III MODEL SIMULATIONS, ANALYSIS, AND RESULTS

An array of potential “alternatives” or “options” to supplement the existing water supply have been identified and considered in formulating a viable, cost effective plan(s) for meeting the water needs of the Red River Valley. Some elements may have been studied in the past and disregarded, but this investigation will revisit these elements as potential sources of water supply.

All alternatives will be considered and evaluated in this study. Some components “washed out” more easily that others due to flaws such as being too small to meet demands, or due to environmental concerns. Alternatives can be generally characterized to fit into two categories: supply increase options and demand management options. Supply increase options include new storage facilities, modifications to existing facilities, improvements in project operations, implementation, conjunctive use, etc. Demand management options include those that reduce the demand on water supplies through such actions as land fallowing (temporary), land retirement (permanent), and municipal, industrial, agricultural water conservation, and water reuse. Combinations of these options have also been considered. For purposes of this document, alternatives will be grouped as no-action (baseline), action-single-component and action-multi-component alternatives.

As part of the Phase II study, scoping meetings were held regarding alternative actions. These sessions resulted in the following alternatives and feature components that were considered in this study.

A. *No Action (Baseline Conditions) Option*
   - ??????Existing (Year 1994) Condition Baseline
   - ? Future (Year 2050) Condition Reclamation Demand Baseline
   - ? Future (Year 2050) Condition Participant City Baseline (HYDROSS Model Run P30K50)

B. *Action Alternatives: Single Component (Feature) Options*
   - ? Utilizing surface water supplies
     - Feature #1: Enlargement of Lake Ashtabula
     - Feature #2: Construction of Lake Kindred on the Sheyenne River
     - Feature #3: Construction of Maple River Reservoir for downstream use
     - Feature #4: Supply Water to the Upper Red River from Maple River Reservoir
     - Feature #5: Construct off-stream storage near Fargo (ring dike)
     - Feature #6: Purchase mainstream Red and Sheyenne River surface irrigation water rights for change of use to municipal and industrial purposes
   - ? Utilizing ground water supplies
     - Feature #7: Secure additional unappropriated ground water and pump from the Spiritwood Aquifer
     - Feature #8: Acquire existing ground water rights by purchasing land from irrigators who are willing sellers

Feature #9: Aquifer water storage and recovery (ground water Recharge)

Feature #10: Build desalination plants to treat water from the Dakota Aquifer

? Reusing and conserving existing supplies

Feature #11: Reuse municipal wastewater from urban irrigation for the cities of Fargo, Moorhead, West Fargo, and Grand Forks

Feature #12: Develop and implement an increased city water conservation program for normal (non-emergency) operations

Feature #13: Drought contingencies - Modify Lake Ashtabula Operation to include minimum pool storage for M&I Supply

? Transfers from out-of basin

Features #14a & b: Import water to the upper Sheyenne River from McClusky Canal at Mile 59 and/or 70

Feature #15: Import Missouri River water to the upper Red River via the Wild Rice River

Feature #16a: Import water from the Missouri River south of Bismarck, ND to the Red River near Wahpeton

Feature #16b: Import water from the Missouri River to the Sheyenne River near Lisbon and then to the upper Red River (via pipeline) to Wahpeton

Feature #17: Import water to Rural water systems

Feature #18: Bismarck (Missouri River water) to Fargo pipeline

Feature #19: Import Missouri River water via McClusky Pipeline To Hillsboro distribution site

Feature #20: Import Missouri River water to the James River and then to Fargo via a Jamestown-Fargo pipeline

Feature #21: Rural water systems supplied by Western Valley Red River Pipeline

C. Action Alternatives: Combination (Multi-Component) Options

· No Action Options

Alternative #1: Future without scenario

· In-basin Options

Alternative #2: Construction of Lake Kindred on the Sheyenne River

Alternative #3: Enlargement of Lake Ashtabula

Alternative #4: Utilize groundwater augmentation

· Transfers from out-of basin

Alternative #5: Bismarck (Missouri River water) to Fargo pipeline

Alternative #6: Lake Oahe (Missouri River water) to Wahpeton pipeline

Alternative #7: Import water to the upper Sheyenne River from the McClusky Canal at Mile 59 and/or 70

Alternative #8: Rural water systems supplied by Western Valley Red River Pipeline from the McClusky Canal

A. NO ACTION (BASELINE CONDITION) OPTION

The following model simulations represent baseline conditions by which proposed water development features will be compared. Existing baseline conditions are represented by 1994 recorded demand conditions. Future baseline conditions represent the projected basin demand conditions (year 2050) as estimated by the Bureau of Reclamation and Participating cities. It should be noted that this report will only focus on utilizing the 2050 Reclamation demand baseline for comparing feature alternatives. In addition, featured alternative model runs will also only use Reclamation demands. The Participant demand baseline run is presented here for information purposes only.

