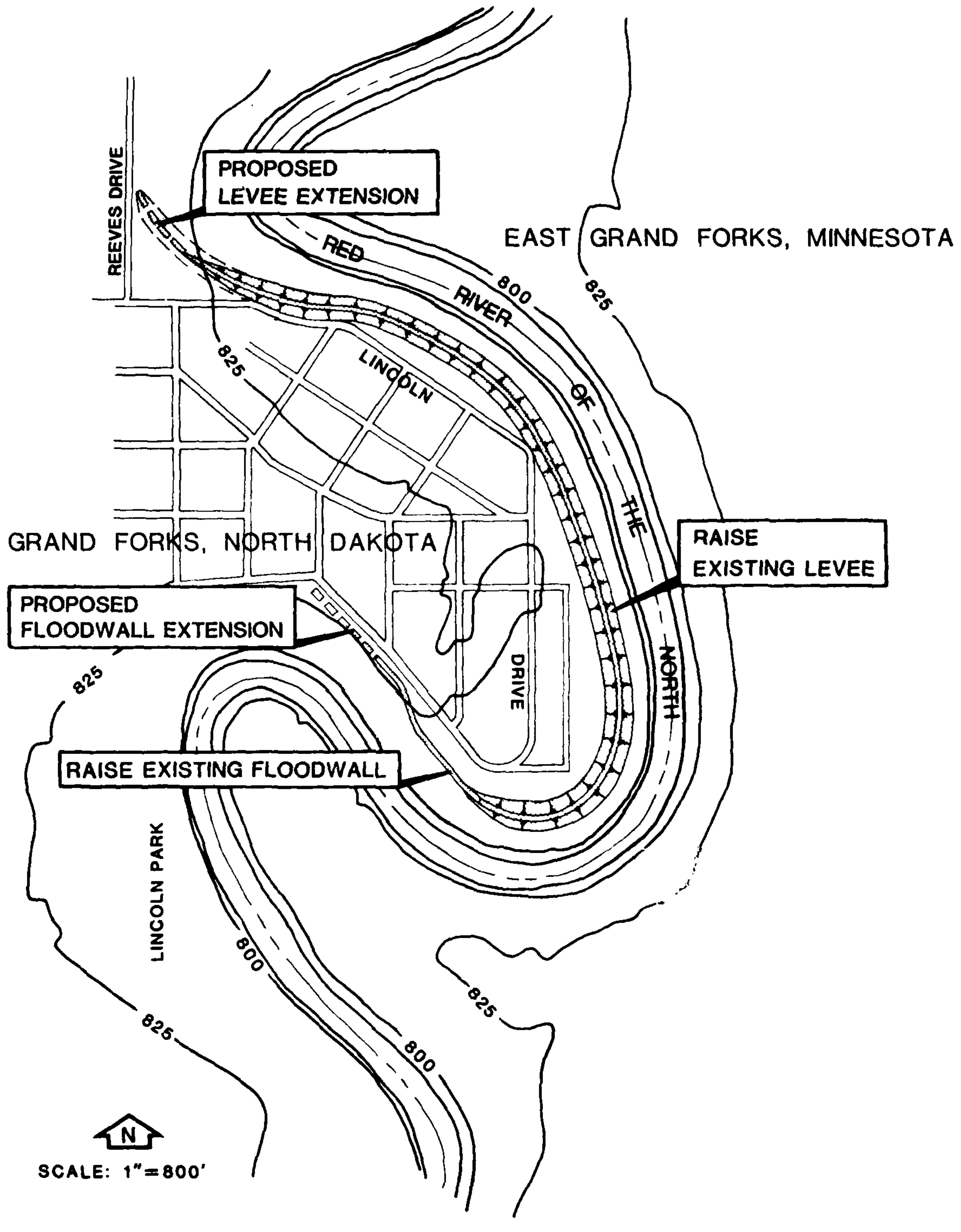
The only economically feasible structural plan was an increase in the level of protection provided by Reach 2's Lincoln Park levee/floodwall under plan L. The reservoir and channel modification plans (N and O) were not analyzed in detail because the Red Lake River reservoir was shown economically infeasible in another study, and reservoirs on the Wild Rice and Sheyenne Rivers would not be operational for years. Channel modification was found to have so little effect as to obviously not justify the costs and environmental impacts.

Certain of the nonstructural measures (plans F, G, H, and K) would lessen flood damages, provide mitigation for flood victims, and prevent unwise future floodplain development. However, these measures alone or in combination, would not provide a comprehensive solution to the city's flood problems.

On the basis of stage 2's findings and later coordination with city officials, eight measures were studied in stage 3:

- Increase the level of protection of the Lincoln Park levee/floodwall - The existing structure provides approximately a 30-year level of protection with 3 feet of freeboard. Surveys showed adjacent high ground would allow a maximum level of protection of only '7 years with 3 feet of freeboard (figure 9).

- Construct a permanent flood barrier for Reach [illegible]'s Riverside Park neighborhood - The alignment used in the economically infeasible stage 2 alternative would be rerouted through the former locations of four homes removed after being flooded in 1979. Two alternatives were considered: a levee around the entire neighborhood and a levee/floodwall to reduce the number of house removals (figure 10).

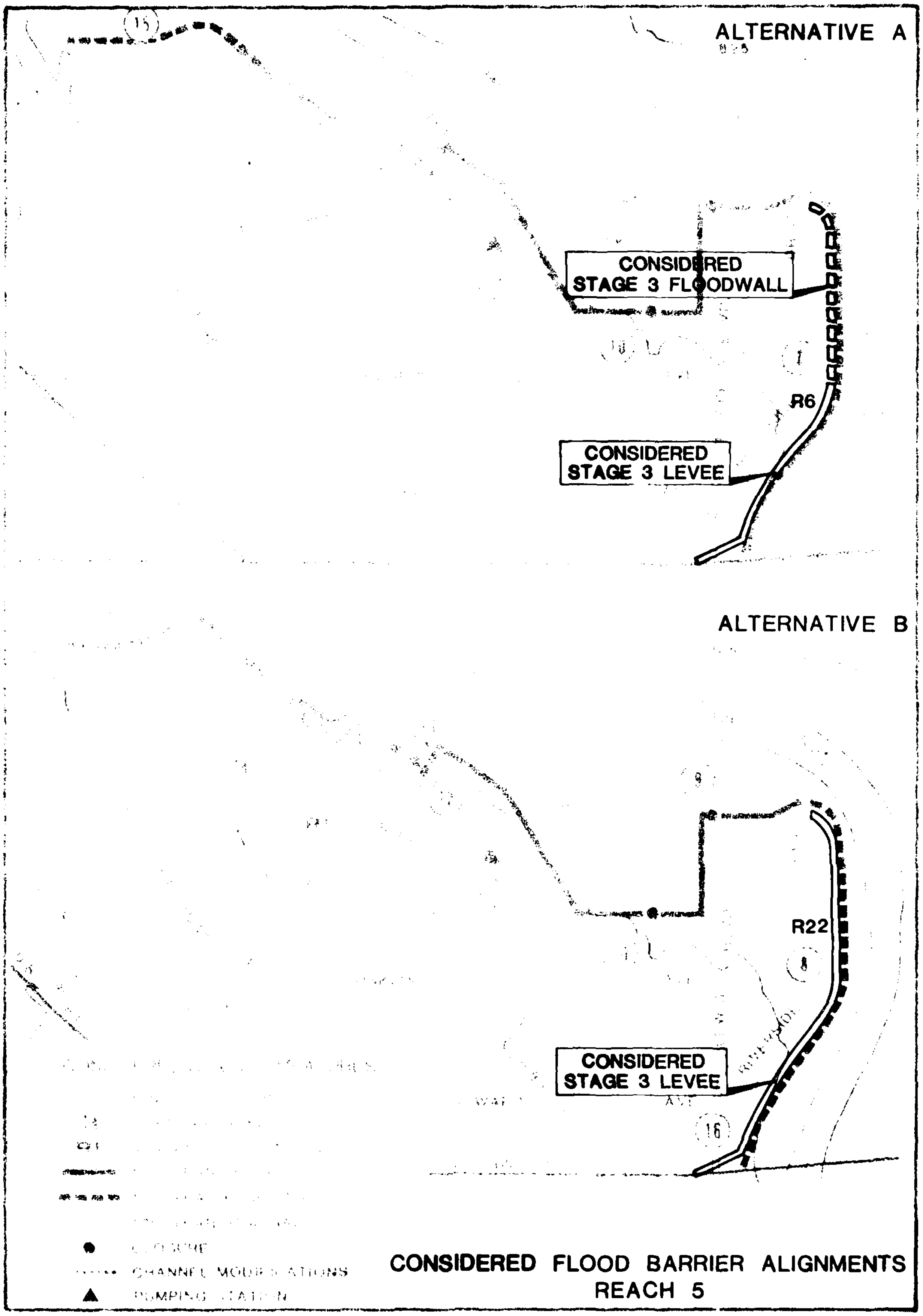


STAGE 3 FLOOD CONTROL

GRAND FORKS N.D. - EAST GRAND FORKS MN.

CONSIDERED REACH 2 FLOOD BARRIER RAISE

FIGURE 9



CONSIDERED FLOOD BARRIER ALIGNMENTS
REACH 5

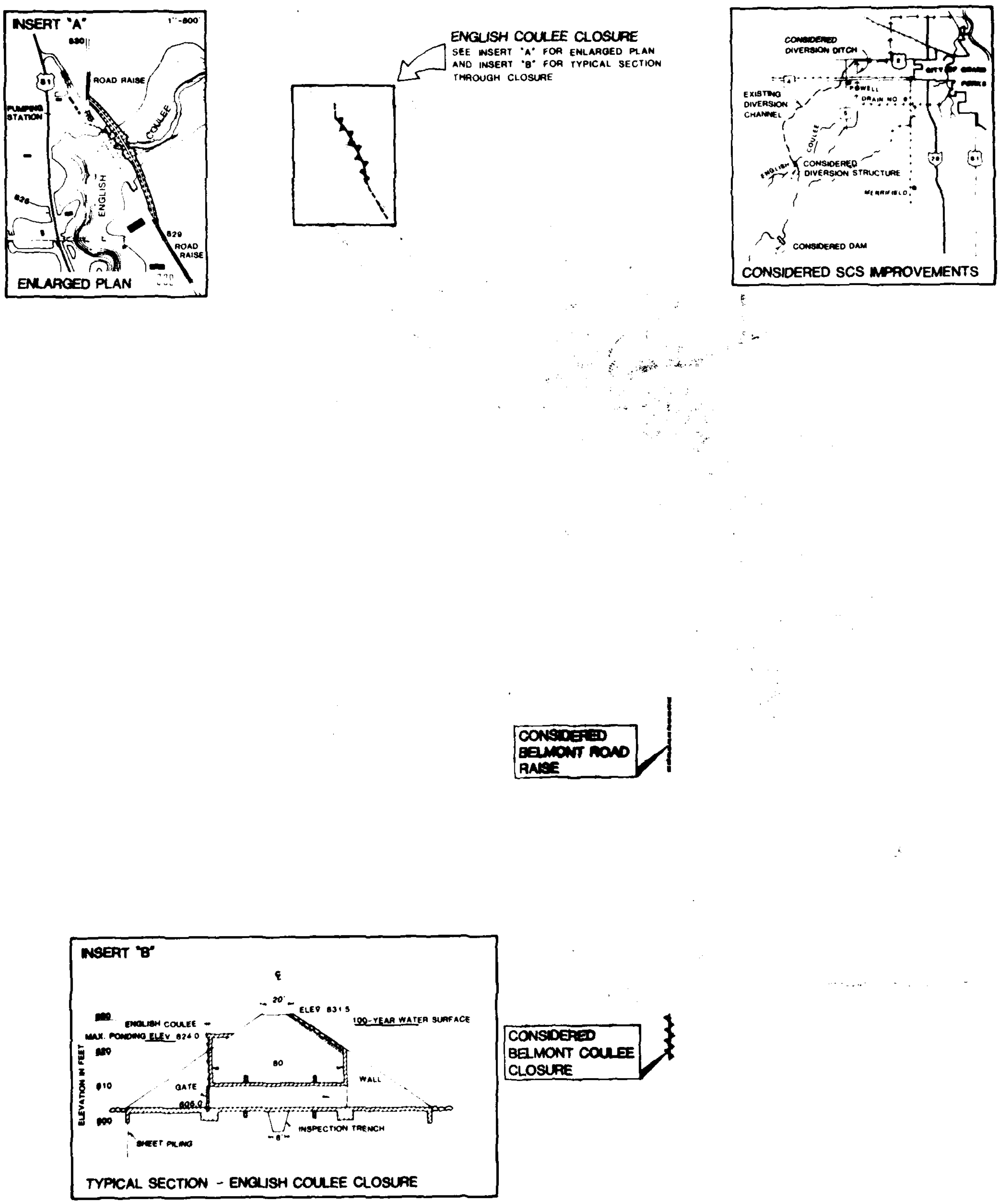
FIGURE 10

- Construct a closure structure/pumping station near the mouth of English Coulee - The controllable outlet usually would be open, permitting normal discharge of coulee flows (figure 11). During high Red River stages, the outlet would be closed to prevent Red River backwater from flooding properties along the coulee. Pumps would discharge coulee runoff to keep ponding below damaging levels. The city, Soil Conservation Service, and Grand Forks County Water Management and Control Board are considering diversion and flow retention schemes for the upper part of the coulee's watershed. Adoption of such a scheme is needed to keep pumping requirements for the closure structure within reason.

- Divert Red Lake River floodwaters via Grand Marais Coulee - This coulee intersects the Red Lake River near Fisher, Minnesota (figure 12). Natural overflows from the river into the coulee begin with about the 5-year flood. Consideration was given to increasing the amount of overflow; however, the coulee's natural channel would have to be enlarged and a number of bridges replaced.

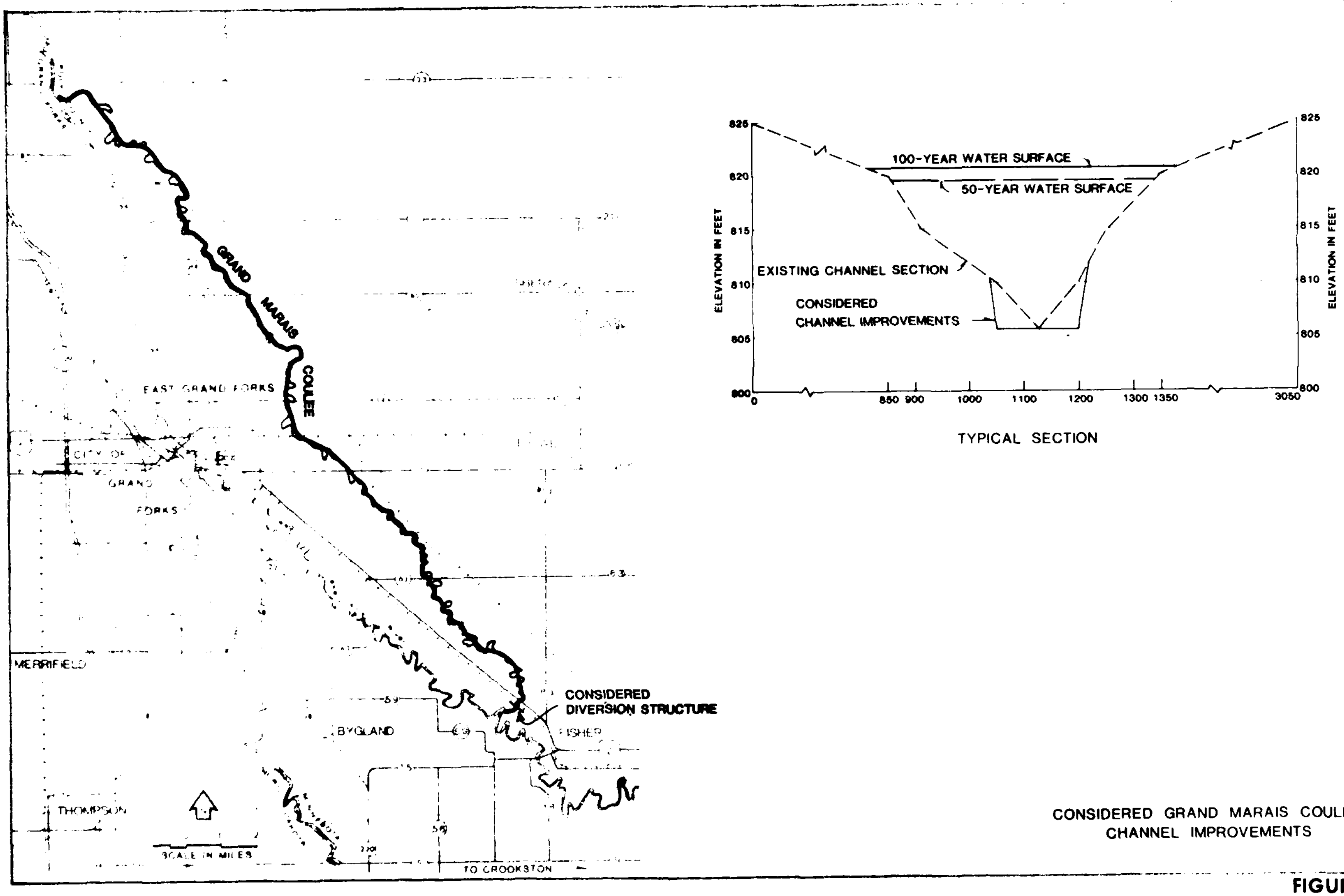
- Combine flood proofing and evacuation in Reaches 1 and 6 - Flood proofing would include low berms or walls to protect walkout basements and small groups of structures, door and window closures, moving damageable equipment to higher floors, raising structures on fill, etc. Structures not suitable for flood proofing would be removed from the floodplain. At a 100-year level of protection, about 200 structures would be involved in Reach 1 (figure 13) and 132 structures in Reach 6 (figure 14).

- Construct closure structure/pumping station at the Belmont Road crossing of Belmont Coulee - The plan that was evaluated was developed by the North Dakota State Water Commission; operation would be essentially the same as for the English Coulee closure.



