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Expanded Geographic Assessment of the Agricultural Risk of Temporary Water Storage for FM Diversion

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Preface

A project as large as the Fargo/Moorhead Area Diversion (FM Diversion) has the potential to affect many different constituents. Various elements of the Diversion have been discussed, studied, and debated; however, the issue of how temporary water retention might affect agricultural production has not received much analytical focus.

The Department of Agribusiness and Applied Economics at North Dakota State University in 2015 conducted the first economic risk assessment of the potential effects of temporary water storage on agricultural production resulting from the use of the FM Diversion. That initial study provided insights on flooding duration, variability of those effects based on land elevation and flood size, expected timeline for the effects of flooding to be gone, quantified the risk of delayed planting and its potential financial impact on producers.

As the understanding of the hydrology associated with FM Diversion's short term water retention improves, the geographic scope of inundation associated with short term water becomes more defined. The first study conducted by NDSU excluded some lands along rivers and tributaries and additional lands further upstream of the embankment largely because hydrology data associated with water storage in those areas were unavailable at that time. Those additional areas are addressed in this study.

Despite the previous NDSU study and this study's expanded geographic scope, several important economic issues remain unquantified. Even though the two studies were not designed to assess all agricultural production-related issues, they provide a strong foundation from which additional agricultural production questions can be addressed.

Table of Contents

List of Tables	vi
List of Figures	x
List of Appendix Tables	xii
List of Appendix Figures	xiv
Glossary of Terms.....	xv
Executive Summary.....	xviii
Study Approach.....	xviii
Results.....	xix
Conclusions	xxiii
Recommendations	xxiv
Introduction	1
Implications for Agricultural Production.....	3
Data and Method	5
Flood Start Dates	6
Planting Start Dates	7
Planting Rates.....	7
Crop Share	7
Crop Prices.....	7
Yield Losses.....	7
Hydrology Data.....	8
Storage Area versus Land Inundated	9
Dry-down Period	9
Planting Framework	10
Study Limitations.....	11
Results.....	12
Hydrology in the Staging Area	12
Evaluation of Potential Planting Delays.....	12
Evaluation of 10-year, 25-year, 50-year, 100-year, and 500-year Flood Events	12
Estimation of Gross Revenues Only in Years With Losses	12
Estimation of Potential Revenue Losses by Crop.....	12
Distribution of Total Revenue Losses.....	12
Hydrology in the Staging Area	13
Evaluation of Potential Planting Delays.....	17
Flood Start Dates and Planting Dates for Wheat, Corn, and Sugarbeets	18
Flood Start Dates and Planting Dates for Soybeans	24
Time Required for Effects of Flooding to be gone During Flood Years.....	29
Summary of Planting Dates, Flood Start Dates, and Time Required for Effects of Flooding to be Gone	35
Evaluation of 10-year, 25-year, 50-year, 100-year, and 500-year Flood Events	37
Probability of Losses During a Flood Event.....	37
10-year Flood Event.....	37
25-year Flood Event.....	38
50-year Flood Event.....	38
100-year Flood Event	38
500-year Flood Event	38
Gross Revenues per Acre With and Without Diversion	45
10-year Flood Event.....	45
25-year Flood Event.....	45
50-year Flood Event.....	46
100-year Flood Event	46

Table of Contents (continued)

500-year Flood Event	46
Estimation of Gross Revenues Only in Years When Diversion Creates Losses	52
Estimation of Potential Revenue Losses by Crop.....	55
Distribution of Revenue Losses.....	58
Sensitivity of Results to Key Parameters	60
Evaluation of 1997 type Flood Event.....	61
Probability of Losses During a Flood Event.....	61
Gross Revenues per Acre With and Without Diversion	63
Estimation of Gross Revenues Only in Years When Diversion Creates Losses	65
Estimation of Potential Revenue Losses by Crop.....	66
Distribution of Gross Revenues	67
Loss of Insurance Coverage	69
Converting Event-level Estimates into Annualized Values.....	69
Conclusions	70
Discussion	70
Economic Conclusions	71
Recommendations	73
References	74
Appendix A Hydrology Data for Storage Areas, With and Without Diversion Conditions, 10-year, 25-year, 50-year, 100-year, 500-year, and 1997-like Flood Events FM Diversion Staging Area	75
Appendix B Likelihood of Per-Acre Revenue Losses by Crop.....	180
Appendix C Low, Average and High Per-Acre Revenue Losses by CropDue to Diversion, Hydrology Groups 3 and 5	271