1. Existing (Year 1994) Condition Baseline

a. Model Run R30k94: ***Existing Demand Condition Baseline***

Run R30k94 Description: This simulation, developed to represent basin conditions under the present (year 1994) level of development was based on recorded 1994 demand levels of municipal and industrial (M&I) water use. M&I demands were based on information provided by the participating cities and water right priority dates provided by the NDSWC. Irrigation demands in North Dakota were based on water right acreage provided by the NDSWC in combination with the Modified Blaney-Criddle (Soil Conservation Service, 1970) crop consumptive use methodology at full water right acreage. Demands in Minnesota were derived from cities and U.S. Geological Survey (USGS) depletion estimates (Guenther, et al., 1990). Tables 18 and 19 list the 1994 M&I demands (annual and monthly) utilized in this simulation.

Lake Ashtabula, located on the Sheyenne River was considered to be the major storage facility in the basin. Baldhill Dam constructed by the Army Corps of Engineers in 1951 forms the Lake. Storage began on July 30, 1949. The original (year 1951) capacity of this facility was adjusted to account for sediment inflow since construction. As part of the simulation, the Lake was operated in accordance with the current operating plan including drawdown and fill requirements. The simulation was started with Lake Ashtabula at its minimum conservation pool and keeping the minimum pool full. Drawdowns were limited to elevation 1257 feet MSL and releases were limited to current structural and channel capacities (2400 cfs). Final compilations of storage shortages were based on the Thomas-Acker Plan (North Dakota State Water Commission 1992). The Thomas-Acker Plan was simulated by splitting the reservoir into five separate, proportionally sized facilities so that each city involved could proportionally have inflow, outflow, and evaporation computed based on its allowed percentage as stated in the agreement. A 6^{th} reservoir was set up to mimic additional storage for use by downstream entities as part of the Lake Ashtabula expansion option. More detail regarding this procedure can be found in the Lake Ashtabula description section of the model discussion.

Table 18. River Valley water Needs Assessment File: Dem94-50.wk4 v.6/23/98

Present (1994) Condition Population and Municipal and Industrial Water Use

Municipality	1994 Population	Water Supply Source	1994 Billed Water Use (gallons)	Estimated Water System Losses (percent)	1994 Raw Water Demands (gallons)	1994 Raw Water Demands (acre-feet)	Raw Water Per Capita Demand (gpc/d)	Billed Water Per Capita Demand (gpc/d)
Fargo	80,928	Red and Sheyenne Rivers	3,434,596,000	25.3 [5]	4,597,660,000	14,110	156	116
West Fargo	13,771	Ground water	454,865,000	N/A [3,4]	445,193,200	1,366	89	90
Moorhead, MN	33,072	Red River and Ground water	1,344,150,000	3.8 [4,5]	1,397,690,000	4,289	116	111
Valley City	7,068	Sheyenne River and Ground water	279,660,000	3.4 [2]	289,440,000	888	112	108
Grand Forks	50,168	Red and Red Lake Rivers	2,068,875,000	15.8 [2]	2,456,154,260	7,538	134	113
East Grand Forks	9,013	Red Lake River	423,199,065	22.8 [2]	548,293,000	1,683	167	129
Grafton	5,086	Red and Park Rivers	250,371,400	16.4 [2]	299,445,300	919	161	135
Drayton	904	Red River	52,000,000 [6]	13.9 [2]	60,385,000	185	183	158
Wahpeton	9,207	Ground water	300,010,000	22.9 [2]	389,256,000	1,195	116	89
Breckenridge, MN	3,682	Ground water	112,172,000	26.5 [2]	152,550,000	468	114	83
Mayville	2,025	Goose River	51,666,110	27.2 [2]	70,946,000	218	96	70
Neche	427	Pembina River	14,686,300	9.1 [3,5]	16,154,930	50	104	94
Park River	1,532	Park River	48,489,375	24.8	64,522,000	198	115	87
Pembina	621	Red River	26,484,023	6.0	28,174,493 [1]	86	124	117
Langdon	2,085	Mount Carmel Dam/Mulberry Ck Res	60,416,200	25.3 [2]	80,878,447	248	106	79
Walhalla	1,052	Ground water	63,725,554	14.0 [2]	74,094,000	227	193	166
TOTALS:	220,641		8,985,366,027		10,970,836,630	33,668		