CONSIDERED ENGLISH COULEE CLOSURE
(AND BELMONT ROAD ALTERNATIVES)

FIGURE 11



CONSIDERED GRAND MARAIS COULEE
CHANNEL IMPROVEMENTS

FIGURE 12

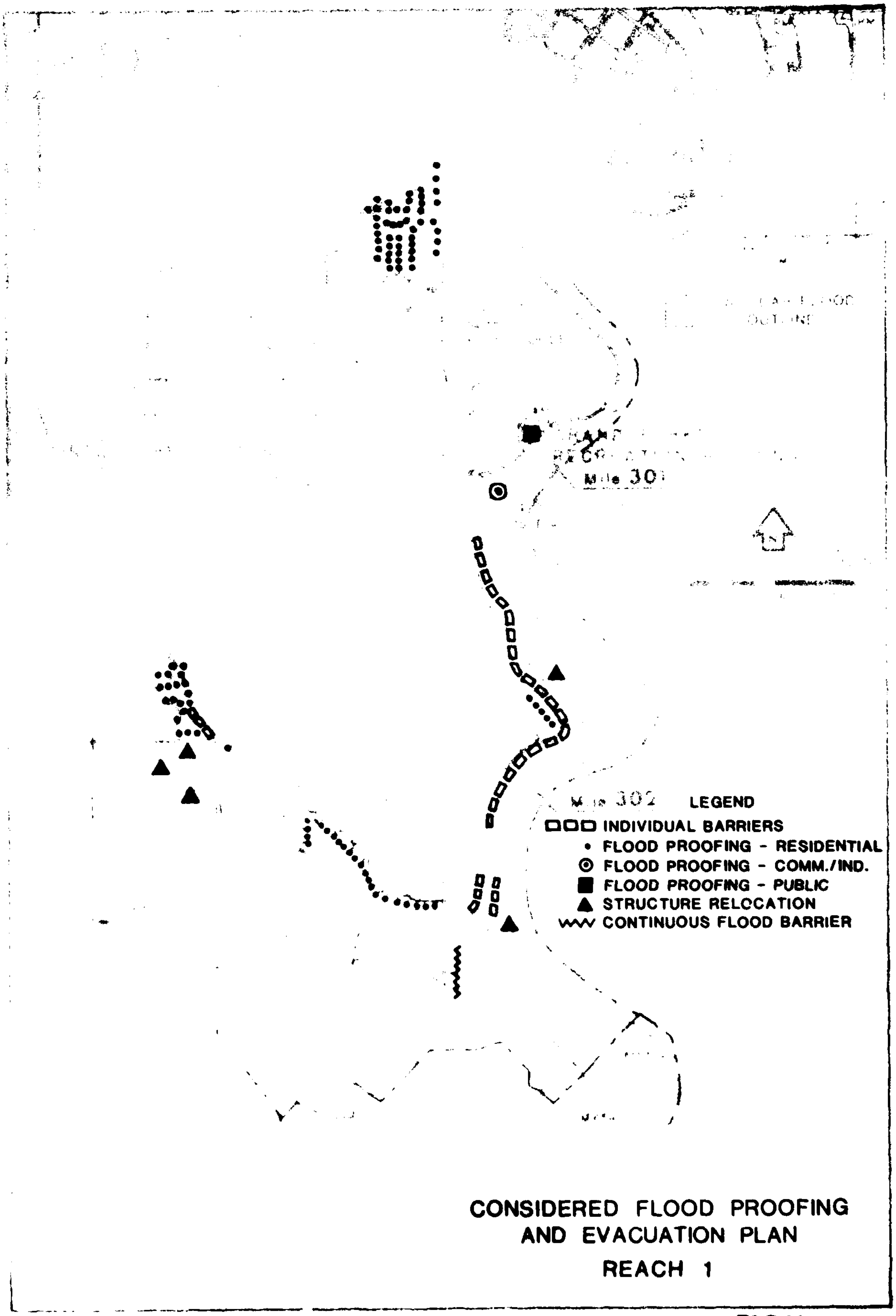

Mile 301
Mile 302
LEGEND
INDIVIDUAL BARRIERS
FLOOD PROOFING - RESIDENTIAL
FLOOD PROOFING - COMM./IND.
FLOOD PROOFING - PUBLIC
STRUCTURE RELCCATION
CONTINUOUS FLOOD BARRIER
CONSIDERED FLOOD PROOFING
AND EVACUATION PLAN
REACH 1

FIGURE 13

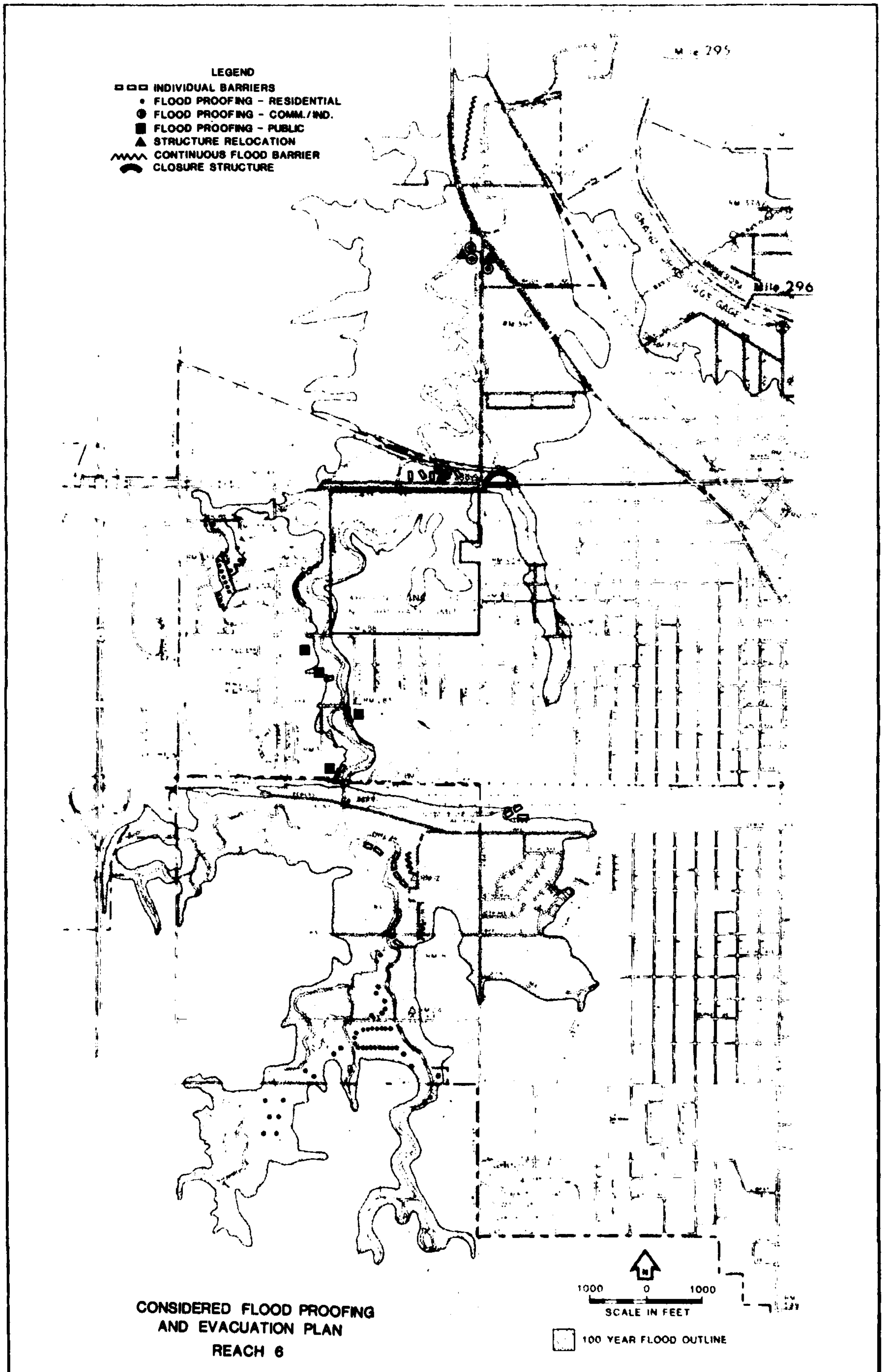

LEGEND
INDIVIDUAL BARRIERS
FLOOD PROOFING - RESIDENTIAL
FLOOD PROOFING - COMM./IND.
FLOOD PROOFING - PUBLIC
STRUCTURE RELOCATION
CONTINUOUS FLOOD BARRIER
CLOSURE STRUCTURE
Mile 295
Mile 296
1000 0 1000
SCALE IN FEET
100 YEAR FLOOD OUTLINE
CONSIDERED FLOOD PROOFING
AND EVACUATION PLAN
REACH 6

FIGURE 14

- Raise Belmont Road to prevent overtopping by Red River floodwaters - The road would be raised between 13th and 17th Avenues South. The maximum practical raise would provide about a 50-year level of protection.

- Flood barriers in Reach 6 - This alternative was dismissed as impracticable and economically unjustifiable. There is insufficient room for Corps-standard levees, and barriers would be too costly given the relatively low density of development.

Table 3 summarizes the results of the economic analyses of the alternatives for the levels of protection considered in stage 3. The only structural measure which appears economically justifiable is the Lincoln Park levee/floodwall raise. However, current policy would not permit Corps involvement in a permanent structural project providing such a low degree of protection to an urban area. The potential for catastrophe, including possible loss of life, is considered too high. If a flood exceeds the level of protection of such a project, the sudden deluge of floodwaters could cause more damages than the slow rise of floodwaters under natural conditions. Furthermore, a permanent project can give an impression of total protection and, therefore, encourage residents to remain even during floods exceeding the design capacity of the project, thereby increasing the risk of injury or loss of life.

The English Coulee closure alternative was marginally infeasible, with a benefit-cost ratio of 0.92 at a 100-year level of protection. Furthermore, the maximum freeboard at this level of protection was less than the desired 3 feet. However, this alternative was recommended for further study because improved data on hydraulics, hydrology, topography, flood damages, and impacts from the Soil Conservation Service's proposals could significantly change the feasibility picture.

The two nonstructural measures - flood proofing and evacuation in Reaches 1 and 6 - also warrant further consideration. In Reach 1, the benefit-cost ratio exceeds 1.0 below the 50-year level of protection. In Reach 6, the benefit-cost ratio is well above 1.0 up to and beyond the 100-year level of protection.

Table 3 - Summary of results of economic analyses

Item	Lincoln Park flood barrier raise	Riverside Park flood barrier: Levee/floodwall	Riverside Park flood barrier: All levee	English Coulee closure structure	Grand Marais coulee diversion	Evacuation and flood proofing Reach 1	Evacuation and flood proofing Reach 6	Belmont Coulee closure structure	Belmont Road raise
25-year protection:									
Total first cost	NA	NA	NA	$1,068,000	NA	$20,000	$117,000	NA	NA
Total annual cost				74,500		1,700	8,400		
Average annual benefits				26,000		12,000	47,000		
Benefit-cost ratio				0.4 (2)		7.1	5.6		
50-year protection:	(1)								
Total first cost	$387,000	$2.595.000	$3,597,000	$1,187,000	$28,798,000	$431,000	$463,000	NA	$284,000
Total annual cost	27,000	192,900	262,100	82,600	1,989,000	31,800	32,[illegible]0		19,800
Average annual benefits	36,900	59,000	59,000	49,000	344,000	31,000	83,000		10,000
Benefit-cost ratio	1.4 (2)	0.3 (2)	0.2 (2)	0.6 (2)	0.2 (2)	0.97	2.5		0.5 (2)
100-year protection:									
Total first cost	NA	$3,643,000	$4,467,000	$1,351,000	$36,314,000	$2.596.000	$1,173,000	$692,000	NA
Total annual cost		269,800	327,500	93,900	2,503,000	182,900	81,800	50,000	
Average annual benefits		88,000	88,000	86,000	421,000	58,000	125,000	25,000	
Benefit-cost ratio		0.3	0.3	0.92	0.2	0.3	1.5	0.5	

(1) Maximum level of protection with 3 feet of freeboard is 47 years.

(2) Current policy precludes Corps participation in a permanent urban structural flood control project with this degree of protection.

The environmental and social impacts of the flood proofing and evacuation alternatives are minor. Relatively few structures would be removed; therefore, social disruption would be insignificant and impacts in any relocation areas would be minimal. Impacts from the English Coulee closure would be minor - no relocations would be needed, and the closure location was previously disturbed.

The flood barrier alternatives would involve removal of 2 to 22 homes, the latter a significant adverse social impact. However, environmental impacts would be minimal because the lands are already developed or used for emergency flood works. The Grand Marais Coulee diversion scheme would result in serious environmental degradation. The routing of larger flows and/or major channel modifications would probably destroy a significant share of the coulee's natural habitat.

The need for a flood emergency plan of action for Grand Forks was clear; much of the city is and will continue to be subject to recurring flood threats and must rely on emergency flood fighting. Therefore, the Corps-sponsored development of a flood fight manual, entitled Flood Emergency Plan for Grand Forks, North Dakota (published as a separate urban study document). This manual was a joint effort by the Corps, its consultant for flood-related investigations in the urban study, and a task force appointed by the mayor. Its objective was to improve the city's preparedness and effectiveness during flood fights. The manual covers:

- Coordination between local, State, and Federal agencies involved in the flood fight or postflood assistance efforts.
- The city's flood fight organization and emergency operations center.
- The flood threat - water surface profiles, flooded area outlines.
- Existing flood works - permanent and emergency flood barriers.
- Preflood preparations - training, inspections, maintenance, stockpiling.
- Flood fighting - mobilizing city resources and volunteers, raising flood barriers, dike patrols, citizen self-help plans.

- Contingency plans for emergencies - evacuation procedures and routes.
- Postflood activities - cleanup, damage assessments.

The Corps also sponsored development of pamphlets and a narrated slide program (describing the flood fight plan) the city could use as a public education tool.

Recommendations from the stage 3 flood control studies regarding further investigations were directed to Corps higher authorities:

- The following alternatives should be studied in greater detail to determine the feasibility of Federal involvement:
  - Reach 1 - Combined flood proofing and evacuation.
  - Reach 6 - English Coulee closure.
  - Reach 6 - Combined flood proofing and evacuation.
- The feasibility of increasing the flow capacity of the Burlington Northern railroad bridge crossing English Coulee near DeMers Avenue should be analyzed.
- The above studies should be conducted under the Corps' small flood control project continuing authority. (This authority - Section 205 of the 1948 Flood Control Act, as amended - offers a quicker path to potential construction than a standard feasibility study.)

Recommendations were also directed to local interests regarding what they might do with a reasonable investment to significantly reduce flood susceptibility. Structural measures recommended for consideration included some found economically unjustifiable using Corps design criteria, but which might be built by the city with modifications to cut costs (for example, handling interior drainage with portable pumps instead of a permanent pumping station). Nonstructural measures were generally aimed at improving floodplain controls, emphasizing flood insurance, and maintaining the city's flood fight capabilities.

- Consider constructing a closure structure at the Belmont Road crossing of Belmont Coulee.
- Consider raising Stanford Road near Highway 2 to prevent backwater flooding from the English Coulee.
- Consider raising Belmont Road between 13th and 17th Avenues South.
- Consider relocating the Lincoln Park recreation building.

Urban Drainage Studies

Urban drainage studies were undertaken at the request of Grand Forks officials for assistance in developing an urban drainage master plan to help combat the tendency for continuing urban development to generate increased runoff. The study covered the 1980-2030 time frame and the area out outside the sewered portion of the city and within the city's land use zoning jurisdiction (which extends 2 miles beyond the city limits) plus an additional 1 mile south into the rapidly developing area between Interstate 29 and the Red River (figure 15).

Two drainage system options were developed. Both assumed two changes in the existing drainage pattern (figure 16) to reduce the runoff reaching the urbanized portion of English Coulee:

- Completion of a planned diversion structure by the Grand Forks County Water Management and Control Board to route part of the flow from the upper part of the coulee's watershed around Grand Forks.

- Construction of a 3 1/4-mile west-east ditch along 47th Avenue South.

Option A (figure 17) differs from Option B (figure 18) in that Option B includes runoff ponding areas, whereas Option A assumes direct runoff into storm sewers and ditches and thence to English Coulee and the Red River. Option B's temporary runoff storage would reduce peak discharges; therefore, this option can use smaller sewers than those needed with Option A. The temporary storage areas would be sized to keep runoff peaks with 2030 development at current rates.