List of Tables

<u>Table</u>	<u>Page</u>
1 Comparison of Agricultural Parameters with and without 2015 Data	6
2 Description of General Hydrology Conditions for Storage Areas Within the FM Diversion Staging Area	13
3 Acreage Inundated by Spring Flood Events, by Flood Frequency, With and Without FM Diversion Staging Area	14
4 Total Acreage of Storage Areas affected by Spring Flood Events, by Flood Frequency, With and Without FM Diversion Staging Area.....	14
5 Difference in Storage Areas Acreage affected by Spring Flood Events, by Flood Frequency, With and Without FM Diversion Staging Area.....	15
6 Acreage of Hydrology Groups, by Size of Flood Event, FM Diversion Staging Area	16
7 Days from Staging Activation until Water Leaves the Storage Area, Average of All Storage Areas Within Each Hydrology Group for Each Flood Event.....	16
8 Distribution of Storage Areas, by State, by Size of Flood Event, and Hydrology Group.....	17
9 Historical Dates, Red River Reaches 17,000 cfs in Fargo, Regional Planting Start Dates for Sugarbeets in North Dakota, 2000 through 2014	20
10 Monte Carlo Simulation, Distribution of the Difference in Days between Staging Area Activation and Regional Planting Reaching 20 percent Completion for Sugarbeets, Corn, and Wheat	23
11 Historical Dates, Red River Reaches 17,000 cfs in Fargo, Regional Planting Start Dates for Soybeans in North Dakota, 2000 through 2014.....	25
12 Monte Carlo Simulation, Distribution of the Difference in Days between Staging Area Activation and Regional Planting Reaching 20 percent Completion for Soybeans	28
13 Total Days from Staging Area Activation until Effects of Flooding are gone, With and Without Diversion, by Size of Flood Event.....	29
14 Difference in Days Required for Effects of Flooding to be gone between Existing Conditions and With the Diversion.....	30
15 Comparing the Days until the Effects of Flooding are Over with the Days from Staging Activation until Regional Planting Reaches 20 Percent Completion for Sugarbeets in North Dakota.....	34

List of Tables (continued)

<u>Table</u>	<u>Page</u>
16 Comparing the Days until the Effects of Flooding are over to the Days from Staging Activation until Regional Planting Reaches 20 Percent Completion for Soybeans in North Dakota.....	34
17 Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 10-year Flood Event	40
18 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 10-year Flood Event	40
19 Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 25-year Flood Event	41
20 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 25-year Flood Event	41
21 Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 50-year Flood Event	42
22 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 50-year Flood Event	42
23 Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 100-year Flood Event	43
24 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 100-year Flood Event	43
25 Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 500-year Flood Event	44
26 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 500-year Flood Event	44
27 Gross Revenues, by Hydrology Group, With and Without Diversion, 10-year Flood Event	47
28 Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 10-year Flood Event	47
29 Gross Revenues, by Hydrology Group, With and Without Diversion, 25-year Flood Event	48

List of Tables (continued)

<u>Table</u>	<u>Page</u>
30 Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 25-year Flood Event	48
31 Gross Revenues, by Hydrology Group, With and Without Diversion, 50-year Flood Event	49
32 Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 50-year Flood Event	49
33 Gross Revenues, by Hydrology Group, With and Without Diversion, 100-year Flood Event	50
34 Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 100-year Flood Event	50
35 Gross Revenues, by Hydrology Group, With and Without Diversion, 500-year Flood Event	51
36 Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 500-year Flood Event	51
37 Gross Revenues Only in Years With Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 10-year Flood Event	52
38 Gross Revenues Only in Years With Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 25-year Flood Event	53
39 Gross Revenues Only in Years With Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 50-year Flood Event	53
40 Gross Revenues Only in Years With Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 100-year Flood Event	54
41 Gross Revenues Only in Years With Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 500-year Flood Event	54
42 Revenue Loss Averaged Over Entire Monte Carlo Simulation, by Crop, between With and Without Diversion	56
43 Average Value of a Revenue Loss, by Crop, between With and Without Diversion (excludes replications With zero losses)	57
44 Change in Days of Planting Delay With Adjustments to Dry-down Period, Hydrology Group Five, 25-year Flood Event	60
45 Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 1997-type Flood Event	62

List of Tables (continued)