1 No record is available for raw water diversion for Pembina. Assuming a similar loss as was determined for Park River (6%) the listed demand was computed

2 Loss rate computed by determining the ratio between billed (delivered) and raw intake water as provided by the city.

3 Percent loss does not match difference between billed water and raw water for billed water is greated than raw water value because of the billing structure used by the city. In the case of this city water is billed at a gallon per month use rate whether or not the customer uses the set amount of water.

4 Loss estimation provided by the city. Also see footnote 5.

5 Losses for the city of Fargo have varied on an annual basis historically. After discussions with the city engineer, it was agreed to used 17.5 percent as an average annual loss rate in the model under future conditions.

6. City of Drayton figures estimated by back calculation using the raw water demand and loss rate as provided by the city.

7. City of Fargo demand from Bob Welton, City of Fargo. State Figures vary (12930 acre-feet in 1994). The larger of the two numbers was used in the model.

Table 19: Red River Valley Water Needs Assessment File: RRD1994a.WK4 Corresponds with DEM94-50.wk4 dated 1/9/97

1994 Existing Conditions Monthly Demand Summary (Units = 1000s acft/month)

DEMAND BREAKDOWN BY MODEL DIVERSION NUMBER AND MODEL WATER RIGHT DESIGNATION

City/User (d=diversion no.)	Priority Date	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	MAXIMUM ALLOWED *BY WATER RIGHT*
700 VALLEY CITY d991	1963	63.0	69.3	74.6	73.7	83.5	93.2	80.8	75.5	72.8	69.3	65.7	66.6	888.0	6686.0
710 LISBON d992	1982	26.5	29.1	31.3	31.0	35.1	39.2	33.9	31.7	30.6	29.1	27.6	28.0	373.0	373.0
Note: Actual Lisbon use from surface water totalled 3.2 AF/yr in 1994 - used in model															
720 FARGO d104 (non strge)	1957	1001.8	1100.6	1185.2	1171.1	1326.3	1481.5	1284.0	1199.3	1157.0	1100.6	1044.1	1058.3	14110.0	109500.0
730 WEST FARGO d049	1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	200.0
800 MOORHEAD d800	N/A	304.5	334.5	360.3	356.0	403.2	450.3	390.3	364.6	351.7	334.5	317.4	321.7	4289.0	Dummy
740 GRAND FORKS d128	1960	565.4	557.8	572.9	572.9	663.3	686.0	618.1	761.3	670.9	663.3	595.5	610.6	7538.0	33600.0
810 EAST GRAND FORKS d810	N/A	126.2	124.5	127.9	127.9	148.1	153.2	138.0	170.0	149.8	148.1	133.0	136.3	1683.0	Dummy
750 GRAFTON d144	1961	65.2	71.7	77.2	76.3	86.4	96.5	83.6	78.1	75.4	71.7	68.0	68.9	919.0	1296.6
760 DRAYTON d149	1956	13.1	14.4	15.5	15.4	17.4	19.4	16.8	15.7	15.2	14.4	13.7	13.9	185.0	5100.0
770 PEMBINA d164	1989	6.1	6.7	7.2	7.1	8.1	9.0	7.8	7.3	7.1	6.7	6.4	6.5	86.0	154.0

Notes:
1. Lisbon use in 1994 totalled 3.2 acre-feet. This amount was used in the model.
2. Moorheadand East Grand Forks are located in a Riparian Doctrine water law state. A dummy water right was assigned to this city with a priority date 1 day senior to Fargo's water right date.
3. The existing Cargill Plant near Wahpeton was assumed to have a constant demand of 500 acre-feet per month (6000 acre-feet per year).
4. Diversion numbers are model designations only. Actual permit numbers can be found in Attachment H.

