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Basin Wide Flood Flow Reduction Strategy

Flood damage reduction efforts have often focused on individual communities or interests and taken the form of a protection strategy. Commonly implemented protection measures include levees and diversion channels. While these measures are effective and can be implemented in a relatively short time frame, they do little to reduce the overall flood problem. In fact, they simply move excess flood water from one area of the basin to another. This forces basin planners to allocate protection on some basis of need. Determining in essence whether it is ok to protect large communities at the expense of small communities; small communities at the expense of farmsteads; farmsteads at the expense of farmland; and farmland at the expense of natural land (or vice versa).

The primary alternative to a protection strategy is a flood flow reduction strategy. This strategy reduces flows on the mainstem by altering the hydrology of the contributing watersheds as a basin wide effort. The benefits of reduced flooding would be distributed along the entire length of the Red River, not just to targeted communities. Equally important, the benefits would extend far upstream into the tributary watersheds. Implementing this strategy requires allocating the necessary flow reductions to each contributing watershed.

To assist in the flow reduction allocation process, the Red River Basin Commission developed a Red River Mainstem model. The model was based on Mike 11 software developed by DHI Water and Environment Inc, Denmark. It has been calibrated to simulate the 1997 spring flood. Physical features of the Red River and its flood plain are represented in the model as cross-section data. Hydrologic inputs are the measured flows from the main tributaries and derived flows from the ungaged tributary areas. This model can now be used to simulate the mainstem response to reduced flows from tributary areas.

As a preliminary exercise, the tributary flows were reduced in the model to meet a flow reduction goal of 20% along the entire length of the Red River Mainstem. A factor in selecting 20% reduction as an initial goal was the effect it would have had at Grand Forks in 1997. That amount would have reduced the flood to a level that the (then existing) levees would have been expected to withstand. The modeled results are shown on the attached figures. The flow reduction required from each subwatershed is illustrated as the difference between the existing and altered tributary hydrographs.

Tributary reduction strategies were based on timing, by targeting waters contributing the most to mainstem peaks. Other factors considered include tributary damage reduction and the practicality of achieving specific flow reductions. Tributary peak flow reductions ranged from 0 to 50%. Peak flow reductions on strategic tributaries averaged about 35%. The combined flow reduction on all tributaries upstream from Emerson totaled 885,000 acre-feet, which is about 13% of the total 1997 flood volume at Emerson.

The amount of constructed storage required to achieve a 20% reduction would likely be greater than 885,000 acre-feet depending on the quality (efficiency) of storage provided. Flow reduction can be achieved by implementing a wide variety of measures including on-channel or off-channel impoundments; culvert sizing or waffle storage; wetland restoration or land use change. Gate controlled flood storage impoundments are the most efficient measure to reduce flood flows. Strategically located and precisely operated, they may have close to 100% efficiency in meeting the flow reduction goal. That is, the amount of constructed storage required to meet the 20% reduction goal would not be much greater than 885,000 acre-feet. On the other hand, flood specific factors such as variability in runoff will likely leave some constructed storage underutilized. Other measures, such as culvert sizing, provide only short term storage. Short term storage, in the right location, can reduce peak flows, but in the wrong location, it can actually increase peak flows. A mix of measures may be the best approach. The combined efficiency of the mix in meeting the tributary flood flow reduction goal would have to be determined locally.

The modified tributary hydrographs from the 1997 flow reduction model will serve as a starting point for an allocation process. The allocation goal should be to distribute to each watershed a fair share of the responsibility to manage its flood flows and the local benefits that can be realized by doing so. Each watershed would determine, through the use of its own models, what would be required to modify its outflow hydrograph to approximate the flow reduction shown. They would be encouraged to do so in ways that also meet local flood control goals, so the resulting reduced outflow hydrographs may vary more or less from that originally allocated and thus result in more or less benefits on the mainstem. Some watershed areas may be unwilling or unable to meet their allocation goal. Their share would then need to be reallocated to another area. The model could then be used to determine the most effective ways to reallocate tributary flow reductions to achieve the mainstem goal.