<u>Table</u>	<u>Page</u>
46 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 1997-type Flood Event.....	62
47 Gross Revenues, by Hydrology Group, With and Without Diversion, 1997-type Flood Event	64
48 Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 1997-type Flood Event.....	64
49 Gross Revenues Only in Years With Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 1997-type Flood Event	65
50 Average Value of a Revenue Loss, by Crop, between With and Without Diversion, (excludes replications With zero losses), 1997-Like Flood	66

List of Figures

<u>Figure</u>	<u>Page</u>
1 Storage Areas Associated With FM Diversion Staging Area, 2016	2
2 Example of the Analytical Framework of the Time Line from Activation of Staging Area to When Planting can Occur for Storage Areas having Spring Flooding.....	11
3 Historical Planting Start Dates for North Dakota Sugarbeets and Dates when Red River Reached 17,000 cfs in Fargo, 2000 through 2014	19
4 Comparison of Planting Start Dates for North Dakota Sugarbeets in Flood and Non-flood Years, 2000 through 2014.....	20
5 Comparison of Dates for 20 Percent Planting Completion for North Dakota Sugarbeets in Flood and Non-flood years, 2000 through 2014.....	21
6 Distributions of the Dates for Staging Area Activation, Corn, Wheat, Sugarbeets, and Soybean Planting Dates Corresponding With 20 Percent Completion.....	22
7 Monte Carlo Simulation, Difference in Days between Staging Area Activation and Regional Planting Reaching 20 percent Completion, Sugarbeets, Corn, and Wheat	23
8 Historical Planting Start Dates for North Dakota Soybeans and Dates when Red River Reached 17,000 cfs in Fargo, 2000 through 2014	24
9 Comparison of Planting Start Dates for North Dakota Soybeans in Flood and Non-flood Years, 2000 through 2014.....	26
10 Comparison of Dates for 20 Percent Planting Completion for North Dakota Soybeans in Flood and Non-flood years, 2000 through 2014.....	26
11 Monte Carlo Simulation, Difference in Days between Staging Area Activation and Regional Planting Reaching 20 percent Completion for Soybeans.....	27
12 Extra Days Needed For Effects of Flooding to be gone, due to the Diversion, 10-year Event ...	31
13 Extra Days Needed For Effects of Flooding to be gone, due to the Diversion, 25-year Event ...	31
14 Extra Days Needed For Effects of Flooding to be gone, due to the Diversion, 50-year Event ...	32
15 Extra Days Needed For Effects of Flooding to be gone, due to the Diversion, 100-year Event .	32
16 Extra Days Needed For Effects of Flooding to be gone, due to the Diversion, 500-year Event .	33
17 Sorted Distribution of Total Revenue Losses, Hydrology Group Three, All Flood Event Sizes, for All Monte Carlo Replications	58

List of Figures (continued)

<u>Figure</u>	<u>Page</u>
18 Sorted Distribution of Total Revenue Losses, Hydrology Group Five, All Flood Event Sizes, for All Monte Carlo Replications.	59
19 Sorted Distribution of Total Revenue Losses, All Hydrology Groups, All Flood Event Sizes, for All Monte Carlo Replications	59
20 Sorted Distribution of Total Revenue Losses, Hydrology Group Three, 1997-like Flood Event, for All Monte Carlo Replications	67
21 Sorted Distribution of Total Revenue Losses, Hydrology Group Five, 1997-like Flood Event, for All Monte Carlo Replications.	68
22 Sorted Distribution of Total Revenue Losses, All Hydrology Groups, 1997-like Flood Event, for All Monte Carlo Replications	68