A minimum operational release of 13 cfs was included in the simulation based on the operating plan. A maximum release of 2,400-cfs (maximum operational level – to account for downstream channel capacity) and a minimum of 13 cfs were observed in the simulation. Lakes Orwell and Traverse, and the Red Lakes in northwestern Minnesota were also included in the model, but at much less detail. Rather, historic depleted flows as derived by Guenther, et.al. (1991) were used to represent operations of these facilities.

No instream flow requirements were included in this simulation, as there are no state requirements to maintain instream flows in rivers and streams of North Dakota. A discussion and analysis of modeled versus desired instream flow levels for this model run are contained in the final report of this study as well as in the Phase I, Part B instream flow report (Raines, 1998).

A summary of existing city and industrial shortages, river flow activity and Lake Ashtabula activity for this run are discussed below and are listed in Tables 20 through 23. A more detailed listing of monthly shortages by city can be found in Attachment H discussion of the run results follows.

Run R30K94 Results: Under the conditions simulated by this model run, the year with maximum shortages was 1934. During this year, M&I shortages were estimated to total 4,210 acre-feet. Of these shortages 2,290 were attributed to cities and 1,920 were from "other" industry including the Cargill and New Industry plants. M&I shortages occurred in 11 of the 54 years simulated, most of these being in the 1930s drought period.

Irrigation shortages were also noted for this study. Irrigation water rights were mostly junior to M&I rights. The worse case year for irrigation totaled 11,100 acre-feet in shortages. The average annual shortage for the 54-year simulation was 1,300 acre-feet. Irrigation shortages were observed in the basin each year. *These irrigation shortages should be viewed with caution. They are representative of an attempt to meet full water right crop production each year*. In reality, during dry years, irrigators with junior water rights may be forced to limit their irrigation levels to fewer acres. Also, this analysis does not consider lands placed out of production as part of a variety of soil conservation and agricultural programs. The irrigation portion of this study merely demonstrates a worse case situation with maximum acreage under cultivation.

Lake Ashtabula proved to be a vital source of water under the conditions of this simulation. The reservoir provided water to meet most of the demands for Fargo, West Fargo, Lisbon, Valley City, and Grand Forks during the simulated 1930s drought. In fact, Lake Ashtabula's entire conservation storage of 40,160 acre-feet was utilized during this period. The average monthly lake content for the 54-year simulation period was 63,634 acre-feet. The average monthly release from the lake was approximately 102 cfs.

Table 20: City Shortage Summary for Run R30K94

Condition: Year 1994 demands (existing conditions)

	Drayton	East Grand Forks[1]	Fargo[2]	Moorhead[3]	Grafton	Grand Forks[2]	Lisbon[2, 4]	Valley City[2]	West Fargo[2,5]
No. years with shortages:	1	0	0	9	2	0	0	0	0
Average annual shortage for 54-year simulation period (acre-feet):	1	0	0	180	5	0	0	0	0
Average annual shortage for years with shortages (acre-feet):	30	0	0	1082	140	0	0	0	0
Largest annual shortage (acre-feet) and year:	30 (1937)	0	0	2290 (1934)	210 (1937)	0	0	0	0
Largest shortage percent of Total surface water demand (percent):	16.2	0	0	53.3	23.3	0	0	0	0

[1] East Grand Forks potentially could have shortages on the Red Lake River. Since limited detail was included in the model on the Red Lake River watershed, only shortages pertaining to the Red River of the North are listed.
[2] Fargo, Grand Forks, Lisbon, Valley City, and East Grand Forks storage shortages based on storage allocations as set forth in the Thomas-Acker Plan (North Dakota State Water Commission [NDSWC] memorandum to Director, Hydrology Division dated, November 27, 1992).
[3] The city of Moorhead is not supplied by Lake Ashtabula. Shortages indicated are for the Red River only.
[4] Although Lisbon is not one of the original "Participant communities" of this effort, the city did experience shared storage and other shortages in several scenarios; therefore, it was included in this table for informational purposes.
[5] No Surface demands existed for West Fargo in 1994.