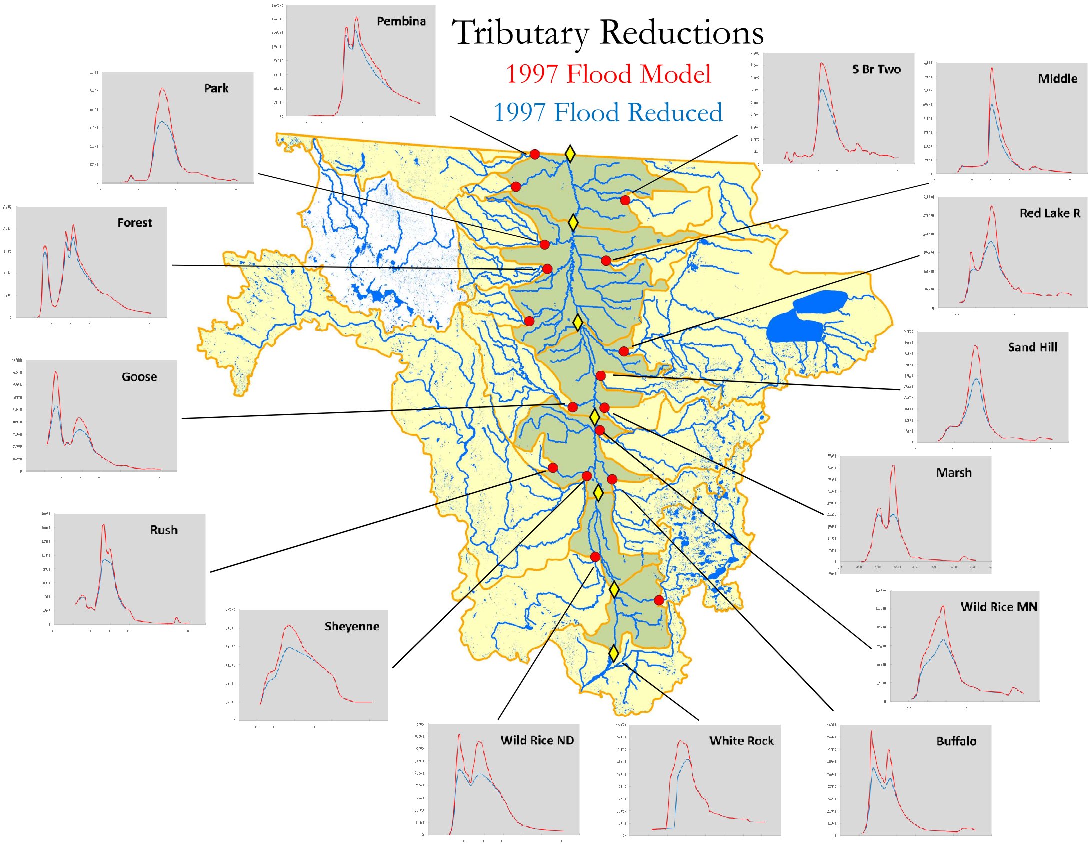
Implementing flood flow reduction will require significant investments over a relatively long time frame. The cost of gate controlled flood storage has recently been about $1,000 per acre-foot. At that price, 1 million acre-feet of gate controlled storage would cost about $1 billion. The most cost effective projects tend to get constructed first, so it is probable that the costs of later projects will be higher. This, along with inflation, will likely increase the final cost of implementation. Flood flow reduction projects can present great opportunities for multipurpose benefits such as water supply, water quality and other water related natural resources. Including these benefits will add to the overall costs. Those additional costs should not be allocated to flood damage reduction, but they do need to be considered in estimating the total amount of public investment (and benefit) that may be desired. Although the time frame for implementation is highly dependent on the availability of funding, it is also influenced by public acceptance and resolve. Historic construction rates of about 10,000 acre-feet per year have not been particularly difficult to maintain. At that rate it would take 100 years to construct 1,000,000 acre-feet. Given a very high priority of support, it could possibly be accomplished within 25 years.

Unlike quick fix strategies, flood flow reduction will provide a long term solution to the persistent and widespread flooding problems that plague the entire Red River Basin.