List of Appendix Tables

<u>Appendix Table</u>	<u>Page</u>
A1 Storage Area Data, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling.....	76
A2 Duration of Water Inundation, by Storage Area, by Flood Event Frequency for With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area.....	81
A3 Time from Activation of Staging Area to Inundation, by Storage Area, by Flood Event Frequency for With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area	86
A4 Time from Activation of Staging Area to When Flood Water Leaves, by Storage Area, by Flood Event Frequency for With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area.....	91
A5 Acreage of Storage Areas That Do Not Flood in Either the With or Without Diversion Conditions, by Storage Area, by Flood Event Frequency (Hydrology Group One)	96
A6 Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is the Same Duration With and Without Diversion Conditions, by Storage Area, by Flood Event Frequency (Hydrology Group Two).....	101
A7 Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is Longer With the Diversion, by Storage Area, by Flood Event Frequency (Hydrology Group Three).....	106
A8 Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is Shorter With the Diversion, by Storage Area, by Flood Event Frequency (Hydrology Group Four).....	111
A9 Acreage of Storage Areas That Flood With the Diversion but Would Not Flood With Existing Conditions, by Storage Area, by Flood Event Frequency (Hydrology Group Five).....	116
A10 Designation of Storage Areas in Common Hydrology Groups, by Size of Flood Event, FM Diversion Staging Area.....	121
A11 Duration of Water Inundation, by Storage Area, 1997-Like Flood Event, With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area	127
A12 Time from Activation of Staging Area to Inundation, by Storage Area, for 1997-Like Flood Event, With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area.....	131

List of Appendix Tables (continued)

<u>Appendix Table</u>	<u>Page</u>
A13 Time from Activation of Staging Area to When Flood Water Leaves, by Storage Area, for 1997-Like Flood Event, With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area	136
A14 Acreage of Storage Areas That Do Not Flood in Either the With or Without Diversion Conditions, by Storage Area, 1997-Like Flood Event (Hydrology Group One)	141
A15 Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is the Same Duration With and Without Diversion Conditions, by Storage Area, for 1997-Like Flood Event (Hydrology Group Two)	147
A16 Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is Longer With the Diversion, by Storage Area, for 1997-Like Flood Event (Hydrology Group Three).....	152
A17 Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is Shorter With the Diversion, by Storage Area, for 1997-Like Flood Event (Hydrology Group Four)	157
A18 Acreage of Storage Areas That Flood With the Diversion but Would Not Flood With Existing Conditions, by Storage Area, for 1997-Like Flood Event (Hydrology Group Five).....	162
A19 Designation of Storage Areas in Common Hydrology Groups, 1997-Like Flood Event, FM Diversion Staging Area	167
B1 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Corn and Soybeans, 10-year Flood Event.....	179
B2 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Wheat and Sugarbeets, 10-year Flood Event.....	180
B3 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Corn and Soybeans, 25-year Flood Event.....	181
B4 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Wheat and Sugarbeets, 25-year Flood Event.....	182
B5 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Corn and Soybeans, 50-year Flood Event.....	183

List of Appendix Tables (continued)

<u>Appendix Table</u>	<u>Page</u>
B6 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Wheat and Sugarbeets, 50-year Flood Event.....	184
B7 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Corn and Soybeans, 100-year Flood Event.....	185
B8 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Wheat and Sugarbeets, 100-year Flood Event.....	186
B9 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Corn and Soybeans, 500-year Flood Event.....	187
B10 Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Wheat and Sugarbeets, 500-year Flood Event.....	188
C1 Per-Acre Revenue Losses, by Crop, due to Diversion (High and Low 5% of Observations And Average), Hydrology Group 3	190
C2 Per-Acre Revenue Losses, by Crop, due to Diversion (High and Low 5% of Observations And Average), Hydrology Group 5	190

List of Appendix Figures

<u>Appendix Figure</u>	<u>Page</u>
A1 Hydrology Groups for Storage Areas, 10-year Flood Event.....	172
A2 Hydrology Groups for Storage Areas, 25-year Flood Event.....	173
A3 Hydrology Groups for Storage Areas, 50-year Flood Event.....	174
A4 Hydrology Groups for Storage Areas, 100-year Flood Event.....	175
A5 Hydrology Groups for Storage Areas, 500-year Flood Event.....	176
A6 Hydrology Groups for Storage Areas, 1997-like Flood Event	177