Table 21: Industrial Shortage Summary for Run R30K94

Condition: Year 1994 demands (existing conditions)

	Existing Cargill Plant 1 Wahpeton
No. years with shortages:	10
Average annual shortage for 54-year simulation period (acre-feet):	189
Average annual shortage for years with shortages (acre-feet):	1021
Largest annual shortage (acre-feet) and year:	1740 (1934)
Largest shortage percent of Total surface water demand (percent):	29

Note: Cargill plants at Abercrombie, Fargo, Kindred, and Drayton not considered being in operation for this simulation

Table 22: River Flow Activity for Selected Flow Points for Run R30K94[3]
Condition: Year 1994 demands (existing conditions)

	Estimated Non-Damaging Channel Capacity[1,2] (cfs)	**Number Of Months Above Channel Capacity**	**Average Monthly Flow (cfs)**	**Highest Simulated Monthly Flow (cfs)**	**Lowest Simulated Monthly Flow (cfs)**
Sheyenne River Near Warwick	600	11	49	1421	0
Sheyenne River Below Baldhill Dam	4000	0	102	2400	9
Sheyenne River Near Valley City	2500	3	107	2890	8
Sheyenne River Near Lisbon	2250	5	127	3212	<1
Sheyenne River Near Kindred	2800	1	159	2984	0
Red River Near Fargo	3000	19	552	9897	0
Red River Near Halstad	15000	4	1317	20595	8
Red River Near Grand Forks	21000	8	2669	36189	10
Red River Near Emerson	26000	11	3561	72506	9

1. Pat Foley, Corps of Engineers – St. Paul District, Personal Communication.
2. Raines, 1998.
3. Rounded to nearest whole cfs.

Table 23: Lake Ashtabula Storage Activity for Run R30K94
Condition: Year 1994 demands (existing conditions)

Storage Facility	Maximum Storage (acft)	Minimum Storage (acft)	Average Monthly Storage (acft)	Months below or at Minimum Storage	Maximum Outflow (cfs)	Minimum Outflow (cfs)	Average Outflow (cfs)
Lake Ashtabula Combined Storage	68160	30101	63634	1	2400	9	102
Lake Ashtabula (Fargo Portion)	38260	15700	35393				
Lake Ashtabula (West Fargo Portion)	1022	452	974				
Lake Ashtabula (Grand Forks Portion)	21350	9310	20098				
Lake Ashtabula (Lisbon Portion)	409	181	392				
Lake Ashtabula (Valley City Portion)	7157	3161	6777				
	Maximum Storage	**Minimum Storage**	**Average Monthly Storage**				
Lake Ashtabula Combined Elevation (feet)	1265.9	1257.3	1265.5				
Lake Ashtabula Combined Surface Area (Acres)	5550	3530	5429				

2. Future (Year 2050) Condition Baseline (No Action Alternatives)

a. Model Run R30K50: ***Year 2050 conditions under projected Reclamation demands with existing Corps of Engineers Lake Ashtabula operation plans in effect***

Run R30K50 Description: This run simulated the Red River Valley under the same operating conditions as in the above 1994 run but with the exception that year 2050 Reclamation demand conditions were assumed to be in existence. This demand included four "New Industry units" of demand placed on the lower Sheyenne and upper and lower Red Rivers to simulate potential industrial growth in the study area. Tables 4 and 5 display the Reclamation M&I demand levels used in this simulation.

Irrigation demands were kept at the same level as the 1994 existing condition simulation (run R30K94).

Lake Ashtabula was operated at a minimum elevation 1257 feet MSL (a capacity of 28,000 acre-feet – adjusted from 1994 conditions to account for sediment deposition). This was the starting capacity for the lake for this simulation. The maximum top of conservation capacity of the lake, allowing for sedimentation was 66,600 acre-feet. All other operational characteristics of Lake Ashtabula were the same as in the existing condition run (R30K94).

A summary of shortages, river flow activity and Lake Ashtabula activity for this run are discussed below and are listed in Tables 24 through 27.

Run R30K50 Results: Under the conditions simulated by this model run, the year with overall maximum shortages was 1934. During this year, M&I shortages were estimated to total 53,560 acre-feet. Of this shortage 31,400 acre-feet was attributed to cities and 22,160 acre-feet was from "other" industries including the Cargill and New Industry plants. Shortages occurred in 47 of the 54 years simulated. The largest shortages occurred during the extreme drought years experienced in the 1930s .

Irrigation shortages were also noted for this study. Irrigation water rights were mostly junior to M&I rights. The worse case year (1934) for irrigation totaled 14,100 acre-feet in shortages. The average annual shortage for the 54-year simulation was 1,600 acre-feet. Shortages were observed in the basin each year. *These irrigation shortages should be viewed with caution. They are representative of an attempt to meet water right crop production each year*. In reality, during dry years, irrigators with junior water rights may be forced to limit their irrigation levels to fewer acres. Also, this analysis does not consider lands placed out of production as part of a variety of soil conservation and agricultural programs. The irrigation portion of this study merely demonstrates a worse case situation with maximum acreage under cultivation.