Tributary Reductions

1997 Flood Model

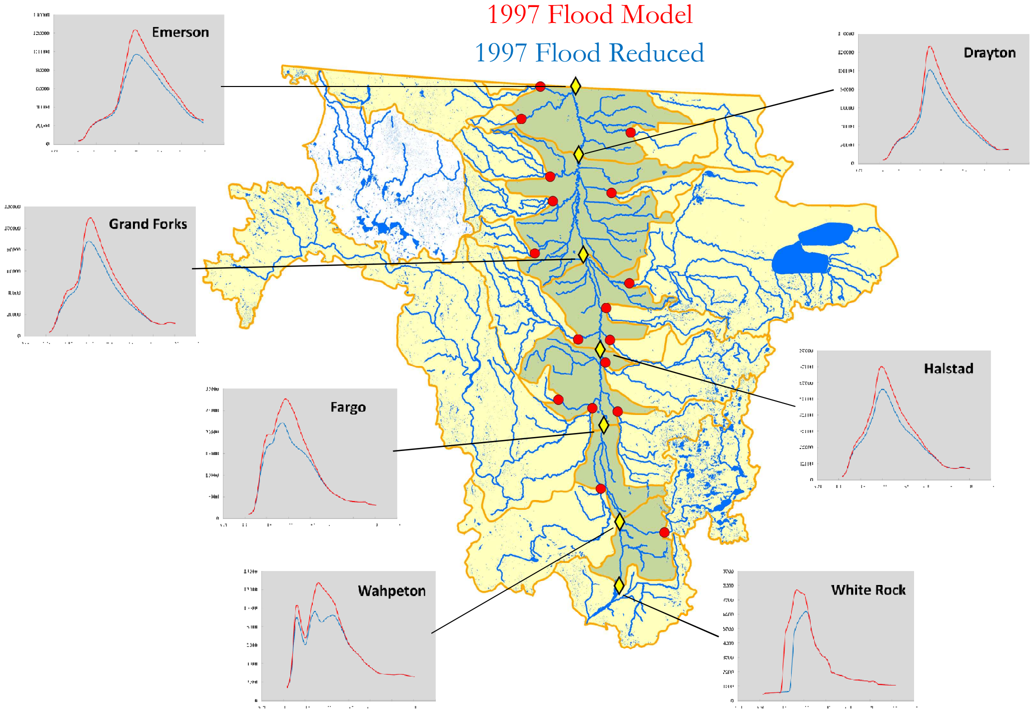
1997 Flood Reduced



Mainstem Results

1997 Flood Model

1997 Flood Reduced



20% Reduction Model

Summary of Tributary Flow Reductions

1997 Spring Flood

1/20/2010

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	Peak Flow Reduction	Peak Flow Reduction	Volume Reduction	Volume Reduction		Reduction Focus
Gaged Tributaries	%	cfs	%	acft		
BdS R @ White Rock	20%	1542	20%	61760		Store early water
Ottertail R @ Orwell	0	0	0	0		No reduction
Wildrice ND @ Abercrombie	35%	2854	17%	57908		Peak flow reduction
Sheyenne R @ Harwood	23%	2401	11%	68395		Peak flow reduction
Rush R @ Amenia	35%	508	13%	4324		Peak flow reduction
Buffalo R @ Dilworth	35%	2930	17%	38158		Peak flow reduction
Wild Rice MN @ Hendrum	35%	3610	20%	74385		Peak flow reduction
Goose R @ Hillsboro	35%	2820	16%	35356		Peak flow reduction
Marsh R nr Shelly	51%	2100	18%	15247		Peak flow reduction
Sand Hill R @ Climax	35%	1510	21%	22161		Peak flow reduction
Red Lake R @ Crookston	35%	9600	13%	119097		Peak flow reduction
Turtle R nr Arvilla	10%	90	13%	4615		Store late water
Forest R @ Minto	14%	300	7%	5875		Store late water
Middle R @ Argyle	35%	1330	23%	15067		Store late water
Park R @ Grafton	35%	1800	20%	26462		Peak flow reduction
S Br Two R @ Lake Bronson	27%	1100	14%	15208		Store late water
Tongue R @ Akra	7%	50	4%	1580		Store late water
Pembina R @ Neche	13%	1900	9%	51113		Peak flow reduction
Average/Total	**22%**		**13%**	**616709**		
Ungaged Areas	%	cfs	%	acft		
Rabbit R @ TH 75 ung	35%	2108	26%	24377		Peak flow reduction
BdS ungaged	13%	1135	9%	12119		Peak flow reduction
Ottertail ung	13%	500	12%	7217		Peak flow reduction
Fargo ungaged	13%	3000	13%	30433		Store late water
Halstad ung	13%	7500	13%	81002		Store late water
RLR ung	12%	1600	10%	11427		Store late water
GF ungaged	12%	4400	10%	32015		Store late water
Snake R ung	16%	1367	15%	17128		Store late water
Tamarac R ung	13%	563	12%	7179		Store late water
Drayton ung	8%	1370	10%	22208		Store late water
Emerson ung	7%	3000	7%	23364		Store late water
Average/Total	**14%**		**12%**	**268468**		
Total volume of flow reduction on the tributaries				**885177**	**acre-feet**	
				13%	**of total volume**	