Glossary of Terms

Affected Acreage	Total acreage of storage area that has some flooded acreage, even if the inundation does not cover the entire storage area. For example, if a storage area is 500 acres in size, but only 200 acres are submerged with flood water, the flooded acreage is 200 and the affected acreage is 500.
Days of Delay	The difference in total days between the Without and With Diversion conditions, and does not necessarily reflect the number of days a producer may be delayed. For example, a storage area has 20 total days (days to flood, days of inundation, and dry-down) for Without Diversion conditions and 25 total days With Diversion. The days of delay due to the Diversion is 5 days; however, the number of days of planting delay may be more, the same, or less than the 5 days of difference between conditions—the extent of the delay depends upon when regional planting begins.
Distribution	The range of a known value given the statistical characteristics of the underlying information or data. It represents the relative number of times each possible outcome will occur in a number of trials or replications. Values in a distribution often are combined with the probability of that value occurring over a specified period or under a specific set of conditions.
Dry-down	A period for the land to dry out to the extent that normal field operations may occur. The dry-down period was assumed to include time for removal of flood residue.
Effects of Flooding are gone	In this study, ‘effects of flooding are gone’ refers to when a storage area has gone through the required dry-down period. At that point, the land may be planted (if regional planting has started) or in the situations where regional planting has not begun, those lands will have to wait for general conditions to improve before planting.
Existing Conditions/ Without Diversion	Refers to the hydrology-related conditions currently present within the staging area and within each individual storage area. “Existing conditions” is synonymous with the terms “Without Diversion.”
Flood Event	Spring flood events resulting primarily from snow melt that are sufficiently large to require use of the staging area as part of the FM Diversion.
Flooded Acreage	Only the actual acreage of lands within storage areas that are inundated (submerged) with flood water. These acreages can be equal to the total size of the storage area if the entire storage area is submerged or can represent a portion of acreage within a storage area.
Flood Start	The calendar date when the Red River reaches 17,000 cubic feet per second (cfs) in Fargo. Snow melt and runoff would already be occurring prior to this date so the definition does not necessarily define when a spring flood event actually begins.

Flood Size/Frequency	Flood size or frequency is usually defined by the annual likelihood that the event would occur in any given year. The annual probability of a flood event occurring is inversely related to the size of the flood event; a 25-year flood event is smaller than a 50-year flood event. The annual chance of 25-year flood event is 4 percent whereas the annual chance of a 50-year flood event is 2 percent.
Gross Revenue	Defined as crop yield times crop price. Insurance indemnities and federal farm program payments are excluded.
Hydrology	In this study, hydrology is used as a general reference to the flooding or lack of flooding currently being modeled for storage areas within the staging area. The hydrology information used in this study is the result of modeling the distribution, movement, and volume of flood waters in the southern Red River Basin.
Monte Carlo	A Monte Carlo simulation is an analysis technique that allows for a range of outcomes to be evaluated based on the statistical distribution(s) of factors or values that may affect a particular outcome. The technique uses a random selection of possible model inputs by ‘pulling’ a value from a statistical distribution. The technique is helpful in defining the frequency, probability, and risk associated with a large number of potential outcomes.
Olympic Average	An Olympic average eliminates the high and low observations and then averages all remaining observations. An Olympic average often is a useful estimator because it is less sensitive to outliers than a simple mean but will still give a reasonable estimate of central tendency or mean for many statistical models.
Period of Record	The range of years of basin hydrology that was used by the U.S. Army Corps of Engineers for FM Diversion project design and evaluation. The period of record is 1942 through 2009.
Replication	Defined in this study to represent one combination of the factors generated in the Monte Carlo simulation. A replication would be analogous to the combinations present in one particular year.
Risk	Risk is a term often used to describe financial situations where the outcome of a particular set of conditions may not be known but the odds of occurring can be reasonably measured.
Staging Area	‘Staging Area’ refers to the area of the FM Diversion project where water will be temporarily stored during spring flood events. Retention of water will be created through man-made levies and natural topography. Water collected in the staging area will subsequently be drained away through the Red and Wild Rice rivers and the Diversion channel.
Staging Activation	The calendar date during a spring flood event when the staging area would begin storing water. Staging activation date, in this study, is when the Red River reaches 17,000 cfs in Fargo, even though the Diversion will likely be activated

prior to the Red River reaching 17,000 cfs in Fargo using gauges and flow monitoring upstream of Fargo.

Standard Deviation	A measure of how widely values deviate or differ from the average. Standard deviation is a common measure of variability.
Storage Area	Geographic units within the staging area that are delineated by man-made (e.g., roads) and natural features. The effects of temporary water storage were treated equally for all acres within an individual storage area. These areas are identified by range, township, county, acreage, and elevation (msl). For hydrology purposes, the storage areas are treated as one homogenous tract.
Target Yield	Yield that agricultural producers strive to obtain and adjust the level of inputs and farm practices to achieve.
Total days	The number of days from when the staging area is activated to the end of the dry-down period. That period may or may not differ between existing conditions and conditions expected with use of the Diversion.
Uncertainty	Uncertainty is a term applied to situations where it may be impossible to reasonably measure the odds of something occurring.
With Diversion	Refers to the hydrology conditions that are expected to prevail during large spring flood events when the FM Diversion project is operational.

