White Paper – FM Diversion – Flood Frequency and Retention
Final – February 18, 2013

Flood Frequency:

Following the historic flood of 1997, the Federal Emergency Management Agency (FEMA) Regions V and VIII, along with the U.S. Army Corps of Engineers (USACE) – St. Paul District initiated a study to update the hydrology and hydraulics for the Red River of the North (RRN) mainstem. The study is titled "Regional Red River Flood Assessment Report, Wahpeton, North Dakota/Breckenridge, Minnesota to Emerson, Manitoba" and is dated January, 2003. Subsequently, FEMA, Region VIII initiated a study to update the hydrology, hydraulics, and floodplain mapping for the RRN and Wild Rice River in southern Cass County, ND and Clay County, MN. These studies formed the basis for the effective Digital Flood Insurance Rate Map (DFIRM) for Clay County, MN dated April 17, 2012 and preliminary partial county-wide DFIRM for Cass County, ND dated July 31, 2012. Both the FEMA and USACE led studies included calibration of the hydraulic models to the 1997 historic flood event. The FEMA study maintains the hydrology from the prior FIS for the RRN at Fargo. This hydrology was developed in 1971 and does not take into account recent flood events. The FEMA study included the RRN through the communities of Oxbow/Hickson/Bakke Subdivision. The Oxbow/Hickson/Bakke Subdivision area was not included in the USACE study since the two study areas did not overlap.

Following the historic 2009 flood on the Red River, the U.S. Army Corps of Engineers – St. Paul District (USACE) fast-tracked an ongoing feasibility study to evaluate long-term flood protection options for the cities of Fargo, ND and Moorhead, MN. As part of the feasibility study, hydrology for the Red River was updated and a new hydraulic model (unsteady HEC-RAS) was developed. The hydrology utilized the recommendations of an Expert Opinion Elicitation (EOE) panel that concluded the region is in a wet cycle. The EOE panel included a field of experts in hydrology and hydraulics from several Federal and State agencies that are familiar with the RRN watershed and climate change. Based on this recommendation a wet cycle period of record from 1942 to 2009 was used for the hydrology development for this study, and the proposed FM Area Diversion Project. The USACE hydrology also included a full Period of Record (POR) analysis that included records from 1902 to 2009 along with the historic 1897 flood event.

The following table provides a summary of the hydrology developed for the FEMA/USACE study as well as the USACE feasibility study leading to the proposed FM Area Diversion Project. Discharges for the Red River are provided for both the USGS Fargo streamgage as well as the USGS Hickson streamgage. Discharges for the Wild Rice River are provided for the USGS Abercrombie streamgage. Historic discharges for these locations are also provided for the 1997, 2006, 2009, 2010, and 2011 historic flood events.

Event	RRN Discharge (cfs) at USGS Gage at Fargo, ND	RRN Discharge (cfs) at USGS Gage at Hickson, ND	WRR Discharge at USGS Gage at Abercrombie, ND	Hickson percentage of Fargo	Abercrombie percentage of Fargo
10-year FEMA	10,300	7,648	4,944	74.3	48.0
10-year USACE EOE	17,000	10,500	6,185	61.7	36.4
10-year USACE POR	13,865	8,400	5,900	60.6	42.6
50-year FEMA	22,300	12,307	10,430	55.2	46.7
50-year USACE EOE	29,300	19,000	11,655	64.8	39.8
50-year USACE POR	26,000	19,000	11,700	73.1	45.0
100-year FEMA	29,300	14,173	13,220	48.4	45.1
100-year USACE EOE	34,700	22,000	13,780	63.4	39.7
100-year USACE POR	33,000	23,100	13,500	70.0	40.9
500-year FEMA	50,500	21,818	20,460	43.2	40.5
500-year USACE EOE	61,700	37,000	18,342	60.0	29.7
500-year USACE POR	66,000	35,000	18,000	53.0	27.2
1997 Historic	28,000	13,300	9,470	47.5	33.8
2006 Historic	19,900	14,400	9,180	72.3	46.1
2009 Historic	29,500	23,700	14,100	80.3	47.8
2010 Historic	21,200	12,200	8,790	57.5	41.5
2011 Historic	27,200	13,900	11,800	51.1	43.4

Flooding on the RRN at Fargo is largely driven by combined flows from the RRN and Wild Rice River. These flows are attenuated somewhat by the natural floodplain storage at the Wild Rice River and RRN confluence before they reach Fargo. Flooding on the RRN at Hickson is driven by flows on the RRN which include a combination of flows from the Bois de Sioux and Ottertail Rivers. As shown in the table above, the relative flow on the RRN at Hickson compared to the RRN at Fargo varies by flood event.