Lake Ashtabula proved to be a vital source of water under the conditions of this simulation. The reservoir provided water to meet most of the demands for Fargo, West Fargo, Lisbon, Valley City, and Grand Forks during the 1930s drought. In fact, Lake Ashtabula's entire conservation storage of 38,300 acre-feet was utilized during this period. The lake reached its minimum of 28,000 acre-feet in 71 months of the simulation (approximately 11 percent of the total simulated months). The average monthly lake content for the 54-year simulation period was 59,138 acre-feet. The average release from the lake was 102 cfs. A maximum release of 2,400 cfs (maximum operational level) and a minimum of 0 cfs were observed. The potential of using a portion of the remaining 28,000 acre-feet (set aside for fish and wildlife purposes) during extreme drought has been raised as an alternative solution to meet shortage needs. This alternative was tested as part of the simulation designated R00K50 (See Feature #13). See section 2.b for participant city demand model run P30K50 description and results.

Table 24 - City Shortage Summary for Run R30K50

Condition: Year 2050 Reclamation demands (Future Baseline conditions)

	Drayton	East Grand Forks[1]	Fargo[2]	Moorhead[3]	Grafton	Grand Forks[2]	Lisbon[2, 4]	Valley City[2]	West Fargo[2]
No. years with shortages:	1	0	11	10	2	0	2	1	15
Average annual shortage for 54-year simulation period (acre-feet):	1	0	2146	461	19	0	2	8	104
Average annual shortage for years with shortages (acre-feet):	60	0	10536	2487	260	0	60	430	376
Largest annual shortage (acre-feet) and year:	60 (1937)	0	25330 (1934)	5270 (1936)	290 (1937)	0	90 (1940)	430 (1940)	1490 (1940)
Largest shortage percent of total surface water demand (percent):	7.9	0	69.2	60.1	49.1	0	24.1	34.3	26.1

[1] East Grand Forks potentially could have shortages on the Red Lake River. Since limited detail was included in the model on the Red Lake River watershed, only shortages pertaining to the Red River of the North are listed.

[2] Fargo, Grand Forks, Lisbon, Valley City, and East Grand Forks storage shortages based on storage allocations as set forth in the Thomas-Acker Plan (North Dakota State Water Commission [NDSWC] memorandum to Director, Hydrology Division dated, November 27, 1992).

[3] The city of Moorhead is not supplied by Lake Ashtabula. Shortages indicated are for the Red River only.

[4] Although Lisbon is not one of the original "Participant communities" of this effort, the city did experience shared storage and other shortages in several scenarios; therefore, it was included in this table for informational purposes.

Table 25: Industrial Shortage Summary for Run R30K50

Condition: Year 2050 With Reclamation Demands

	Existing Cargill Plant 1 Wahpeton	Potential New Industry Plant 2 Fargo	Potential New Industry Plant 3 Abercrombie	Potential New Industry Plant 4 Drayton	Potential New Industry Plant 5 Kindred
No. years with shortages:	14	21	22	5	47
Average annual shortage for 54-year simulation period (acre-feet):	788	1006	1016	93	962
Average annual shortage for years with shortages (acre-feet):	3039	2587	2493	1000	1105
Largest annual shortage (acre-feet) and year:	5500 (1934)	5500 (1934)	5500 (1934)	1500 (1934)	4080 (1936)
Largest shortage percent of total surface water demand (percent):	92	92	92	25	68

Table 26: River Flow Activity for Selected Flow Point for Run R30K50[3]

Condition: Year 2050 With Reclamation Demands

	Estimated Non-Damaging Channel Capacity[1,2] (cfs)	**Number Of Months Above Channel Capacity**	**Average Monthly Flow (cfs)**	**Highest Simulated Monthly Flow (cfs)**	**Lowest Simulated Monthly Flow (cfs)**
Sheyenne River Near Warwick	600	11	49	1421	0
Sheyenne River Below Baldhill Dam	4000	0	102	2400	<1
Sheyenne River Near Valley City	2500	3	110	2890	0
Sheyenne River Near Lisbon	2250	5	130	3219	0
Sheyenne River Near Kindred	2800	1	158	2990	0
Red River Near Fargo	3000	19	510	9848	0
Red River Near Halstad	15000	4	1297	20584	<1
Red River Near Grand Forks	21000	8	2626	36148	0
Red River Near Emerson	26000	11	3537	72477	15

1. Pat Foley, Corps of Engineers – St. Paul District, Personal Communication.
2. Raines, 1998.
3. Rounded to the nearest whole cfs.