Expanded Geographic Assessment of the Agricultural Risk of Temporary Water Storage for FM Diversion

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Executive Summary

The proposed Fargo/Moorhead Area Diversion (FM Diversion) is intended to reduce the flood risk for Fargo, Moorhead, and other communities in Cass County, North Dakota and Clay County, Minnesota. The FM Diversion is comprised of a water storage embankment and tie-back levies upstream of Fargo, flood protection dikes in the Fargo/Moorhead communities, and a Diversion channel to route water around the Fargo/Moorhead/West Fargo metro area. The embankment, tie back levies, and natural rise in the Red River basin will create a staging area in which water will be temporarily collected during times of high flow during spring flood events.

The implications of temporary water storage raise a number of questions, such as the effects of inundation on public infrastructure (e.g., roads, bridges), cultural landmarks (e.g., cemeteries), residential and commercial structures, delivery of public services (e.g., fire and rescue), and agricultural lands.

This study expands the geographic scope of a previous agricultural risk study¹. This effort and the first study both represent a preliminary evaluation of how temporary water storage during spring flood events may influence agricultural production within the staging area.

Study Approach

In an attempt to provide a broad assessment of the potential agricultural effects, **the study included the following factors:**

- **Gross revenues:** Revenues from crop production in the staging area during flood years Without the Diversion and With the Diversion.
- **Flood event start dates:** Range of likely dates when the staging area would be activated based on historical observations of when the Red River has reached 17,000 cfs in Fargo.
- **Regional planting start dates:** Dates when spring planting begins.
- **Planting rates:** Time required to plant crops based on overall spring planting conditions.
- **Agronomic considerations:** Crop rotations, periods when planting delays result in yield losses, dates when crops may be switched, and dates when crops would qualify for prevented planting.
- **Crop yields:** The anticipated yields that agricultural producers strive to obtain and adjust the level of inputs and farm practices to achieve. Crops modeled were wheat, corn, sugarbeets, and soybeans. The percentage of each crop was based on county-level planting data.
- **Yield reduction functions:** Amount of target yield lost due to delays in planting.
- **Crop prices:** A 7-year Olympic average of marketing year prices.

¹ Previous report is available at: <http://ageconsearch.umn.edu/bitstream/211469/2/AAE745.pdf>

- **Dry-down period:** A 10-day period was used to represent the time necessary for the land to dry-down and complete any required clean up after being inundated, With or Without the Diversion.
- **Hydrology Data:** Detailed hydrology data for 175 storage areas comprising 64,422 acres was provided by Houston-Moore Group in cooperation with the U.S. Army Corps of Engineers.
 - **Flood Size** – 10-year, 25-year, 50-year, 100-year, 500-year, and 1997-like flood events
 - **Acreage Flooded**—acreage of land inundated based on general field elevation and size of flood event.
 - **Duration of Flooding**— number of days storage areas were flooded and when flood waters leave the storage areas.
 - **Without Diversion and With Diversion**—both hydrology conditions were modeled.
 - **Flood Effects vary by Storage Area and Flood Size**
 - Hydrology Group 1 - Areas that do not flood With or Without the Diversion
 - Hydrology Group 2 - Areas that already flood but flood duration is unchanged With Diversion
 - Hydrology Group 3 - Areas that already flood but flood duration is longer With the Diversion
 - Hydrology Group 4 - Areas that already flood but flood duration is shorter With the Diversion
 - Hydrology Group 5 - Would not normally flood but will now flood With Diversion

Excluding the 10-year flood event, the majority of acreage evaluated in this study will either flood longer (Group 3) With the Diversion or will now flood (Group 5) With the Diversion.
- **Key Assumptions and Omissions:**
 - **Crop Insurance** – the implications of Federal crop insurance coverage for lands affected by operation of the Diversion staging area were not addressed. Loss of Federal crop insurance mitigation of spring flooding would increase the per-acre losses on some lands and increase overall losses in the staging area during a flood event.
 - **Affected Acreage** – if any portion of a storage area was inundated all acreage of the storage area was assumed to be affected. This assumption could increase the overall acreage affected by spring flooding but would not affect the per-acre losses.