As shown in the table above, the 2009 flood event at Hickson was a larger statistical flood event than at Fargo. The 2009 flood discharge at Hickson approached a 100-year flood based on the USACE hydrology, while it was approximately a 50-year flood at Fargo based on the USACE hydrology. It is typical that a flood event will have discharges of varying frequencies along a river's path due to the regional variation of precipitation and runoff. The 2009 flood was driven by a number of factors, including above average moisture in the fall of 2008; significant frost in the ground as a result of cold temperatures and limited initial snowpack in the fall of 2008; heavy snowpack in the watershed upstream from Fargo-Moorhead; and a rapid warm-up combined with heavy rains in portions of the watershed that led to a rapid snowmelt. This rain combined with the rapid snowmelt was a major factor in the size of the flood event at Hickson.

During historic flood events, including the 2009 flood, the communities of Fargo, ND and Moorhead, MN, along with rural areas in Cass County, ND and Clay County, MN implemented significant flood fighting efforts to protect properties within those communities. These measures primarily included the construction of emergency clay and

sandbag levees. The communities have also constructed a number of permanent levees and floodwalls since the 2009 flood. The permanent projects were subject to permitting and review by the appropriate agencies and were constructed in compliance with local, state, and federal rules. While protecting properties, the permanent and emergency flood protection measures limit the conveyance of water through the Red River by constricting the flow of water. This increases water levels in the Red River through the communities which extends to upstream areas. The constriction also tends to reduce the amount of discharge through the communities due to the higher stages and subsequent storage of water upstream. Modeling performed during the feasibility study has shown that any upstream impacts attenuate to zero in the Oxbow/Hickson/Bakke Subdivision area.

Retention:

A number of studies have been conducted to investigate the benefits of retention along the RRN mainstem. These studies include:

- ***Red River Basin Commission – Long Term Flood Solutions for the Red River Basin, September, 2011.*** The Red River Basin Commission issued their final report on Long Term Flood Solutions (LTFS) for the Red River Basin in September, 2011. The LTFS study evaluated storage requirements in the Red River Basin to achieve a 20% flow reduction of 1997 peak flows along the Red River mainstem. The LTFS study showed this reduction is achievable, and estimated 125,000 acre-feet of storage would be required upstream from Wahpeton/Breckenridge to achieve this goal, which would result in a stage reduction of approximately 2.4 feet at Wahpeton/Breckenridge during a simulated 1997 flood event. Similarly, the LTFS showed an estimated storage of 240,000 acre-feet would be required upstream from Fargo/Moorhead to achieve the 20% reduction goal, which would result in a stage reduction of approximately 2.3 feet at Fargo/Moorhead during a simulated 1997 flood event. As noted in the 'flood frequency' table above, the 1997 flood event at Fargo is now considered less than a 50-year event by the USACE.

- ***U.S. Army Corps of Engineers – Fargo-Moorhead and Upstream Feasibility Study.*** Modeling performed by the U.S. Army Corps of Engineers estimated that a system of impoundments with 200,000 to 400,000 acre-feet of storage could reduce the flood stage at Fargo-Moorhead by 1.6 feet for a 32,000 cfs flood event, which is slightly less than a 100-year event defined by the USACE.

- ***FM Diversion, Phase 3***. Initial design and planning for the proposed FM Area Diversion Project resulted in downstream impacts that were deemed unacceptable. These impacts varied from 6 inches to 2 feet on the RRN for the 100-year flood event, depending on the location and width of the floodplain. Houston Engineering, Inc. and Moore Engineering, Inc. performed an evaluation for the Southeast Cass Water Resource District to determine the amount of retention that would be needed to mitigate the downstream impacts. The study results were

presented to the FM Metro Flood Study Work Group on March 4, 2010 and showed approximately 215,000 acre-feet of effective storage would be needed to mitigate the downstream impacts. The effective storage was computed where the major tributaries enter the RRN mainstem. The study estimated this would equate to 400,000 to 600,000 acre-feet of distributed storage throughout the RRN watershed upstream from Halstad, MN.

- ***Wild Rice River Retention Studies.*** Local Water Resource Districts in North Dakota have completed a sensitivity analysis for the 2009 flood event on the Wild Rice River that demonstrated how distributed storage is not a viable option to replace the storage component of the diversion channel. Modeling showed that if this option were pursued for the Wild Rice River, nearly all of the distributed storage would need to be placed in eastern Richland County. Additionally, even if this occurred, the distributed storage would not be enough to replace the storage required for the diversion channel. These results could also be applied to other tributaries and Wilkin County.

The results of these studies are fairly consistent and estimate potential benefits from upstream storage. These studies show that while some flood reduction benefits can be achieved on the RRN through retention, retention alone does not provide the desired level of flood protection for communities along the RRN mainstem. This includes Fargo-Moorhead as well as the communities of Oxbow/Hickson/Bakke Subdivision. This is why retention was eliminated as a stand-alone plan for a flood solution as part of the Final Fargo-Moorhead Metro Feasibility report and Environmental Impact Statement (July 2011). Similarly, the volume of retention needed farther upstream in the RRN watershed to mitigate downstream impacts from the FM Diversion would be significantly higher than the approximately 200,000 acre-feet included in the upstream staging area.

With that being said, retention can still provide local benefits and limited downstream benefits. In recognition of these benefits, the Flood Diversion Authority has committed $25 Million toward retention projects upstream of the FM Area.