Table 27: Storage Activity for Run R30K50
Condition: Year 2050 With Reclamation Demands

Storage Facility	Maximum Storage (acft)	Minimum Storage (acft)	Average Monthly Storage (acft)	Months below or at Minimum Storage	Maximum Outflow (cfs)	Minimum Outflow (cfs)	Average Outflow (cfs)
Lake Ashtabula Combined Storage	66600	28000	59138	71	2400	0	102
Lake Ashtabula (Fargo Portion)	37363	15708	32402				
Lake Ashtabula (West Fargo Portion)	999	420	863				
Lake Ashtabula (Grand Forks Portion)	20846	8764	19011				
Lake Ashtabula (Lisbon Portion)	400	668	378				
Lake Ashtabula (Valley City Portion)	6993	2940	6484				
	Maximum Storage	**Minimum Storage**	**Average Monthly Storage**				
Lake Ashtabula Combined Elevation (feet)	1266	1257	1265				
Lake Ashtabula Combined Surface Area (Acres)	5550	3373	5222				

b. Model Run P30K50: ***Future year 2050 conditions under projected Participant city demands with existing Lake Ashtabula operation plans in effect***

Run P30K50 Description: This run simulated the Red River Valley under the same operating conditions as in the above R30k50 run but with the exception that year 2050 *Participant* (demands estimated by the participating focus communities) demand conditions were assumed in place (see Tables 6 and 7). Lake Ashtabula was operated minimum at elevation 1257 (a capacity of 28,000 acre-feet – also the starting capacity for the simulation). The maximum top of conservation capacity for the lake, allowing for sedimentation, was 66,600 acre-feet. All other operational Ashtabula criteria were the same as in the 2050 Reclamation Demand Baseline simulation (run R30k50).

A summary of shortages, river flow activity and Lake Ashtabula activity for this run are discussed below and are listed in Tables 28 through 31. A more detailed listing of monthly shortages by city can be found in Attachment H discussion of the run results follows.

Run P30K50 Results: Under the conditions simulated by this model run, the year with maximum shortages was 1934. During this year, M&I city shortages were estimated to total 80,910 acre-feet. Of these shortages 57,220 acre-feet were attributed to cities and 23,690 were from "other" industry including the Cargill plants. City M&I shortages occurred in 46 of the 54 years to varying degrees.

Irrigation shortages were also noted for this study. The worse case year (1934) for irrigation totaled 14,280 acre-feet in shortages. The average annual shortage for the 54-year simulation was 1,590 acre-feet. Shortages were observed in the basin each year. *These irrigation shortages should be viewed with caution. They are representative of an attempt to meet water right crop production each year.* In reality, during dry years, irrigators with junior water rights may be forced to limit their irrigation levels to fewer acres. Also, this analysis does not consider lands placed out of production as part of a variety of soil conservation and agricultural programs. The irrigation portion of this study merely demonstrates a worse case situation with maximum acreage under cultivation.

Lake Ashtabula proved to be a vital source of water under the conditions of this simulation. The reservoir provided water to meet most of the demands for Fargo, West Fargo, Lisbon, Valley City, and Grand Forks during the 1930s drought. In fact, Lake Ashtabula's entire conservation storage of 38,300 acre-feet was utilized during this period. The lake reached its minimum of 28,000 acre-feet in 80 months of the simulation (approximately 12 percent of the months). The average monthly lake content for the 54-year simulation period was 58,520 acre-feet. The average release from the lake was 102 cfs. A maximum release of 2,400 cfs (maximum operational level) and a minimum of less than one cfs were observed.