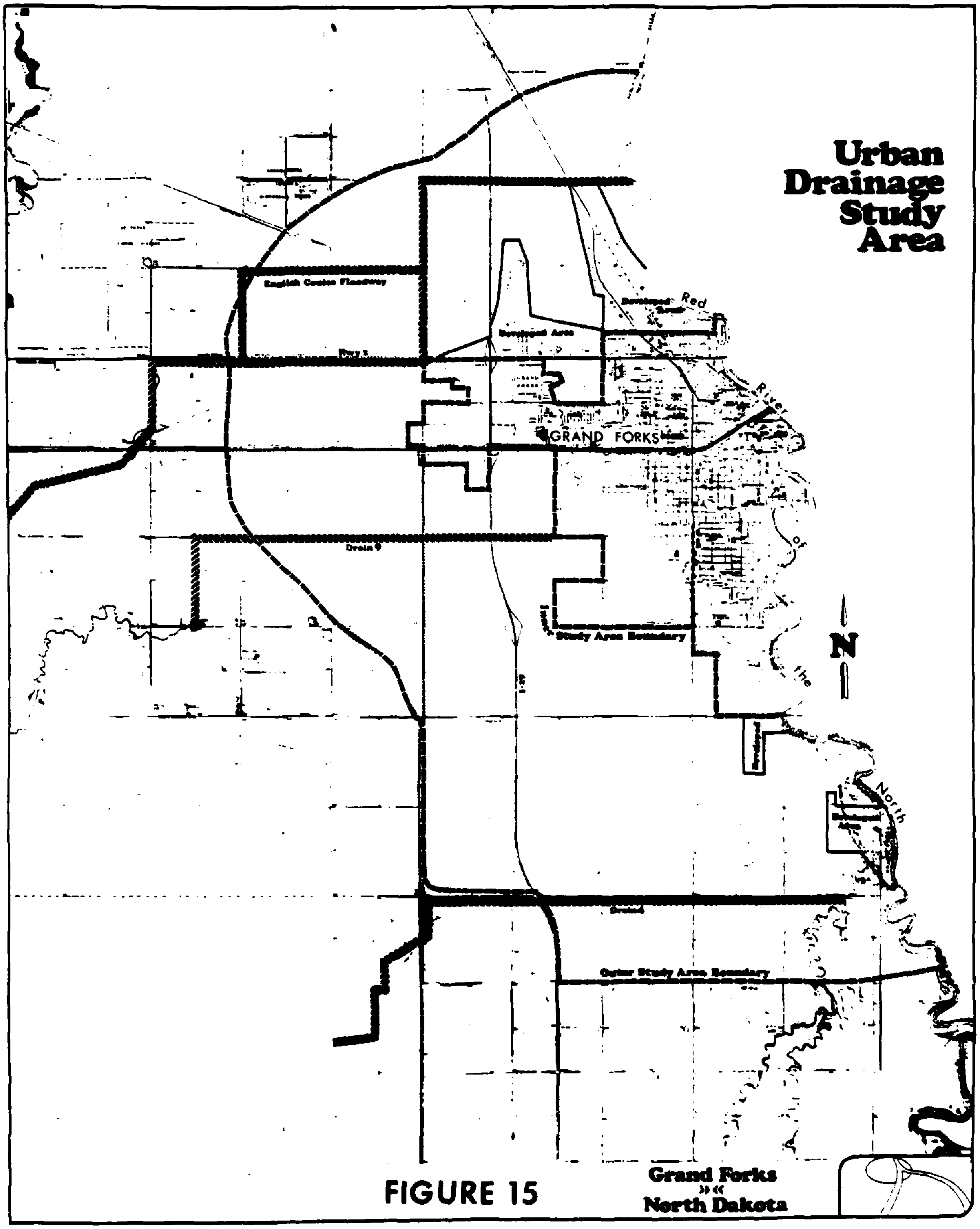
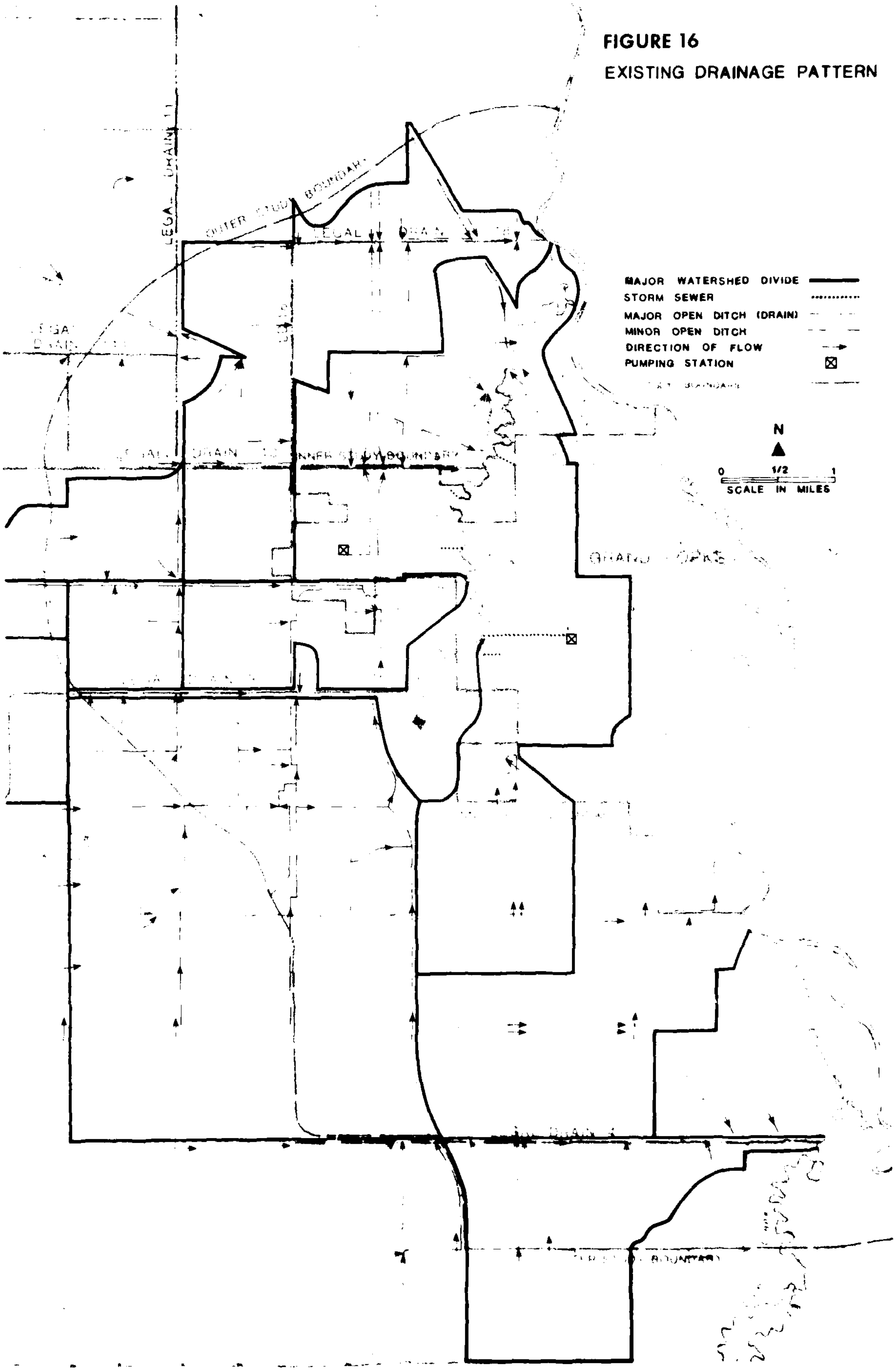

Urban
Drainage
Study
Area
Drain 9
GRAND FORKS
Red
River
of
the
North
Study Area Boundary
Outer Study Area Boundary
N
Grand Forks
North Dakota

FIGURE 15

FIGURE 16

EXISTING DRAINAGE PATTERN



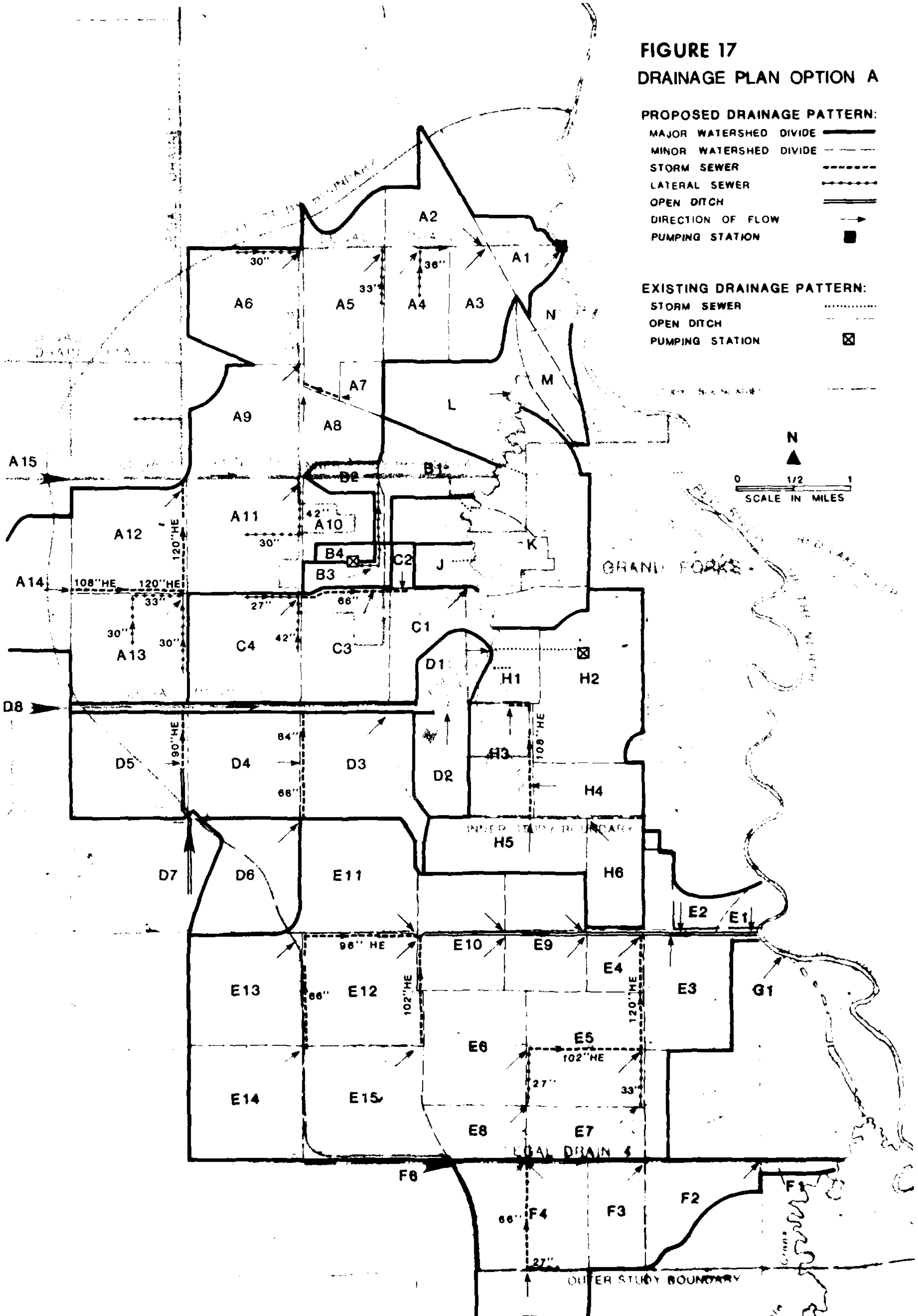


FIGURE 17
DRAINAGE PLAN OPTION A

Figure 18 shows a conceptual view of Option B; the actual location, size, and shape of the temporary storage areas would be determined by detailed case-by-case studies as implementation became necessary. Storage areas could be combined as long as the volume of the single area equaled or exceeded the sum of the individual volumes. Dual-purpose storage areas could be developed, such as depressed parking lots or ball fields. In some cases, permanent ponds with extra capacity for the required storage might be preferable for aesthetic purposes. Option B gives the city flexibility in land use zoning; the eventual development can be selected on the basis of criteria other than the effect on runoff because the storage areas keep peak runoff from changing.

Construction of the storage areas could be deferred until development took place, thereby spreading out the economic impact. The developers would be responsible for providing the storage areas, but would benefit from smaller assessments from the city because of the smaller sewers needed with Option B.

The urban drainage report recommended combining the outlets of Legal Drain 18 and English Coulee (figure 16) and constructing a closure structure/pumping station to prevent backwater flooding from high Red River stages. (This plan is similar to the English Coulee closure alternative developed independently during the flood control studies.) A facility could first be constructed near the mouth of the coulee; at a later date, when development along Legal Drain 18 became intensive enough to warrant protection, the mouth of the legal drain could be plugged, a ditch dug to divert the legal drain's flow into the coulee, and the pumping capacity increased accordingly.

FIGURE 18
DRAINAGE PLAN OPTION B

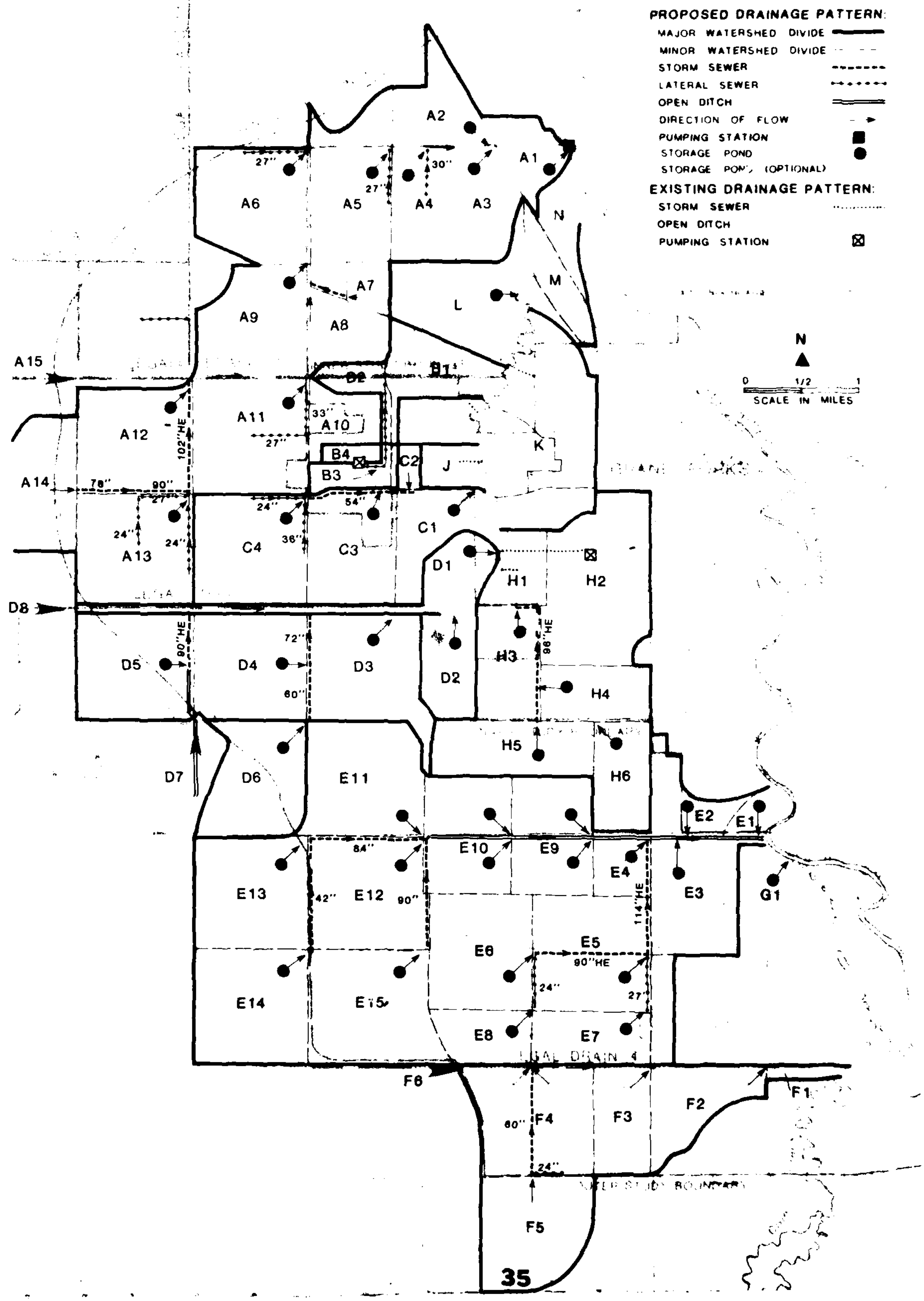


Table 4 summarizes cost estimates for the two options. These costs do not reflect the city's costs for administering the urban drainage program. Nor are the developers' costs for Option B's storage areas shown. The latter costs are difficult to estimate because they are so dependent on the type of storage facility and site-specific characteristics. Also, the schemes being considered for controlling runoff from the upper part of the English Coulee's watershed will have major impacts on the urban drainage picture and could significantly affect the cost estimates.

Table 4 - Summary of urban drainage cost estimates

Item	Cost Option A	Cost Option B
First costs:		
47th Avenue South ditch	$730,000	$647,000
Storm sewers	18,366,000	13,784,000
Closure structure/pumping station	5,220,000	3,916,000
Contingencies	6,890,000	5,186,000
Engineering	3,445,000	2,593,000
Total	34,651,000	26,126,000
Annual costs:		
Interest and amortization at 6 7/8 percent and 50 years	2,471,000	1,863,000
Operation and maintenance	29,000	24,000
Total	2,500,000	1,887,000

Option B, because of its storage areas, would have greater construction impacts (soil erosion, turbidity, dust, noise, loss of trees, etc.) than Option A. Conversely, Option B has the potential for much greater long-term environmental/social enhancement (for example, if the storage areas are developed in association with parks and recreation areas).

Because of its greater cost effectiveness, flexibility, and recreational and aesthetic potential, Option B was recommended for implementation as the city's urban drainage master plan.

WATER SUPPLY

PROBLEMS, NEEDS, AND CONCERNS

Major communities in the study area depend on the Red and Red Lake Rivers for water supply. Smaller communities and rural residents rely on groundwater supplied by individual wells and three rural water supply associations. The stage 2 study recommended that these associations and other self-supplied water users continue to furnish their own water rather than join a regionalized system. In stage 3, the urban study focused on Grand Forks, East Grand Forks, and the Grand Forks Air Force Base (which gets its water from Grand Forks).

Urban water demand projections through the year 2030 were based on analyses of current demands, interviews with major water users, projections of population and land uses, and assumptions regarding improved industrial efficiencies, increased agricultural processing, and new industries. Projected average day demands were used to evaluate water sources and estimate treatment plant operation and maintenance costs. Projected maximum day demands were used to size water treatment and transmission facilities.

Grand Forks' and East Grand Forks' municipal water supply systems are interconnected so that in an emergency water could be transferred between the cities. Grand Forks draws its raw water from both the Red and Red Lake Rivers. East Grand Forks has an intake only on the Red Lake River; a proposal to increase the reliability of the city's raw water supply by adding an intake on the Red River has not been acted on.

Both rivers have low-head dams - the Red River at Riverside Park and the Red Lake River near its confluence with the Red River. The pools behind these dams store raw water in the channel, serving a critical need when droughts reduce river flows below those required by the cities and water users downstream. These dams need periodic maintenance and replacement; recent repairs to the Red River dam have extended its useful life to 1990.

The Grand Forks water treatment plant capacity is 12 mgd (million gallons per day), a figure which has been reached by the maximum day demand. Plant expansion is needed to handle any future growth in demand. However, the plant is located in a completely built-up area and major expansion would require removal of adjacent housing or plant location at a new site.

The East Grand Forks water treatment plant's rated capacity of 4 mgd cannot be reached until an operating problem at rates exceeding 3 mgd is corrected. Since the present maximum day demands are about 2 mgd, this problem has not been a major concern as yet. The maximum day demand is projected to reach 4 mgd about 2005 by which time the plant will have to be operating 24 hours per day compared to the present 8 to 10 hours per day. Undeveloped land adjacent to the plant could be used for expansion.

Additional items of concern included:

- Adequacy of existing raw water sources - The cities' demands are expected to more than double by 2030. Similarly, other water users in the Red and Red Lake River basins will also be withdrawing more water from these sources. Can these rivers or other potential sources meet all these demands?

- Adequacy of existing water treatment processes - National standards for drinking water quality have been enacted in accordance with the Safe Drinking Water Act (Public Law 93-523). In addition, the Environmental Protection Agency is considering regulations that would require advanced water treatment to remove organic chemical contaminants. The North Dakota and Minnesota Health Department believe that organic chemical contaminants are not a problem in the study area and that most organic contaminants could be removed during the pretreatment process. However, if the proposed regulations are made more stringent, advanced water treatment might have to be added.

- Adequacy of major water transmission lines - Existing transmission lines serving the two cities are adequate, provided they are maintained properly and replaced on a regular basis. The single line delivering Grand Forks' water to the Air Force Base, however, is not reliable as exemplified by a history of breaks and leaks.

DEVELOPMENT AND EVALUATION OF ALTERNATIVES

Raw Water Source

Three potential sources to increase water supply were considered in detail in stage 3:

- Garrison Diversion water augmenting Red River flows.
- Groundwater from area aquifers.
- Red and Red Lake River surface waters, including in- and off-channel storage.

In addition, water conservation was evaluated as a means of reducing demand.

The multipurpose Garrison Diversion project is designed to divert Missouri River water into central and eastern North Dakota. The water would be used for irrigation, municipal and industrial water supply, recreation, and fish and wildlife purposes. The original plan was reduced in scope because of fears related to environmental effects from the quantity and quality of return flows. The revised plan would transfer water to the Sheyenne River, which is a tributary of the Red River. This water would eventually enter Canada, which is very concerned about the possible interbasin transfer of biota and the impacts on fisheries and wildlife.

The efforts of environmental interests and Canada have delayed major progress on the project for several years. In May 1981, a U.S. District judge ruled that the Federal and State Governments could not proceed with construction until Congress reauthorized the plan. It is unlikely that this project will be completed in the near future. Therefore, the Garrison Diversion project was not considered a viable source of water for the study area.

Groundwater is available in the study area's vicinity from bedrock and overlying glacial drift deposits. However, most aquifers are not satisfactory urban water sources because of quality or quantity problems. Bedrock aquifers in the area are unsuitable because of low well yields, small storage volumes, and highly mineralized water.

Three glacial drift aquifers (figure 19) - the Elk Valley, Inkster, and Beach Ridge aquifers - contain relatively good quality water. The mean annual precipitation in this region is about 20 inches, only about 2 inches of which recharge the glacial drift aquifers. Therefore, to satisfy the 2030 projected municipal water demand, approximately 175 square miles of recharge area would be needed to prevent "mining" water.

The Inkster aquifer was rejected because of its small storage volume and recharge area; it is already being used by a rural water district and local farmers. The Elk Valley aquifer is the best groundwater source near the study area. However, the aquifer's storage is too small to prevent mining and over 85 percent of the aquifer would be required to meet the urban area's projected water demands without mining. This aquifer is the sole supply for the cities of Larimore and Northwood, North Dakota, and numerous farmers get their domestic, livestock, and irrigation water from this aquifer. The North Dakota State Water Commission has serious reservations over allowing the Grand Forks-East Grand Forks urban area use of the Elk Valley aquifer. It was concluded that this aquifer could not be used to meet the urban area's projected demands, and its use as a supplemental or partial supply was rejected because of the high costs for the well field and 30 to 35 miles of transmission pipelines.

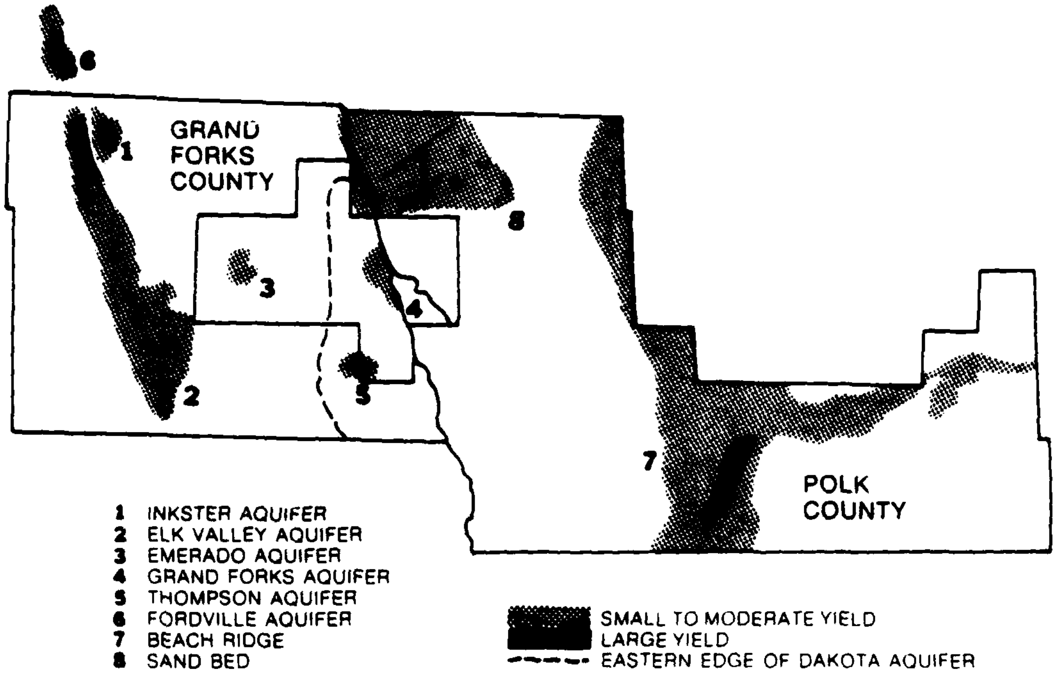


FIGURE 19 - Major Glacial Drift Aquifers, Grand Forks and Polk Counties

The Beach Ridge aquifers in Polk County were also evaluated. These aquifers are fairly good sources; the city of Crookston, Minnesota, is converting from Red Lake River water to Beach Ridge groundwater. However, the same constraints that applied with the Elk Valley aquifer - low recharge rate, transmission distance (about 40 miles), and existing water users - make the Beach Ridge aquifers unsatisfactory sources for the urban area.

Elimination of the Garrison Diversion project and nearby aquifers as viable sources of raw water left only the Red and Red Lake Rivers as possible sources. Fortunately, analyses showed these rivers could meet the urban area's needs.

The flows of these rivers have been significantly altered by reservoirs constructed since 1930:

- Red Lakes Reservoir on the Red Lake River. The control structure built in 1931 was replaced in 1952.
- Orwell Reservoir on the Ottertail River was completed in 1953.
- Lake Ashtabula (Baldhill Dam) on the Sheyenne River was completed in 1950.

A detailed low-flow analysis examined the flows in the Red and Red Lake Rivers in relation to the urban area's projected 2030 water demands and flow requirements downstream. The computerized analysis simulated existing reservoir operations and used projected basin-wide withdrawals and return flows. In this manner, the need for supplemental in- or off-channel storage during the selected design event - a 50-year drought - could be determined.

The analysis showed that the Red River would experience flow shortages for approximately 29 days during the 50-year design drought; the Red Lake River would experience about 9 months of flow deficiency during this drought. Table 5 summarizes the storage requirements for droughts of various severities to meet the cities' 2030 water demands (plus 10 percent for contingencies and an allowance for evaporation losses from the in-channel pools provided by the low-head dams).

Table 5 - In-channel storage needs

River	City	Drought return frequency (years)	Flow deficiency duration (days)	Total storage required (ac-ft)
Red	Grand Forks	20	17	240
		50	29	500
		100	35	630
Red Lake	East Grand Forks	20	186	800
		50	270	970
		100	450	1,330

Available in-channel storage behind the Red River and Red Lake River low-head dams was estimated to be 2,200 and 1,000 acre-feet, respectively. Therefore, Red Lake River flows supplemented by the existing in-channel storage can satisfy East Grand Forks' 2030 water demands with the design 50-year drought; a 100-year drought would require an additional 300 acre-feet, which would be available if a backup intake was constructed in the Red River pool. The Red River pool alone can meet the combined 2030 demands of the two cities even with a 100-year drought.

The existing in-channel storage is drawn upon during droughts as frequent as the 10-year event. Therefore, although the analysis showed no additional in- or off-channel storage is needed, it is imperative to retain the existing storage via conscientious maintenance and periodic replacement of the low-head dams.

Water Conservation

Water conservation reduces peak demands and/or total water use, thereby extending the lives of water sources and treatment facilities, reducing operating costs, and reducing capital investments for future expansions. Water conservation measures may be adopted on a permanent basis or used only during drought emergencies. Five basic techniques were considered:

- Reductions in treatment plant and distribution system losses.
- Public education programs.
- Ordinances mandating water use reductions.
- Pricing changes discouraging waste.
- Industrial water conservation.

The East Grand Forks plant could reduce its current losses, estimated to be about 15 percent of the raw water entering the plant. The Grand Forks plant's losses are minimal. The urban area experiences a relatively low 5 to 10 percent unaccounted for loss from the distribution systems. The communities should improve existing programs, including water main replacement, leak detection, and meter maintenance.

Public awareness and education programs promote personal and community participation in water conservation. The limited availability of water and the economic benefits of reduced capital and operating costs can be stressed. These programs can be carried out through the schools, news media, water bill inserts, pamphlets, etc.

Residential programs can reduce leakage (mostly from worn out faucet washers and toilet tank valves), which accounts for 5 to 10 percent of all residential consumption. Water-saving devices retrofitted into existing fixtures (for example, toilet tank dams and shower head flow restrictors) can reduce residential water use up to 20 percent.

Ordinances can reduce peak demands and/or total water use. Peak demand can be reduced by regulating the schedule of uses (for example, lawn watering and car washing). Total water use can be reduced via plumbing codes requiring water-saving fixtures.

Pricing systems include the declining block rate (unit price decreases as total use increases), uniform rate, increasing block rate, and peak load rate. Both Grand Forks and East Grand Forks use the declining block rate, which does not encourage water conservation.

Industrial water conservation could reduce industrial water use about 10 to 20 percent, equivalent to 3 to 6 percent of the total urban area's use. For example, American Crystal Sugar has indicated that production at the East Grand Forks plant could be doubled without increasing water consumption.

Table 6 lists various water conservation measures and their respective advantages and disadvantages. A comprehensive, effective water conservation program could reduce average and maximum day demands about 8 and 10 percent, respectively. Thus, water conservation could:

Table 6 - Methods of urban water conservation implementation, advantages, and disadvantages

Techniques to Reduce Water Consumption	Implementation	Advantages	Disadvantages
Leak detection and repair of water agencies' distribution systems.	Institutional	1. Reduces unaccounted water losses. 2. Reduces undermining damage to streets, sidewalks, and other structures.	1. Because leaking water [illegible] to the ground water, water agencies sometimes ignore losses 2. Low cost of lost water may not equal cost of detection and repair.
Leak detection and repair of consumers' systems.	Voluntary Institutional	1. Can reduce other home repair costs such as those from wood rot. 2. Many leaks simple and inexpensive to repair. 3. Reduces operational costs.	1. Difficult to induce flat-rate consumers and apartment dwellers to repair leaks 2. Could be expensive to consumer if he needs professional service
Education	Voluntary Mandatory Institutional	1. Induces voluntary water conservation. 2. Changes long established, wasteful consumer habits. 3. Achieves long-lasting results by influencing younger generation. 4. Ensures greater success and acceptance of other water saving means.	1. Effective program requires coordinated efforts of local and state agencies
Efficient irrigation using automatic devices	Voluntary	1. Healthier plants. 2. Decreased maintenance. 3. Mechanical type savings.	1. Periodic adjustments required 2. Expensive initial cost.
Native and other low-water-using plants in landscaping.	Voluntary Institutional	1. Established native and other low-water-using plants need little or no irrigation. 2. Established plants need little care.	1. General preference for exotic plants 2. Narrow selection of native plants in nurseries 3. Difficult to establish some low-water-using plants and general lack of knowledge on care. 4. Somewhat higher costs because native and other low-water-using plants are not readily available.
Modification (retrofit) of existing plumbing fixtures	Mandatory Voluntary Institutional	1. Many devices are nominal in cost. 2. Enables water and energy conservation in existing facilities and therefore has potential rapid, widespread savings. 3. Water savings mechanically effected 4. Reduces wastewater conveyance and treatment load.	1. Inconsistent effectiveness of retrofit devices because of variable design and construction of existing fixtures. 2. Consumer removal or tampering with retrofit devices because of suspected poor performance 3. Some devices require skilled installation and/or follow-up adjustment. 4. May cause blockage problems in marginal sewage collection systems.
Water saving plumbing fixtures in new and replacement construction.	Mandatory	1. Mechanical devices render savings despite user habits. 2. Reduce wastewater conveyance and treatment load.	1. Possible resistance to redesign and retooling to manufacture water conserving devices. 2. Drain pipe slope tolerances are more critical 3. Initially, consumers may resist acceptance 4. Initially, higher unit cost of water saving devices until demand increases production and reduces cost. 5. May cause blockage problems in marginal sewage collection systems.
New technology	Voluntary Institutional	1. Greater water and energy savings than conventional designed devices. 2. Reduce wastewater conveyance and treatment load.	1. Uncertain long-term effectiveness. 2. Consumer and institutional resistance to innovations. 3. Higher initial costs. 4. Conformance with existing codes and regulations, may require changes or variations. 5. May cause blockage problems in marginal sewage collection systems.
Metering	Institutional	1. Easier to implement than some of the other suggested methods. 2. May induce consumers to begin conserving water.	1. Consumer objection. 2. High capital cost. 3. Requires changes in rate structure and billing procedure.
Sewer service charges based on water consumption	Institutional	1. More equitable than flat-rate basis to pay operational cost of sewage treatment. 2. Achieve dual benefits of reduced water consumption and wastewater flow.	1. Requires well designed rate structure. 2. Need to segregate inside and outside water consumption.
Pricing	Institutional	1. May be relatively easy to implement. 2. Can affect all customers. 3. Can be strong inducement to effect consumer savings.	1. Consumer objection. 2. Requires well designed pricing structure to achieve effective, equitable pricing. 3. Often require changes in rate structure, meter reading, and billing procedures.

- Reduce 2030 total water use about 1.3 mgd, equivalent to the demands of about 13,000 people.
- Reduce the 2030 water treatment plant design capacity by 10 percent (3 mgd), thereby reducing capital and operating costs.
- Extend the life of the existing East Grand Forks plant to 2015, 10 years beyond current projections.

Water Supply Alternatives

Each alternative has four components corresponding to the selected raw water source, water treatment method, use of water conservation, and use of separate Grand Forks and East Grand Forks treatment plants and transmission systems or a combined system implemented in 1990 or 2005. The following four-part numbering system was devised to identify each alternative:

- Water supply sources

  I Surface water from the Red and Red Lake Rivers.
  II Garrison Diversion water.
  III Groundwater.

- Water treatment to meet. . .

  A Interim primary drinking water standards.
  B Proposed advanced drinking water standards.

- Water conservation

  1 Without water conservation.
  2 With water conservation

- Separate or combined systems

  a Separate systems
  b Combined system constructed in 2005.
  c Combined system constructed in 1990.

It was shown earlier that the only viable raw water sources were the Red and Red Lake Rivers; therefore, only I-type alternatives were evaluated in detail. Also, it was assumed that:

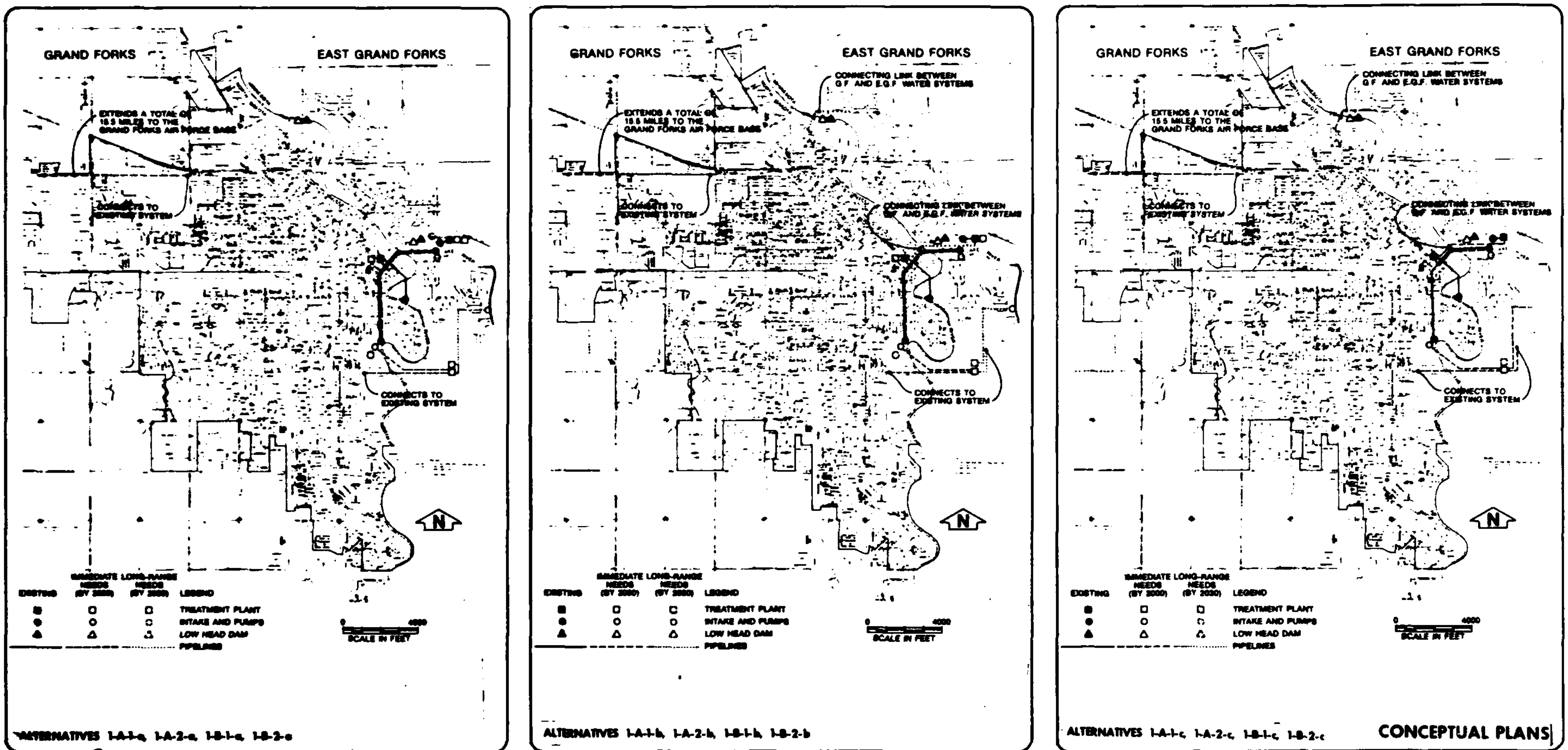
- Grand Forks would continue to furnish water to the Air Force Base and that a second transmission line would be installed to improve the reliability of this service.

- Self-supplied industries and rural water districts would continue to meet their own needs.

- The Grand Forks treatment plant capacity would be increased immediately.