Table 28 - City Shortage Summary for Run P30K50

Condition: Year 2050 With Participant City Demands

	Drayton	East Grand Forks[1]	Fargo[2]	Moorhead[3]	Grafton	Grand Forks[2]	Lisbon[2, 4]	Valley City[2]	West Fargo[2]
No. years with shortages:	1	0	13	10	2	1	2	3	13
Average annual shortage for 54-year simulation period (acre-feet):	1	0	6018	466	9	5	1	19	113
Average annual shortage for years with shortages (acre-feet):	321	0	24997	2514	240	270	40	350	470
Largest annual shortage (acre-feet) and year:	320 (1937)	0	51130 (1934)	5340 (1934)	370 (1937)	270 (1937)	50 (1940)	680 (1940)	1140 (1940)
Largest shortage percent of total surface water demand (percent):	7.7	0	76.2	60.1	23.3	1.1	13.4	37.3	23.2

[1] East Grand Forks potentially could have shortages on the Red Lake River. Since limited detail was included in the model on the Red Lake River watershed, only shortages pertaining to the Red River of the North are listed.

[2] Fargo, Grand Forks, Lisbon, Valley City, and East Grand Forks storage shortages based on storage allocations as set forth in the Thomas-Acker Plan (North Dakota State Water Commission [NDSWC] memorandum to Director, Hydrology Division dated, November 27, 1992).

[3] The city of Moorhead is not supplied by Lake Ashtabula. Shortages indicated are for the Red River only

[4] Although Lisbon is not one of the original "Participant communities" of this effort, the city did experience shared storage and other shortages in several scenarios; therefore, it was included in this table for informational purposes.

Table 29: Industrial Shortage Summary for Run P30K50

Condition: Year 2050 With Participant City Demands

	Existing Cargill Plant 1 Wahpeton	Potential New Industry Plant 2 Fargo	Potential New Industry Plant 3 Abercrombie	Potential New Industry Plant 4 Drayton	Potential New Industry Plant 5 Kindred
No. years with shortages:	25	32	32	5	47
Average annual shortage for 54-year simulation period (acre-feet):	1201	1398	1463	93	962
Average annual shortage for years with shortages (acre-feet):	2595	2359	2469	1000	1106
Largest annual shortage (acre-feet) and year:	6000 (1934)	6000 (1934)	6000 (1934)	1500 (1934)	4080 (1936)
Largest shortage percent of Total surface water demand (percent):	92	92	92	25	68

Table 30: River Flow Activity for Selected Flow Point for Run P30K50[3]
Condition: Year 2050 Demands With Participant City Demands

	Estimated Non-Damaging Channel Capacity[1,2] (cfs)	**Number Of Months Above Channel Capacity**	**Average Monthly Flow (cfs)**	**Highest Simulated Monthly Flow (cfs)**	**Lowest Simulated Monthly Flow (cfs)**
Sheyenne River Near Warwick	600	11	49	1421	0
Sheyenne River Below Baldhill Dam	4000	0	102	2400	<1
Sheyenne River Near Valley City	2500	3	110	2890	0
Sheyenne River Near Lisbon	2250	5	129	3219	0
Sheyenne River Near Kindred	2800	1	158	2990	<1
Red River Near Fargo	3000	19	477	9805	0
Red River Near Halstad	15000	4	1290	20580	<1
Red River Near Grand Forks	21000	8	2619	36129	0
Red River Near Emerson	26000	11	3529	72462	13

1. Pat Foley, Corps of Engineers – St. Paul District, Personal Communication.
2. Raines, 1998.
3. Rounded to nearest whole cfs.

Table 31: Storage Activity for Run P30K50

Condition: Year 2050 With Participant City Demands

Storage Facility	Maximum Storage (acft)	Minimum Storage (acft)	Average Monthly Storage (acft)	Months below or at Minimum Storage	Maximum Outflow (cfs)	Minimum Outflow (cfs)	Average Outflow (cfs)
Lake Ashtabula Combined Storage	66600	28000	58520	80	2400	<1	102
Lake Ashtabula (Fargo Portion)	999	420	853				
Lake Ashtabula (West Fargo Portion)	20846	8764	18967				
Lake Ashtabula (Grand Forks Portion)	400	168	377				
Lake Ashtabula (Lisbon Portion)	6993	2940	6423				
Lake Ashtabula (Valley City Portion)	66600	28000	58520				
	Maximum Storage	**Minimum Storage**	**Average Monthly Storage**				
Lake Ashtabula Combined Elevation (feet)	1266	1257	1265				
Lake Ashtabula Combined Surface Area (Acres)	5550	3373	5222				