Figure 20 shows the resulting conceptual plans. Table 7 shows the equivalent annual costs, which cover interest on and amortization of the capital investment (at 6 7/8 percent), plus operation, maintenance, and minor replacement costs, less an allowance for salvage value. This table shows the most economical alternative to be a combined system in 2005 regardless of treatment process or use of water conservation. As expected, it is less expensive to meet interim drinking water standards than advanced drinking water standards; however, if the proposed or more stringent advanced standards are adopted and monitoring shows unacceptable levels of organic contaminants, then advanced treatment will be necessary. Water conservation reduces treatment/transmission facility capital and operating costs, hence table 7's costs. However, costs for implementing conservation measures were not factored into the table's figures. Therefore, with and without conservation costs cannot be compared directly.

Table 8 shows the year, purpose, and amount of major capital expenditures for the four alternatives based on combining the cities' systems in 2005. Table 9 displays the environmental, social, and economic impacts of the alternatives considered. The top matrix compares the "no action" alternative to those meeting advanced drinking water standards or using water conservation. The bottom matrix compares the "no action" alternative to those with separate or combined treatment facilities.



CONCEPTUAL PLANS

FIGURE 20

Table 7 - Equivalent annual cost summary

Alternative	Cost
I. Surface water[1]	
A. Interim primary drinking water standards	
1. Without water conservation	
a. Separate systems	$4,460,000
b. Combined system constructed in 2005	4,400,000
c. Combined system constructed in 1990	4,830,000
2. With water conservation	
a. Separate systems	4,170,000
b. Combined system constructed in 2005	4,070,000
c. Combined system constructed in 1990	4,330,000
B. Proposed advanced drinking water standards	
1. Without water conservation	
a. Separate systems	5,320,000
b. Combined system constructed in 2005	5,210,000
c. Combined system constructed in 1990	5,820,000
2. With water conservation	
a. Separate systems	4,970,000
b. Combined system constructed in 2005	4,820,000
c. Combined system constructed in 1990	5,100,000

[1] Alternatives using Garrison Diversion project water and groundwater were not developed in detail.

Table 8 - Major capital costs with year 2005 combined facility alternatives

Alternative	Facility	Year	Item	Cost
I-A-1-b	Grand Forks	1990	Refurbish existing 12-mgd treatment plant	$4,970,000
	East Grand Forks	1990	Refurbish existing 4-mgd treatment plant	3,120,000
	Shared facilities	1980	New 6-mgd treatment plant and land	9,670,000
		1980	New supply for 6-mgd pumping	1,569,000
		1990	Replace Red River of the North low-head dam	2,510,000
		1990	Replace Red Lake River low-head dam	3,140,000
		2005	Relocate GF/EGF treatment facilities to new site	
		2005	Expand supply to 30 mgd (RRN and RLR)	2,228,000
		2005	New 30-mgd treatment plant	31,300,000
	Grand Forks Air Force Base	1980	Second transmission line	6,290,000
I-A-2-b	Grand Forks	1990	Refurbish existing 12-mgd treatment plant	5,050,000
	East Grand Forks	1990	Refurbish existing 4-mgd treatment plant	3,000,000
	Shared facilities	1980	New 4-mgd treatment plant and land	7,650,000
		1980	Supply for 4-mgd pumping (RRN)	1,552,000
		1990	Replace RRN low-head dam	2,510,000
		1990	Replace RLR low-head dam	3,140,000
		2005	Relocate GF/EGF treatment facilities to new site	
		2005	Expand supply to 26-mgd (RRN and RLR)	2,024,000
		2005	New 26-mgd treatment plant	27,900,000
	Grand Forks Air Force Base	1980	Second transmission line	6,290,000
I-B-1-b	Grand Forks	1990	Refurbish existing 12-mgd treatment plant	$6,510,000
	East Grand Forks	1990	Refurbish existing 4-mgd treatment plant	3,990,000
	Shared facilities	1980	New 6-mgd treatment plant and land	12,700,000
		1980	Supply for 6-mgd pumping (RRN)	1,569,000
		1990	Replace RRN low-head dam	2,510,000
		1990	Replace RLR low-head dam	3,140,000
		2005	Relocate GF/EGF treatment facilities to new site	
		2005	Expand supply to 30 mgd (RRN and RLR)	2,228,000
		2005	New 30-mgd treatment plant plant	40,700,000
	Grand Forks Air Force Base	1980	Second transmission line	6,290,000
I-B-2-b	Grand Forks	1990	Refurbish existing 12-mgd treatment plant	6,500,000
	East Grand Forks	1990	Refurbish existing 4-mgd treatment plant	3,980,000
	Shared facilities	1980	New 4-mgd treatment plant plant and land	10,000,000
		1980	Supply for 4-mgd pumping (RRN)	1,552,000
		1990	Replace RRN low-head dam	2,510,000
		1990	Replace RLR low-head dam	3,140,000
		2005	Relocate GF/EGF treatment facilities to new site	
		2005	Expand supply to 26 mgd (RRN and RLR)	2,024,000
		2005	New 26-mgd treatment plant	35,900,000
	Grand Forks Air Force Base	1980	Second transmission line	6,290,000

Table 9

IMPACT ASSESSMENT OF WATER SYSTEM DESIGN CONDITION ALTERNATIVES

Impact	No Action[1]	Advanced Standards	With Conservation
Environmental			
Land	No effect.	Minimal.	Minimal.
Man-made Resources	No effect.	No effect.	No effect.
Natural Resources	No effect.	Increased chemical & energy requirements.	Decreased consumption use will increase streamflow. Decreased chemical and energy requirements for treatment.
Water Quality	No effect.	No effect.	Enhanced during low flow.
Air Quality	No effect.	No effect.	No effect.
Wildlife	No effect.	No effect.	No effect.
Hydrologic	No effect.	No effect.	Increased streamflow.
Public Health	Higher potential for problems.	Greater protection.	No effect.
Social			
Noise	No effect.	No effect.	No effect.
Displacement of People	No effect.	No effect.	No effect.
Aesthetics	No effect.	No effect.	Decreased due to changed habits.
Community Cohesion	No effect.	No effect.	May change.
Community Growth	No effect.	No effect.	Minimal effect.
Historical & Archaeological	No effect.	No effect.	No effect.
Transportation	No effect.	No effect.	No effect.
Institutional Relationships	No effect.	No effect.	No effect.
Public Acceptance	No change.	Decreased.	Decreased.
Economic			
Property Values	No effect.	No effect.	No effect.
Tax Revenues	No effect.	No effect.	No effect.
Public Facilities & Services	No effect.	No effect.	No effect.
Business & Industrial Activities	No effect.	May be impaired.	May be impaired.
Employment	No effect.	May be impaired.	May be impaired.
Agricultural Land Lost	No effect.	Minimal.	No effect.
Regional Growth	Not constrained.	May be impaired.	May be impaired.

Notes: (1) Includes the design conditions of Interim Primary Drinking Water standards and without water conservation practices.

IMPACT ASSESSMENT OF SEPARATE AND COMBINED SYSTEM ALTERNATIVES

Impact	No Action[1]	Separate Systems	Combined System
Environmental			
Land	No effect.	Will affect about 20 acres of prime agricultural land for new treatment plants.	Will affect about 15 acres of prime agricultural land for new treatment plant.
Man-made Resources	No effect.	No effect.	No effect.
Natural Resources	No effect.	Additional consumptive use; possible adverse effect at low flow; additional chemicals required for treatment.	Additional consumptive use; possible adverse effect at low flow; additional chemicals required for treatment.
Water Quality	No effect.	Possible adverse effect at low flow.	Possible adverse effect at low flow.
Air Quality	No effect.	During construction.	During construction.
Wildlife	No effect.	No effect.	No effect.
Hydrologic	No effect.	Increased consumption use reduces river flow.	Increased consumption use reduces river flow.
Social			
Noise	No effect.	During construction.	During construction.
Displacement of People	No effect.	No effect.	No effect.
Aesthetics	No effect.	May decrease locally due to large building.	May decrease locally due to large building.
Community Cohesion	May be impaired.	No change.	May change.
Community Growth	Impaired.	No constraint.	No constraint.
Historical & Archaeological	No effect.	No known effect.	No known effect.
Transportation	No effect.	During construction.	During construction.
Institutional Relationships	No effect.	No effect.	Will change.
Economic			
Property Values	May be impaired.	No change.	No change.
Tax Revenue	May be impaired.	May increase.	May increase.
Public Facilities & Services	Impaired.	May enhance.	May enhance.
Business & Industrial Activities	Constrained.	No constraint.	No constraint.
Employment	May not increase.	No constraint.	No constraint.
Agricultural Land Lost	No effect.	About 20 acres of prime agricultural.	About 15 acres of prime agricultural.
Regional Growth	Constrained.	No constraint.	No constraint.

Notes. (1) Includes continued use of existing systems, but no expansions for existing water supply and treatment systems.

On the basis of the relative environmental, social, and economic merits of the alternatives considered, adoption of a plan combining the cities' facilities in 2005 is recommended. Other features and details of the plan - for example, type of treatment and use of water conservation - will be determined by regulations and further studies of cost effectiveness.

DROUGHT EMERGENCY PLAN

General

The low-flow analysis showed that the Red and Red Lake Rivers, supplemented by in-channel storage behind the low-head dams, could meet the urban area's projected 2030 water needs during the design 50-year drought. If East Grand Forks had a water intake in the Red River pool, both cities could weather a 100-year drought.

However, in response to serious local concerns about droughts of even greater severity, the Corps sponsored development of a drought emergency plan. The plan includes:

- A step-by-step water demand reduction plan to follow as available supplies dwindle.
- A review of governmental agencies which could provide assistance in a drought.

The lack of viable alternative water sources made water conservation the cornerstone of the drought emergency plan. There are no alternative surface water sources (such as lakes) for drinking water. The wastewater treatment lagoons might be a source of nonpotable water (e.g., for irrigation), but use of these lagoons as sources of potable water is not acceptable to the Minnesota Department of Health at this time. Nearby groundwater sources are generally poor in quality and quantity. Good quality water from the Elk Valley and Beach Ridge aquifers would be very expensive to recover in quantities sufficient to meet a significant share of the urban area's needs. However, during a severe prolonged drought, water from the Elk Valley aquifer would probably be trucked to the urban area to meet critical needs.

Water Demand Reduction Plan

The water demand reduction plan has five stages corresponding to increasingly severe drought conditions (table 10). The first two stages alert the public that drought conditions might worsen and rely on basically voluntary measures to reduce the total water demand. The last three stages consist of mandatory water reduction measures invoked by local governments during more serious droughts. Policing of compliance would be through public support, monitoring water meters, and inspections. A pricing system penalizing excessive water use should be adopted in conjunction with the drought emergency plan.

Agency Assistance

As the capabilities of local governments are exceeded, outside assistance should be solicited. Figure 21 shows at what stage the various agencies (and representatives at the time the plan was developed) should be contacted. Outside agencies can assist via:

- Information such as weather forecasts, streamflow data, and reservoir operations.
- Technical and financial aid, including manpower, supplies, equipment, and funds.

Table 10 - Five-stage water demand reduction plan[1]

Stage	Estimated reduction in demand (percent)	Implementation criteria[2]: When river flow and supplemental storage cannot furnish	or: When water treatment and supply facilities cannot furnish	Steps
A	-	200 percent of demand plus 8 cfs for next 6 months	100 percent of demand	Alert public and local officials of low-flow situation; increase maintenance and monitoring of water treatment and transmission facilities and water uses.
B	≤ 10	150 percent of demand plus 8 cfs for next 3 months	90 percent of demand	A steps plus request residents to reduce consumption to 90 gcd and retrofit water-saving devices; restrict lawn watering, car washing, pool filling.
C	10-40	100 percent of demand plus 8 cfs for next 1 month	60 to 90 percent of demand	B steps plus limit residents to 75 gcd; reduce air conditioning load on buildings using cooling towers; businesses reduce water pressure and close most restrooms; eliminate most lawn watering.
D	40-60	<70 percent of demand plus 8 cfs (Note: storage would be essentially gone)	40 to 60 percent of demand	C steps plus limit residents to 40 gcd; further reduce air conditioning load; businesses serve no water, shut off sinks in public restrooms, wash linens at commercial laundry outside drought area; discontinue lawn watering and car washing.
F	>60	<50 percent of demand plus 8 cfs (Note: storage would be gone)	<40 percent of demand	D steps plus limit residents to 30 gcd; begin use of alternate potable water sources (Elk Valley aquifer, quarries); set up emergency water supply points to dispense minimum essential water needs for human consumption; use nonpotable water for toilet flushing or use other sanitary facilities, such as chemical toilets; turn off all air conditioning; businesses using water in manufacture haul from outside drought area.

(1) Details are available in Grand Forks-East Grand Forks Urban Water Resources Study Water Supply Appendix.
(2) Assumes low-head dams are effective.

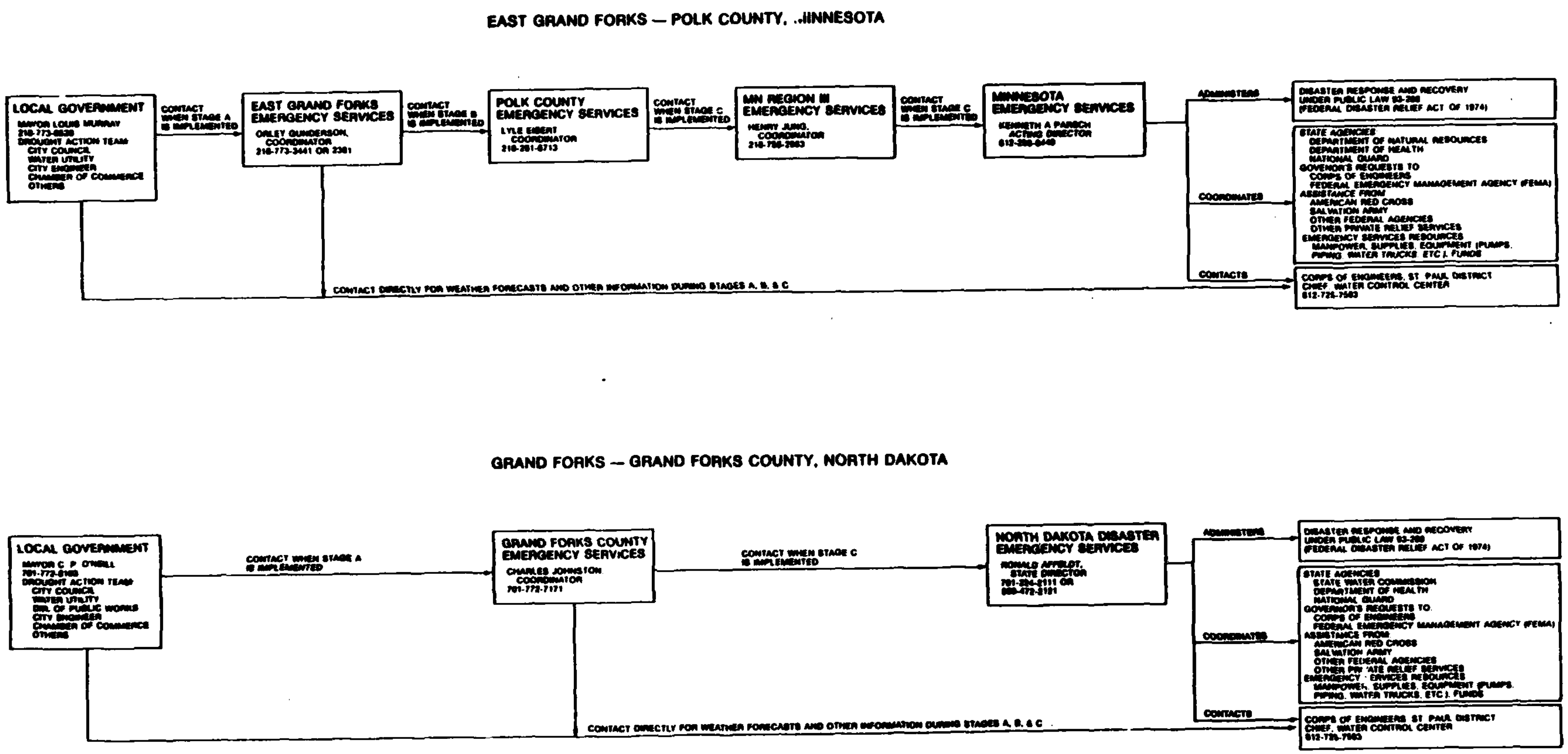


FIGURE 21
Drought Action Organization Chart

WASTEWATER MANAGEMENT

GENERAL

Pollution sources were divided into two categories:

- Major point sources - specifically, wastewater treatment facilities.
- Intermittent point and nonpoint sources - in particular, Grand Forks' combined sewers.

The stage 2 studies addressed both categories. Community planning efforts were already focused on the recommended treatment facility improvements. Therefore, further investigation of major point sources in stage 3 was not needed.

The stage 2 studies found that separation of Grand Forks' combined sewers was the most cost-effective solution to the area's most serious intermittent point and nonpoint pollution source. The city asked the Environmental Protection Agency to accept the stage 2 report as meeting the step 1 requirements of its Construction Grants Program, through which Federal financial assistance could be obtained. However, the Environmental Protection Agency ruled that further studies were needed to reaffirm the findings and recommendations. This, then, was the focus of the stage 3 studies. The stage 3 report, prepared in accordance with the Envonmental Protection Agency's requirements, confirmed the stage 2 findings. At this writing, the city has received step 2 funds and has consultants preparing plans and specifications. Available step 3 money appears adequate to cover about half the sewer separation project; prospects for funds to finish the project are uncertain at this time.

PROBLEMS, NEEDS, AND CONCERNS

Among the issues and questions disclosed during stages 1 and 2 of the urban study were the following:

- Existing wastewater treatment facilities of all communities in the study area - Grand Forks, Thompson, Manvel, and Emerado, North Dakota; East Grand Forks, Minnesota; and the Grand Forks Air Force Base - do not meet State design criteria (although discharges from the facilities do meet current effluent standards).

- New subdivisions south and west of Grand Forks are served by individual septic tank/drainfield systems that are overtaxing the capacity of the soil to assimilate wastes in some areas and adversely affecting both groundwater and surface water.

- What methods of wastewater treatment will meet the Public Law 92-500 1983 (best practical treatment) and 1985 (zero-discharge) goals? Are there advantages to continuing the lagoon method of treatment?

- Are there advantages to converting from separate wastewater treatment facilities to a regional system?

- How can urban runoff quality be improved to reduce the pollutant loads discharged into the rivers?

- During runoff events, Grand Forks' combined sewers are unable to handle the combined wastewater/runoff flow. Therefore, untreated sanitary wastes are discharged into the Red River in the water supply pool upstream of the Riverside Park low-head dam. The overloaded sewers also cause backup of untreated wastes into basements hooked into the combined sewer system. These problems pose serious public health threats.

- The Red and Red Lake Rivers' water quality problems are due mostly to point and nonpoint discharges and poor quality of natural runoff upstream of the urban study area. Reducing the study area's contribution of organic materials and other contaminants would enhance water quality locally but would not significantly improve the rivers' overall water quality.

Four levels of treatment were considered:

- Level I would maintain the existing level of treatment. Treatment facilities would be increased in capacity to handle increased wastewater flows with no change in effluent quality.

- Level II would be secondary treatment as defined by both North Dakota and Minnesota.

- Level III adds further treatment to meet even more stringent effluent criteria. Nitrification could be included if there were dissolved oxygen problems.

- Level IV allows for essentially no discharge of critical pollutants; the effluent quality requirements probably represent the upper limit that can be achieved by existing, practical treatment technology.

Alternative types of treatment appropriate for each level are shown in figure 22. Level IV's two activated sludge processes and follow-up steps constitute alternative "mechanical treatment" systems. This figure and subsequent analyses were based on results of preliminary screenings of possible facility locations, combinations, treatment methods, etc., using professional judgment and experience to discard those options not technically feasible or cost competitive.

The study area has seven treatment facilities - all stabilization ponds - and two pretreatment facilities to handle nine major point sources: Grand Forks municipal and industrial, East Grand Forks municipal and industrial, Thompson, Manvel, Emerado, the Grand Forks Air Force Base, American Crystal Sugar, International Co-op, and Pillsbury (the latter two pretreat their wastewater before discharge into Grand Forks' sewerage system).

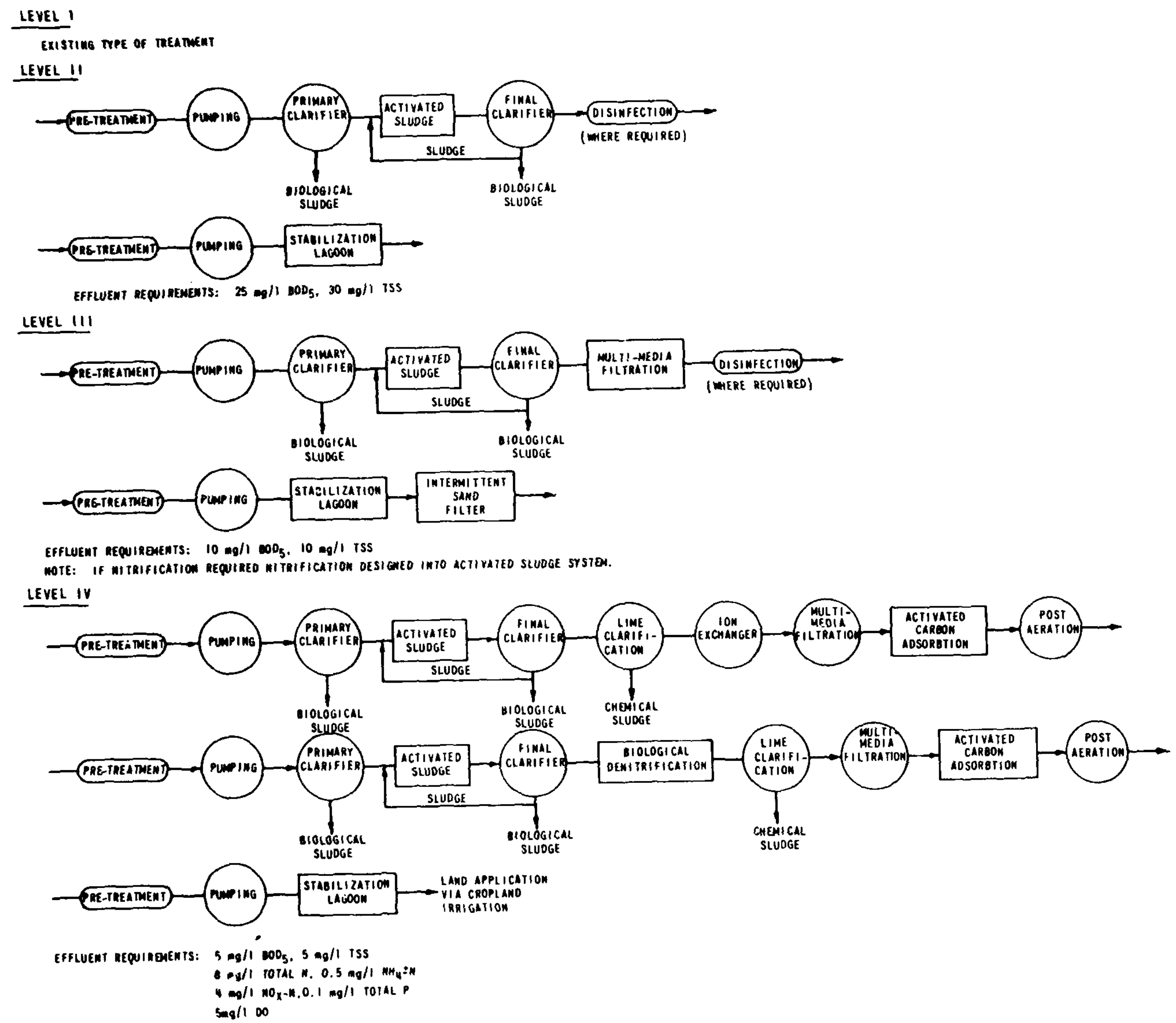


FIGURE 22 - Liquid Waste Treatment Schematics

Alternatives were evaluated assuming:

- Major industries in Grand Forks would continue to use the municipal treatment system.
- Sewage collection would be extended to new growth areas bordering the urban centers.
- Implementation of Grand Forks' current plans for lagoon expansion, industrial pretreatment improvements, and outfall modification.

Table 11 and figure 23 show the improvements considered for the area's seven major dischargers for each level of treatment. Table 12 lists the estimated equivalent annual costs (including interest on and amortization of the capital investment at 6 3/8 percent and October 1977 price levels). The costs for Thompson and Manvel to join a regional system were much higher than to continue local treatment. Therefore, it was recommended that these communities retain their separate lagoon systems, making improvements as needed to meet the appropriate treatment level.

At treatment levels I-III, joint management of separate Emerado and Grand Forks Air Force Base treatment facilities was cheaper than a joint or regional facility or separate facilities managed separately. At level IV, regional or joint facilities become competitive; however, Emerado opposes joint treatment. Therefore joint management of separate facilities appeared to be preferable.

Alternatives considered for Grand Forks, East Grand Forks, and American Crystal Sugar included separate and joint lagoons; joint mechanical treatment for Grand Forks and East Grand Forks would exclude American Crystal Sugar because lagoons are more cost effective for handling its highly seasonal flow. Table 12 shows separate lagoons to be more cost effective at all treatment levels. However, to meet level IV, the separate lagoons alternative would need an additional 6,000 acres for land application of lagoon effluent; the environmental, social, and economic consequences of such a large loss of farmland and wildlife habitat make joint mechanical treatment (which would need only about 30 acres) preferable.

Table 11 - Alternative wastewater treatment systems for urban study area communities

Community/system	Treatment level I	II	III	IV
Thompson				
Separate	Existing lagoon	Lagoon, pretreatment	Lagoon, sand filter	Lagoon, land application
Regional	12-mile, 12-inch force main and 700-gpm, 150-foot head pump station			
Manvel				
Separate	Existing lagoon	Upgrade lagoon	Lagoon, sand filter	Lagoon, land application
Regional	10-mile, 4-inch force main and 150-gpm, 300-foot head pump station			
Emerado - Air Force Base				
Separate	Lagoon expansion	Lagoon expansion	Lagoon expansion, sand filter	Lagoon expansion, land application
Joint management of separate facilities	Lagoon expansion	Lagoon expansion	Lagoon expansion, sand filter	Lagoon expansion, land application
Joint facilities	Lagoon expansion	Lagoon expansion	Lagoon expansion, sand filter	Lagoon expansion, land application
	Plus 2-mile, 12-inch force main and 700-gpm, 50-foot head pump station			
Regional	12-mile, 20-inch force main and pump station			
Grand Forks-East Grand Forks-American Crystal Sugar				
Grand Forks separate	Lagoon expansion	Lagoon expansion	Lagoon expansion, sand filter	Lagoon expansion, land application
East Grand Forks separate	Lagoon expansion	Lagoon expansion	Lagoon expansion, sand filter	Lagoon expansion, land application
American Crystal Sugar separate	Lagoon expansion	Lagoon expansion	Lagoon expansion, secondary treatment, land application	Lagoon expansion, secondary treatment, land application
Grand Forks-East Grand Forks joint lagoon	Lagoon expansion	Lagoon expansion	Lagoon expansion, sand filter	Lagoon expansion, land application
	Plus 4-mile, 24-inch force main and 6,250-gpm, 50-foot head pump station			
East Grand Forks-American Crystal Sugar joint lagoon	Lagoon expansion	Lagoon expansion	Lagoon expansion, sand filter	Lagoon expansion, land application
	Plus 2-mile, 18-inch force main and 2,000-gpm, 50-foot head pump station			
Grand Forks-East Grand Forks-American Crystal Sugar joint lagoon	Lagoon expansion	Lagoon expansion	Lagoon expansion, sand filter	Lagoon expansion, land application
	Plus 2-mile, 18-inch force main and 2,000-gpm, 50-foot head pump station plus 4-mile, 30-inch force main and 7,000-gpm, 50-foot head pump station			
Grand Forks-East Grand Forks joint mechanical	None	Activated sludge	Activated sludge, filtration	Activated sludge, filtration, lime clarification and recalcination, ion exchange, activated carbon, postaeration
	Plus 5,000-foot, 36-inch force main			

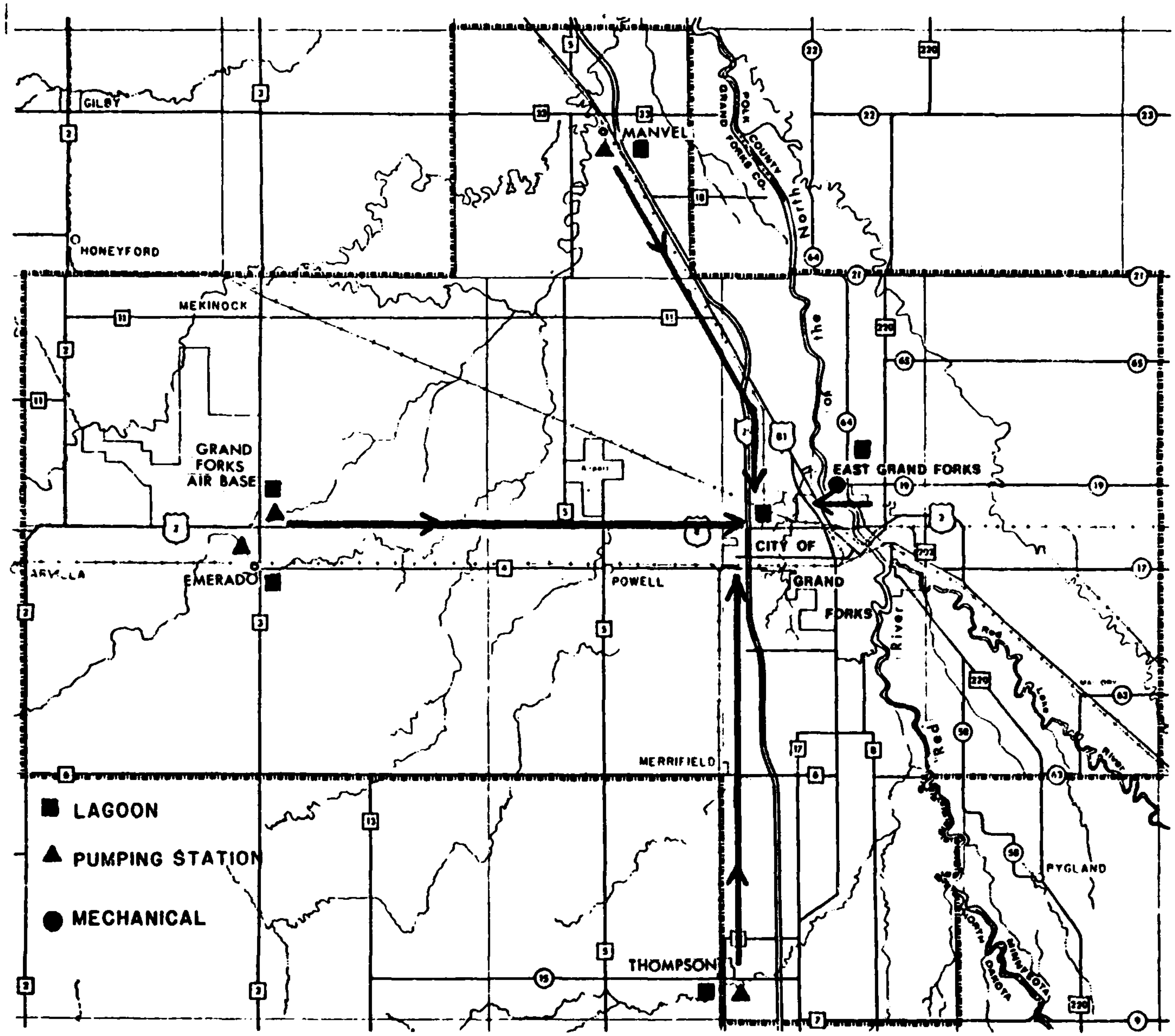


FIGURE 23 – WASTEWATER TREATMENT ALTERNATIVES

Table 12 - Equivalent annual costs of wastewater treatment alternatives.

Community/system	Treatment level I	II	III	IV
Thompson				
Separate	$77,000 (1)	$77,000 (1)	$88,000 (1)	$139,000 (1)
Regional	152,000	152,000	152,000	152,000
Manvel				
Separate	25,000 (1)	25,000 (1)	28,000 (1)	48,000 (1)
Regional	80,000	80,000	80,000	80,000
Emerado - Air Force Base				
Separate	171,000	171,000	218,000	424,000
Joint facilities	174,000	174,000	215,000	398,000
Joint management of separate facilities	154,000 (2)	154,000 (2)	201,000 (2)	406,000 (2)
Regional	378,000	378,000	378,000	378,000
Grand Forks-East Grand Forks-American Crystal Sugar				
Grand Forks separate lagoon	1,087,000	1,087,000	1,308,000	2,106,000
East Grand Forks separate lagoon	205,000	205,000	230,000	596,000
American Crystal Sugar separate lagoon	115,000	115,000	326,000	326,000
Total separate systems	1,407,000	1,407,000	1,914,000	3,028,000
Grand Forks-East Grand Forks joint lagoon and American Crystal Sugar separate lagoon	1,731,000	1,731,000	2,230,000	3,275,000
East Grand Forks-American Crystal Sugar joint lagoon and Grand Forks separate lagoon	1,561,000	1,561,000	1,972,000	3,340,000
Grand Forks-East Grand Forks-American Crystal Sugar joint lagoon	1,784,000	1,784,000	2,182,000	3,258,000
Grand Forks-East Grand Forks joint mechanical and American Crystal Sugar separate lagoon	-	1,828,000 (3)	2,358,000 (3)	3,828,000 (3)
Least total cost for study area	1,663,000	1,663,000	2,231,000	3,621,000

(1) Does not include cost of treatment at regional facility.

(2) Includes cost of interceptor and pumping station; does not include cost of treatment at regional facility.

(3) Does not include nitrification to mechanical plant, which would add about $134,000 in equivalent annual costs.

Grand Forks' and East Grand Forks' plans already are based on improving their lagoon systems, which is in concert with the urban study's findings. Therefore, it was recommended that they proceed as planned. However, if level IV treatment would be mandated, further investigation (including field tests) of land application should be conducted to assess its feasibility in this area's soils; also, more detailed analyses of the mechanical treatment alternative would be needed.

INTERMITTENT POINT AND NONPOINT SOURCE STUDIES

Runoff carried by storm sewers, combined sewers, and overland/ditch flow can be as polluted as untreated municipal wastewater. Stage 2's preliminary screening of urban runoff control alternatives on the basis of cost and effectiveness concluded that separation of Grand Forks' combined sewers was the most cost-effective alternative. As discussed earlier, the Environmental Protection Agency required further more detailed studies as a prerequisite to approving Federal financial assistance for the sewer separation project. The results of these studies, conducted in stage 3, are summarized in the following discussion.

Approximately 850 acres of the city is served by a combined sewer system which collects sanitary waste and stormwater runoff. During dry weather or small runoff events, flow in the combined sewers is pumped through a main interceptor to the wastewater treatment lagoons. During larger runoff events, pump station capacities are exceeded, and combined sewer overflows discharge directly into the Red River.

The impacts of these discharges on the Red River are not quantifiable at this time because the lack of reliable field data makes water quality modeling impracticable. However, there is an unquestioned public health hazard because the combined sewers discharge untreated wastes (containing fecal coliforms, grease and oils, turbidity, and various chemicals and heavy metals) directly into the city's water supply pool behind the Riverside Park low-head dam. Furthermore, combined sewer flows back up into basements, flooding them with these same dangerously polluted materials.

The city has already initiated a phased separation program. The first phase of this program, involving Service Areas 3 and 4 (figure 24), is close to completion. Therefore, these two service areas were excluded from the stage 3 studies.

Table 13 lists the capacities of the combined sewers near the overflow structures of the four service areas that were studied and the equivalent storm event that would cause flows to exceed capacity. Larger events would cause local street flooding; for example, in Service Area 2, the sewer capacity is exceeded about once a year on the average. The table also shows the capacity of each service area's lift station, the storm runoff that can be handled before the combined runoff and sanitary flow exceeds lift station capacity, and the rainfall intensity that will cause too much storm runoff. Clearly, even very small rainfall events exceed the lift stations' capacities; in fact, nearly all runoff in the combined sewer area overflows into the river.

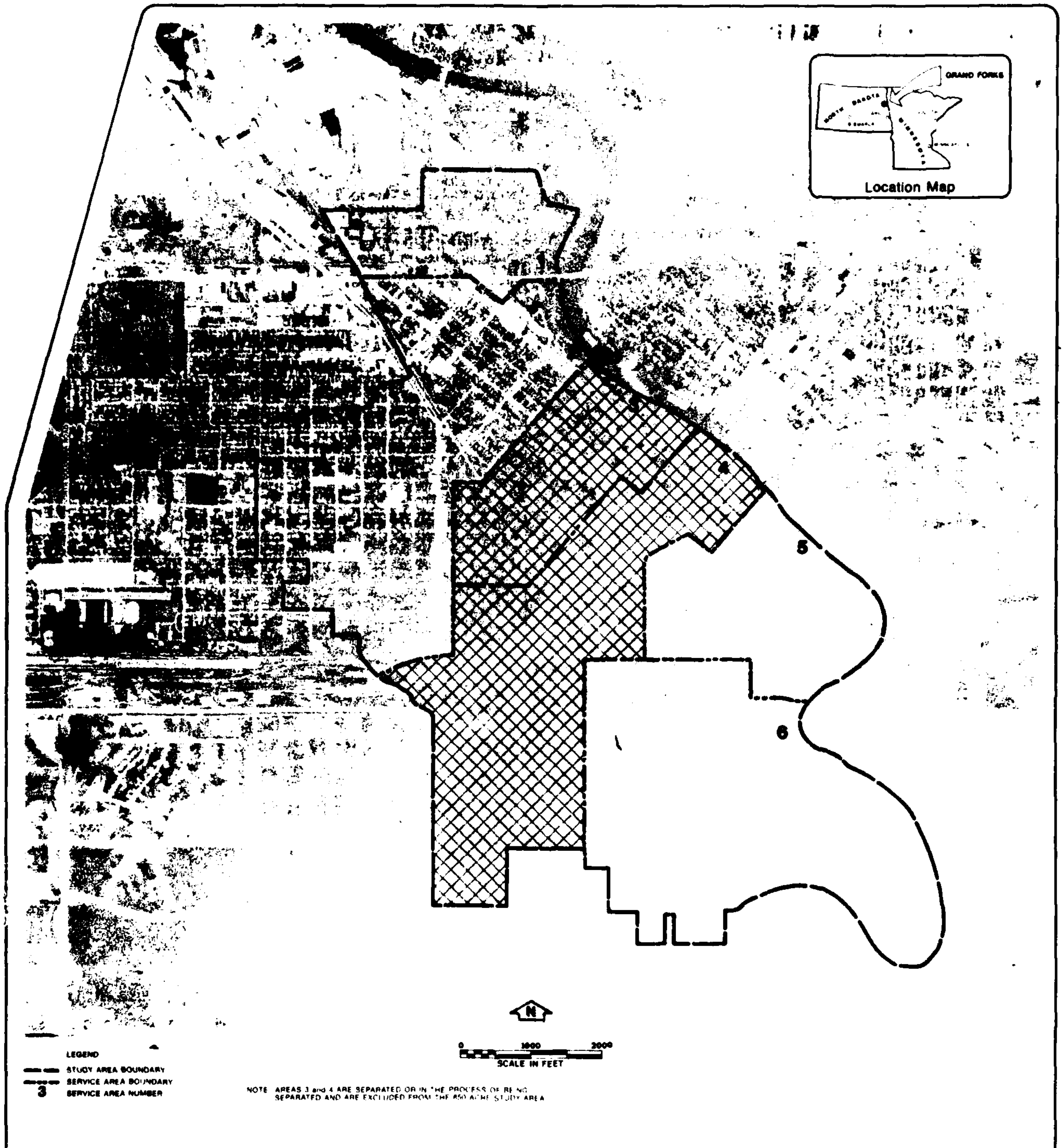


FIGURE 24 - Combined Sewer Area

Table 13 - Service area sewer and lift station capacities

Item	Service area			
	1	2	5	6
Combined sewer capacity (cfs)	69	130	10 (to valve) 65 (to lift station)	65
Allowable storm recurrence interval (years)	5	1	0.5 (to valve) 0.5 (to lift station)	<0.25
Lift station capacity (cfs)	0.27	4.04	0.45	1.45
Allowable storm flow before exceeding capacity (cfs)	0.05	1.19	0.39	0.78
Allowable rainfall intensity before exceeding capacity (inches/hour)	<0.1	<0.1	<0.1	<0.1

Environmental Protection Agency data on typical pollutant concentrations in urban runoff were used to estimate quantities of major contaminants discharged by the combined sewers annually. Performance data from the literature, manufacturers, and the Environmental Protection Agency's Storm and Combined Sewer Section of the Municipal Environmental Research Laboratory established ranges of percentage removal that could be expected from various alternatives. The removal figures, in turn, could be related to the respective costs to determine which alternatives were most cost effective.

Several alternative concepts were eliminated early:

- Flow reduction is distinguished from sewer separation plans discussed later. Decreased sanitary flow would not significantly reduce overflow volumes but could improve overflow quality; however, because the service areas are largely developed, little change in wastewater loads is probable. A reduction in storm runoff entering the combined sewers would increase overland runoff, an impractical alternative in this flat, developed area.

- Combined relief sewers would reduce local flooding but continue discharging untreated wastes into the river.

- In-system storage would not be practical because the existing combined sewer system has insufficient storage capacity.

- Treatment in the existing wastewater treatment plant would involve temporarily storing all runoff, then pumping the runoff to the city's wastewater lagoon. Costs for the huge storage facilities and larger lagoons would be prohibitive.

- Filtration or sedimentation without attenuating peak flow rates would require prohibitively expensive facilities. Alternatives deemed worthy of serious consideration involved temporary storage sufficient to reduce treatment rates.

The following alternatives were evaluated in detail. The first four are combined sewer separation schemes.

- Alternative 1 would involve construction of a new sanitary sewer system and retention of the existing combined sewers as a storm sewer system.

- Alternative 2 would involve construction of a new storm sewer system and retention of the existing combined sewers as a sanitary sewer system.

- Alternative 3 would provide new storm and sanitary sewer systems but attempt to use portions of the existing combined system where feasible. In Service Area 1 (where the existing sewer has a reasonable capacity), this alternative would be identical to alternative 1. In Service Areas 2, 5, and 6, the combined sewers are undersized for storm runoff and were instead considered for conversion to sanitary sewers.

- Alternative 4 would totally abandon the existing combined sewers and construct new separate sanitary and storm sewer systems.

- Alternatives 5 and 6 are optional high-rate filtration systems (figure 25). Alternative 5 (figure 26) is based on treating the overflows at each overflow point; alternative 6 (figure 27) is based on pumping all overflows to one site for treatment.

- Alternatives 7 and 8 are optional sedimentation schemes (figure 28). Alternative 7 would treat the individual overflows (figure 26); alternative 8 would pump all overflows to one site for treatment (figure 27).

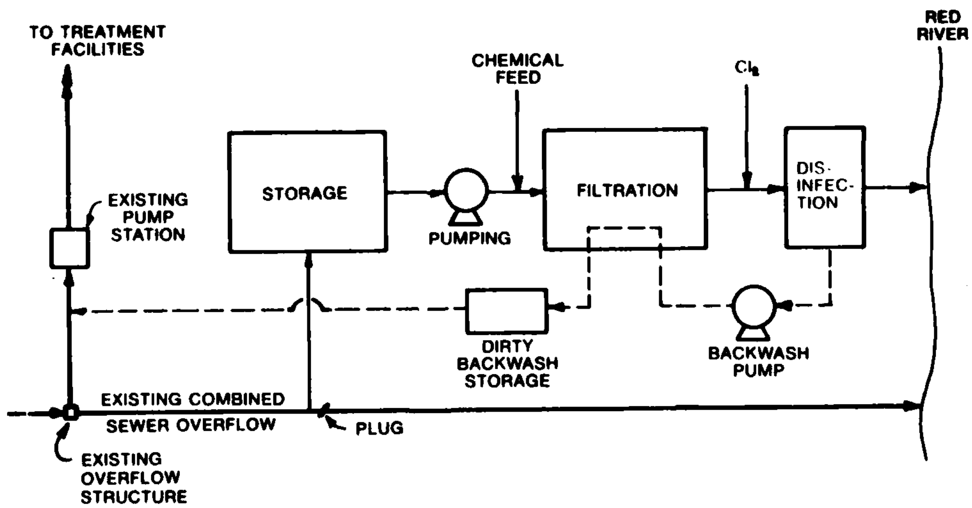


FIGURE 25 - High Rate Filtration Schematic

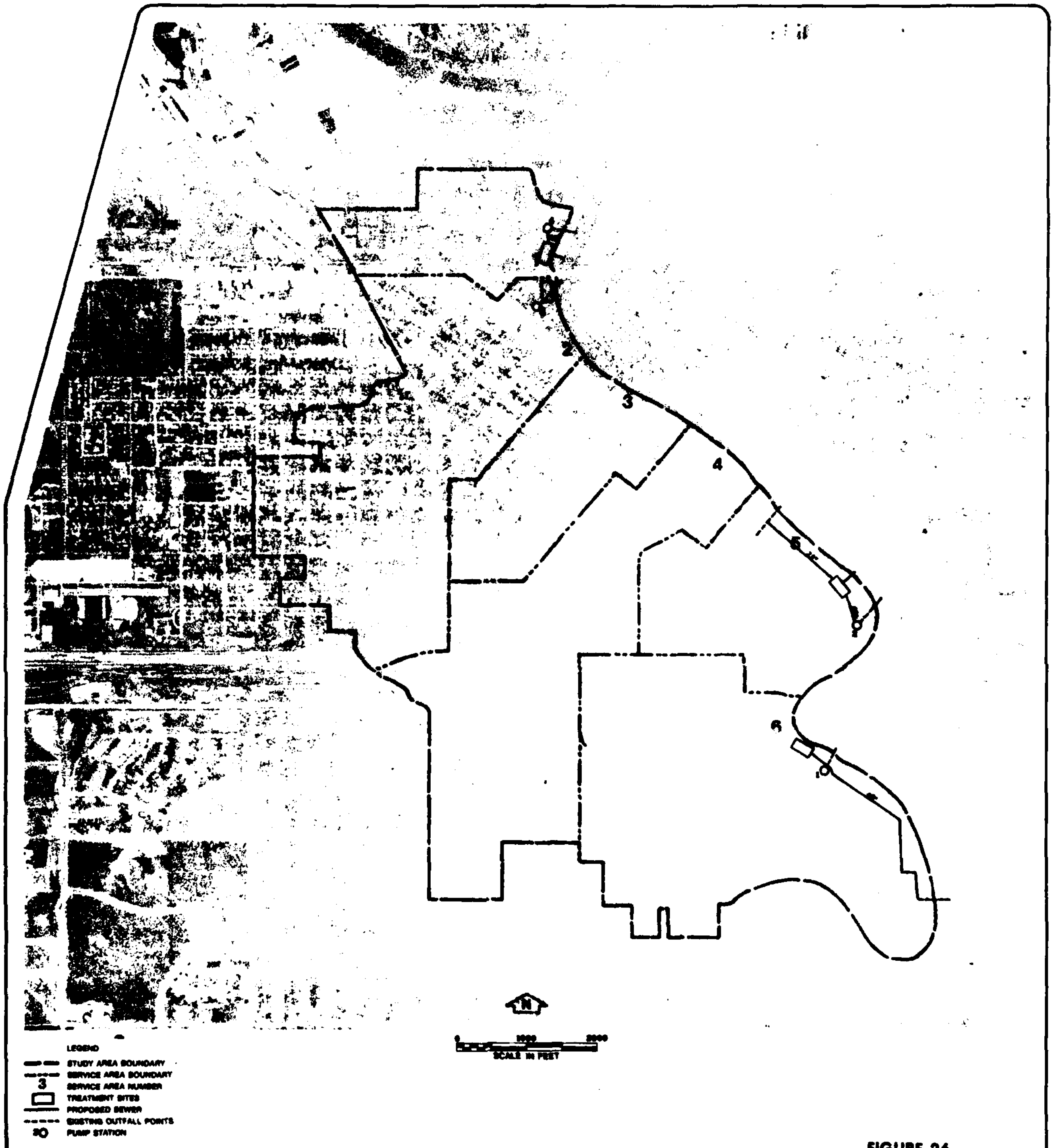


FIGURE 26 -
Alternatives 5, 7 and 9
Treatment
at Individual Service Areas

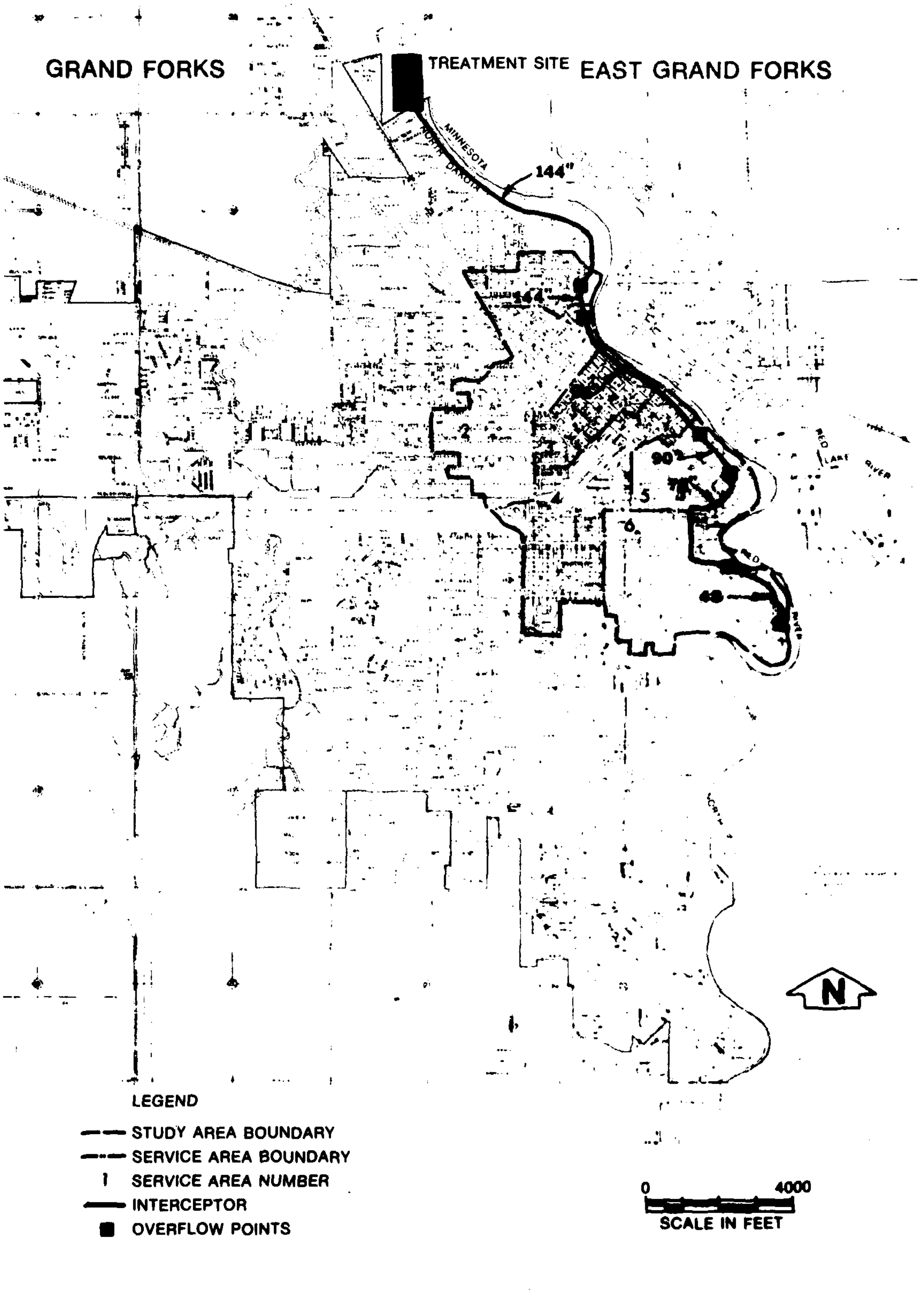


FIGURE 27 - Alternatives 6 and 8
Storage and Treatment — Single Site

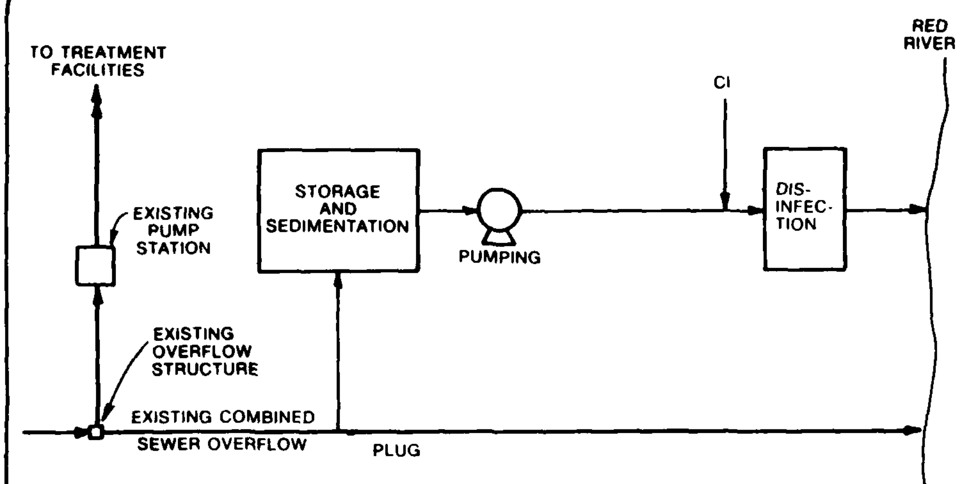


FIGURE 28 - Sedimentation Schematic

- Alternative 9 uses a swirl concentrator at each overflow (figure 29), pump-fed to prevent aggravation of basement back-ups from the concentrator's head loss and ensure proper operation during a flood. The best balance between system costs and performance would be within a design capable of handling the 0.25-year storm. Although this design would allow discharge of untreated wastes into the river an average of four times a year, about 93 percent of the total yearly combined sewer flow would be treated.

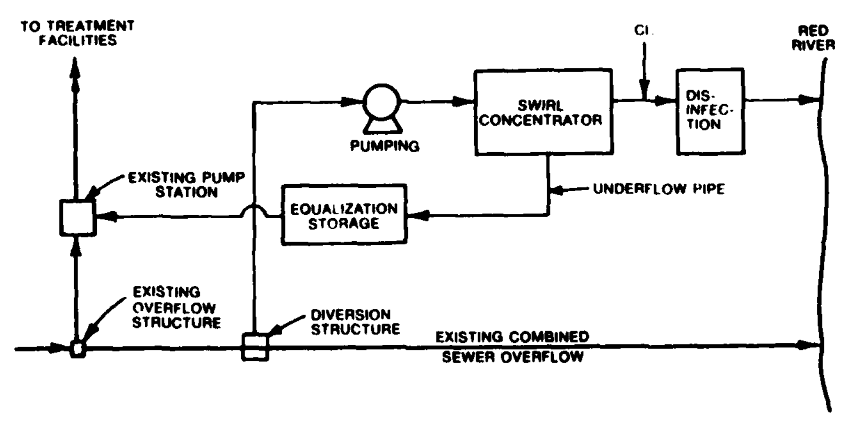


FIGURE 29 - Swirl Concentrator Schematic

- Alternative 10 would relocate the city's three water intakes. One alternative - relocation above the low-head dam's pool - would require an expensive 35-mile pipeline and would lose the raw water storage essential for reliable water supply during droughts. The scheme that was evaluated would relocate the intakes 2 miles upstream of any combined sewer outfall (figure 30); this scheme would reduce the probability of pollutants entering the water intakes but would not solve the basic problem.

- Alternative 11 would use collection system and source management. However, Grand Forks' combined sewer system does not readily lend itself to collection system controls. Source management - street cleaning, sewer flushing, and catch basin cleaning - has relatively minor impacts and would best be used in conjunction with one or more of the other alternatives.

- Alternative 12 - the "no action" plan - would incur no additional costs, but might make the city subject to heavy fines for violating its National Pollutant Discharge Elimination System permit which requires the combined sewer overflows be minimized or eliminated. Most importantly, the public health hazards would continue.

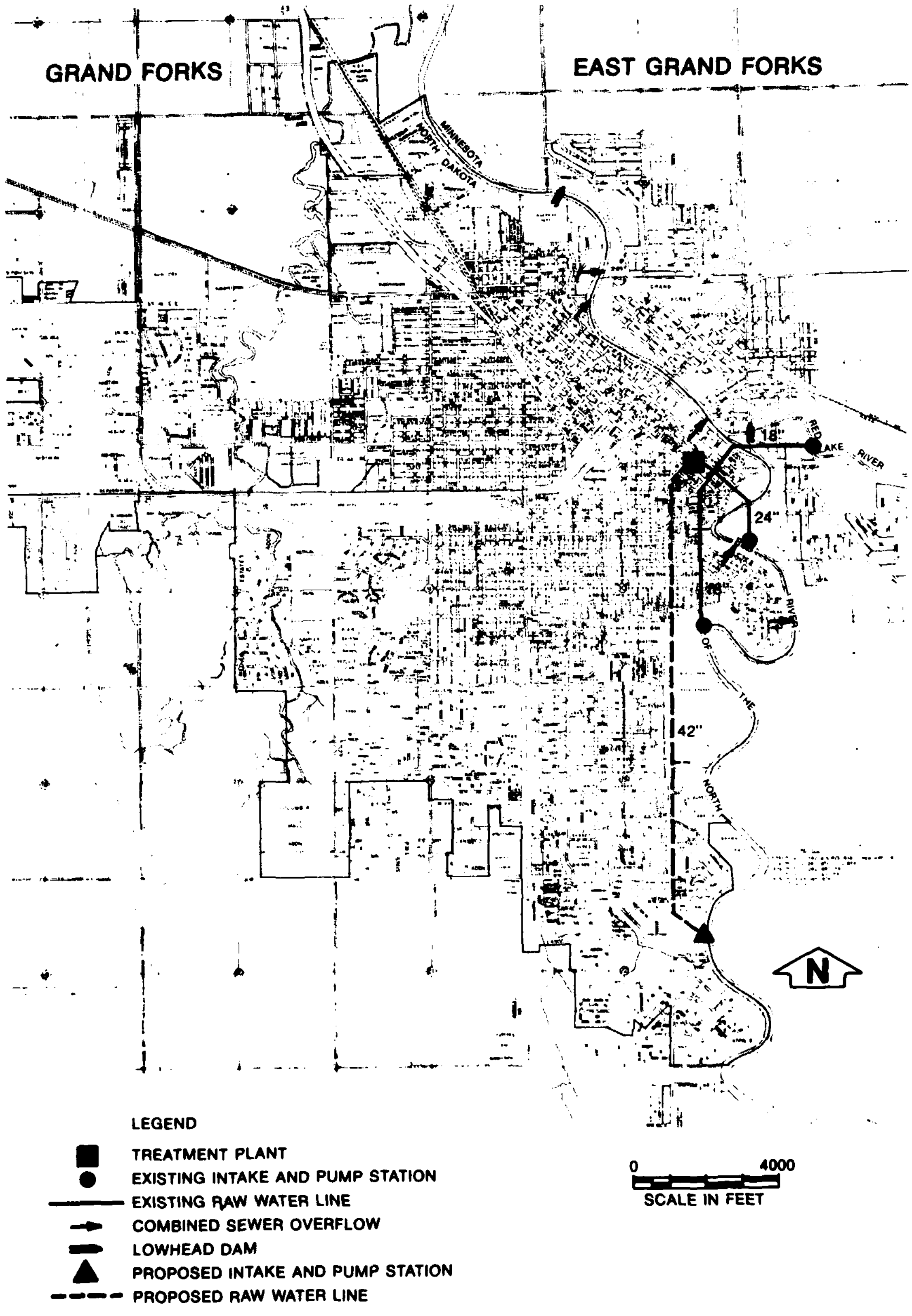


FIGURE 30 - Relocate Water Intake

Table 14 lists the anticipated pollutant removal for each alternative. Table 15 summarizes the environmental, social, and economic impacts of alternatives 1-9. Table 16 shows, for each service area, the alternatives' estimated first costs, equivalent annual costs (including interest on and amortization of first costs, plus operation and maintenance, less salvage value) based on a 20-year planning period at 6 7/8-percent interest and May 1979 prices. This table also shows the estimated BOD removal annually and the unit cost per pound of BOD removed.

Table 14 - Estimated effect of alternatives on pollutant discharges

Alternative	Estimated percent removal of given pollutant		
	BOD(1)	TSS(2)	Fecal coliforms
1 - New sanitary sewer system	80	(3)	95-100
2 - New storm sewer system	80	(3)	95-100
3 - Partially new storm and sanitary systems	80	(3)	95-100
4 - New sanitary and storm systems	80	(3)	95-100
5 - High-rate filtration at each service area	75-85	90-95	100
6 - High-rate filtration at single site	75-85	90-95	100
7 - Sedimentation at each service area	50-60	75-85	100
8 - Sedimentation at single site	50-60	75-85	100
9 - Swirl concentrators	35-45	20-50	100
10 - Relocate water intakes	0	0	0
11 - Collection system and source management	5	13	0
12 - No action	0	0	0

(1) Biochemical oxygen demand.
(2) Total suspended solids.
(3) Since first flush of storm runoff solids would no longer be diverted to wastewater treatment plant, TSS may not be decreased.

Table 15 - Impact assessment

Impact	No Action	Sewer Separation Alternatives 1, 2, 3, & 4	End-of-Pipe Treatment Alternatives 5, 7, & 9	Regionalized Collection and Treatment Alternatives 6 - 8
Environmental				
Land	No effect.	No effect.	Land required downtown.	Up to 15 acres required.
Natural Resources	No effect.	Consumptive use of energy during construction.	Consumptive use of energy during construction, for pumping and chemicals for disinfection.	Consumptive use of energy during consutruction, for pumping and and chemicals for disinfection.
Man-made Resources	No effect.	Alternatives 1, 2, & 3 utilize existing sewer.	No effect.	No effect.
Water Quality	No change.	Improved. May be degraded during construction.	Improved. May be degraded during construction.	Improved. May be degraded during construction.
Air Quality	No effect.	Increased dust during construction.	Increased dust during construction.	Increased dust during construction.
Wildlife	No effect.	Disturbed during construction.	Disturbed during construction.	Disturbed during construction.
Hydrological	No change.	Slight reduction hydraulic load to sewage lagoon.	No change.	No change.
Public Health	No change.	May improve.	No change.	No change.
Social				
Noise	No effect.	Increased during construction.	Increased during construction.	Increased during construction.
Displacement of People	No effect.	No effect.	Possible, depends on site.	No effect.
Aesthetics	No change.	Eliminates basement flooding. Alternatives 2, 3, & 4 reduce street flooding.	Declined.	Declined.
Historical & Archaeological	No effect.	No effect.	No effect.	No known effect.
Transportation	No change.	Increased & disrupted during construction.	Increased & disrupted during construction.	Increased & disrupted during construction.
Institutional Relationships	No effect.	No change.	No change.	No effect.
Community Cohesion	No effect.	May improve.	No effect.	No effect.
Community Growth	No effect.	No effect.	No effect.	No effect.
Public Acceptance	No change.	Improved.	Declined.	Declined.
Economic				
Public Facilities	No effect.	No effect.	No effect.	No effect.
Public Services	No change.	Improved.	No change.	No change.
Employment	No effect.	Increased during construction.	Increased during construction and for operation of facilities.	Increased during construction and for operation of facilities.
Business & Industrial Activity	No change.	Disrupted during construction.	No change.	No change.
Tax Revenues	No effect.	Slight increase.	Decreased.	Decreased.
Property Values	No change.	Improved.	Decreased locally.	Decreased locally

Source: Stanley Consultants

Table 16 - Alternatives' cost estimates for each service area

Alternative	Service area	Total initial cost ($1,000)	Operation and maintenance ($1,000/ year)	Equivalent annual cost ($1,000/ year)	Estimated BOD removal (1,000 pounds/ year)	Unit cost for BOD removal ($/pound BOD)
1 - New sanitary sewer system	1	1,625	3	135	22	6.14
	2	5,474	9	454	77	5.90
	5	2,110	3	174	35	4.97
	6	4,763	7	394	79	4.99
2 - New storm sewer system	1	1,744	5	147	22	6.68
	2	7,136	17	598	77	7.77
	5	2,044	5	171	35	4.89
	6	6,123	12	510	79	6.46
3 - Partially new storm and sanitary systems	1	1,625	3	135	22	6.14
	2	6,089	9	503	77	6.53
	5	2,486	3	205	35	5.86
	6	8,087	9	666	79	8.43
4 - New sanitary and storm systems	1	2,954	3	243	22	11.05
	2	11,234	9	921	77	11.96
	5	3,727	3	305	35	8.71
	6	9,647	8	791	79	10.01
5 - High-rate filtration at each service area	1	3,238	98	368	21	17.51
	2	7,793	271	922	72	12.81
	5	5,012	139	557	33	16.88
	6	9,487	289	1,080	74	14.59
6 - High-rate filtration at single site	-	36,125	214	3,076	200	13.38
7 - Sedimentation at each service area	1	2,951	79	325	14	23.21
	2	6,854	206	779	48	16.23
	5	4,571	109	490	22	22.27
	6	8,515	222	932	49	19.08
8 - Sedimentation at single site	-	34,986	142	2,911	133	21.89
9 - Swirl concentrators	1	2,230	71	260	10	26.00
	2	4,918	168	585	35	16.71
	5	3,222	94	366	16	22.88
	6	6,329	179	714	38	18.79
10 - Collection system and source management	-	120	18	35	14	2.50
11 - Relocate water intakes	-	3,559	66	356	0	NA
12 - No action	-	0	0	0	0	NA

Stage 3 Wastewater STudy, Grand Forks Combined Sewer Analysis Draft Report, November 1979.

The final plan combines the alternatives selected for each of the four service areas on the basis of careful consideration of environmental, social, and economic factors:

- Service Area 1 - Alternative 1 is recommended.
- Service Area 2 - Alternative 1 is most cost effective, but would not resolve street flooding problems. Alternative 3 is recommended instead; it is the next most cost effective and would include new storm sewers where needed to relieve inadequate storm flow capacities in the existing system.
- Service Area 5 - Alternative 2 is recommended.
- Service Area 6 - Alternative 1 is least costly, but would not resolve street flooding problems. Alternative 2 would solve the street flooding, but would cost nearly $1.4 million more. Alternative 1 is recommended, but public hearings may reveal strong public support for spending the extra money to solve street flooding.

Figure 31 shows the recommended plan; table 17 lists its costs.

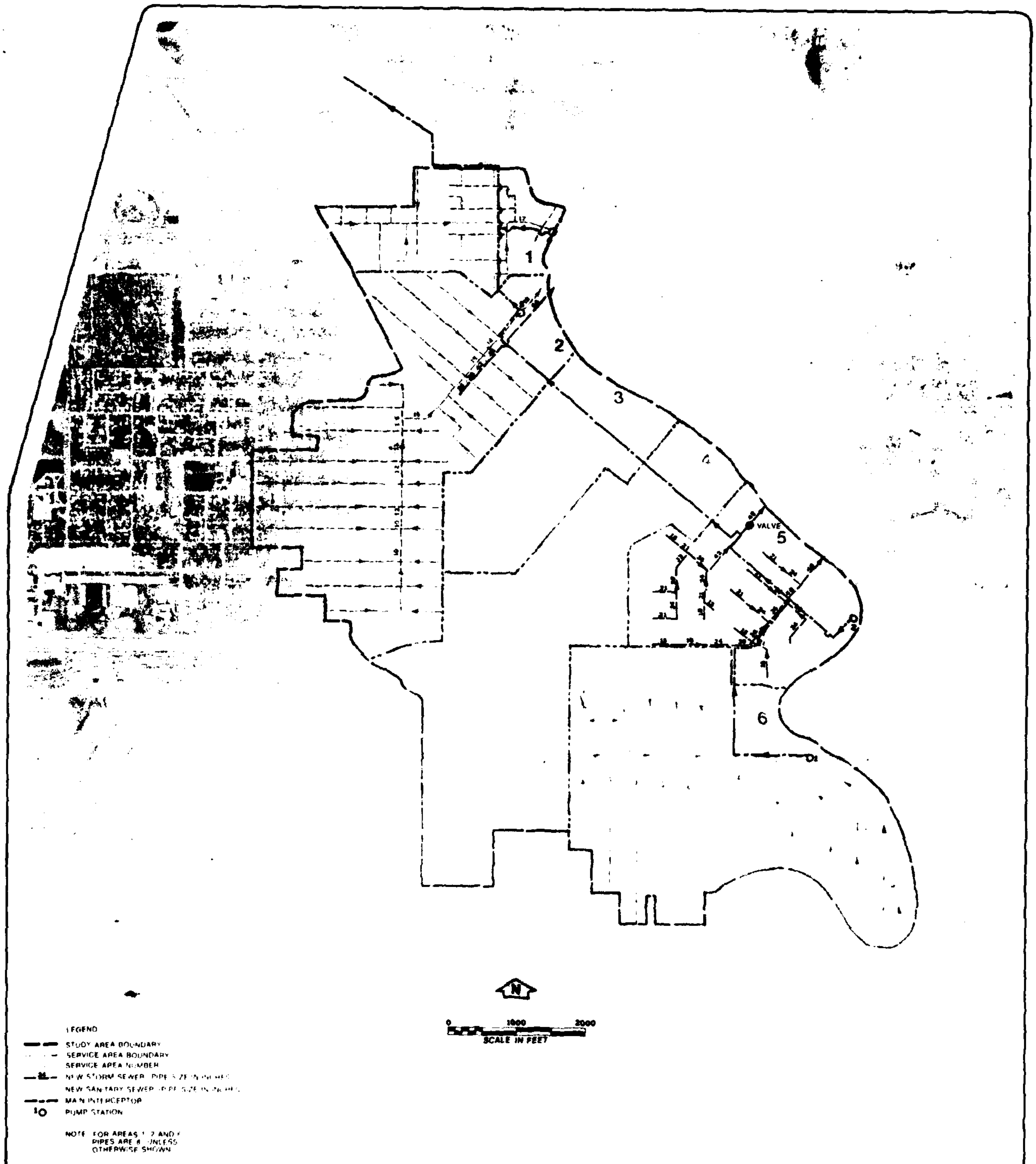


FIGURE 31 - Selected Plan

Table 17 - Selected plan

Service area	Selected alternative	Total initial cost ($1,000)	Operation and maintenance cost ($/year)
1	1	1,625	2,740
2	3	6,089	9,180
5	2	2,044	5,280
6	1	4,763	6,550
Total		14,521	23,750

PUBLIC INVOLVEMENT

The public involvement program was an important part of the urban study. The overall goal of the program was to involve the public (including local, regional, State, and Federal interests and agencies) as fully as possible in the planning process. Several complementary techniques were used to encourage public participation and provide a forum for communication between the public and planners, including meetings, workshops, slide shows, pamphlets, newsletters, and displays.

The program evolved as the urban study progressed. In stage 1, an intensive public relations program was used to reach different segments of the public to gather information and viewpoints regarding the study area's problems, needs, and concerns. By stage 2, agencies and groups interested in active participation had been identified. Alternative solutions were developed and presented to these participants for review and feedback.

In stage 3, public involvement activities have concentrated on reporting the urban study's conclusions and recommendations as they became available to make them of immediate use to local interests. For example, the East Grand Forks flood emergency plan was formally presented to the city before possible spring 1980 floods. The Grand Forks flood emergency plan was formally turned over to the city before spring 1981. Completion of the stage 3 report recommending separation of Grand Forks' combined sewers was based on meeting the schedule and requirements imposed by the Environmental Protection Agency and qualified the city for Federal financial assistance. The five-stage drought emergency plan was adopted by Grand Forks during a severe drought in 1979.

Information developed during the urban study's investigations was summarized in a number of pamphlets and professionally narrated 10- to 20-minute slide programs. Copies of these public information tools were given to Grand Forks and East Grand Forks; possible uses include:

- Training city workers and flood fight volunteers.
- Disseminating suggestions regarding self-help flood fight plans.
- Informing affected neighborhoods and city taxpayers about the health hazards posed by combined sewer overflows and plans and costs for relieving the threat.
- Generating public support for expanding the Grand Forks water treatment plant.
- Introducing the regional approach recommended during the water supply investigation into other urban area concerns (for example, solid waste disposal and mass transit).

RECOMMENDATION

I recommend that:

- The report be distributed to all Federal, State, regional clearinghouse, and local government agencies that have an interest in the control and development of water and related land resources in the study area.

- Those agencies responsible for water and related land resource planning and plan implementation use the findings of the report as a planning aid.

- The report be transmitted to Congress for its information.

WILLIAM W. BADGER
Colonel, Corps of Engineers
Commanding

NCDPD-PF (July, 1981) 1st Ind
SUBJECT: Grand Forks-East Grand Forks Urban Water Resources Study

DA, North Central Division, Corps of Engineers, 536 South Clark Street, Chicago, Illinois 60605

TO: Cdr, USACE (DAEN-CWP-C), WASH, D. C. 20314

I concur in the analysis and recommendations of the District Engineer.

SCOTT B. SMITH
Brigadier General, USA
Commanding