A Monte Carlo simulation, using historical data, was used to generate 10,000 most-likely combinations of flood starts, planting rates, and planting start dates independently. Hydrology data, combined with a dry-down period, were used with the Monte Carlo simulation to estimate the conditions, frequency, and magnitude of planting delays.

Results

The study focused on **1)** the additional time the Diversion adds to the number of days for the effects of flooding to be gone, and **2)** how often those additional days are likely to result in planting delays. A storage area would have delayed planting if the combination of inundation and dry-down periods extended past the date when regional planting starts. Conversely, if the combined time of inundation and dry-down occurred prior to when regional planting started, there would be no planting delays and the storage area would be planted at the same time as other land in the region. These criteria were applied to both existing conditions (Without Diversion) and With Diversion.

- Combining a **dry-down period** with the **hydrology data** revealed:
 - A majority of acres will require a total of 16 to 25 days for effects of flooding to be gone after activation of the staging area.
 - A majority of acres in the study area will flood Without the Diversion for most large flood events, and the Diversion will add 1 to 7 days of additional time for the effects of flooding to be gone.
 - Between 10,800 to 18,500 acres (depending upon flood event size) will flood due to the diversion that would not otherwise flood, and the time for the effects of flooding to be gone on those lands varies from 16 to 25 days after activation of the staging area.
- Examining **regional planting start dates** and likely **flood event start dates** revealed:
 - Annual probability ranges from 40 to 60 percent that the majority of acreage in the staging area, either with existing conditions or With the Diversion, would experience some planting delay for corn, sugarbeets, and wheat in a flood year (i.e., flood year of sufficient size to activate the staging area).
 - Annual probability is less than 15 percent that the majority of acreage in the staging area would experience some planting delays for soybeans in a flood year.

The study focused on those storage areas that flood longer (Group 3) and those storage areas that floods with use of the Diversion but would not otherwise experience spring flooding (Group 5).

Annual Chance of Revenue Loss due to Delayed Planting from Operation of the Diversion						
	Size of Flood Event					
	10-Year	25-Year	50-Year	100-Year	500-Year	1997-like
Storage Areas that Flood Longer With the Diversion (Group 3)						
Any Revenue Loss	33%	64%	67%	75%	75%	93%
\$1 to \$25 per acre	33%	64%	67%	75%	75%	20%
More than \$25 per acre	<0.1%	<0.1%	<0.1%	<0.5%	<0.2%	<73%
Storage Areas that Floods With the Diversion but would not Flood under Existing Conditions (Group 5)						
Any Revenue Loss	29%	53%	56%	60%	60%	81%
\$1 to \$25 per acre	28.5%	46%	49%	49%	44%	26%
More than \$25 per acre	0.5%	6.5%	7.3%	11%	16%	55%

Note: *Per-acre revenue losses represent a composite of corn, wheat, soybeans and sugarbeets, based on their respective share of county crop acreage. Therefore, losses per acre for any hydrology group represent an average of the storage areas within that group and an average of revenues from all crops, even if some crops did not experience a planting delay or revenue loss.*

Despite the high probability of a planting delay during a 25-year or larger flood, the overall average per-acre losses within the storage areas was relatively small. Average losses were modest as a result of averaging all replications (years) with no losses (e.g., early flood with late regional planting start) and averaging revenues from soybeans, which have little revenue loss and represent the largest share of acreage among the four crops (e.g., over 50 percent in Cass County).

Estimated revenue losses, averaged for all acres within the hydrology groups, are unlikely to equal event-level revenue losses for individual producers. For example, for producers planning to raise soybeans, the probability and magnitude of revenue losses are quite low. However, for a producer

raising corn in the same storage area, the planting delays due to the Diversion may result in revenue losses substantially larger than the average reported for the overall storage area or hydrology group.

Range of Per-Acre Crop Losses Observed in the Study, Storage Areas that Flood Longer						
	10-Year	25-Year	50-Year	100-Year	500-Year	1997-Like
----- Corn -----						
Lower (5%)	-\$5.22	-\$24.60	-\$23.23	-\$31.80	-\$19.05	-\$45.04
Average	-\$0.79	-\$5.74	-\$5.65	-\$8.57	-\$5.05	-\$15.34
Upper (5%)	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
----- Wheat -----						
Lower (5%)	-\$6.84	-\$27.65	-\$24.32	-\$29.43	-\$18.09	-\$27.62
Average	-\$1.41	-\$10.13	-\$9.54	-\$12.91	-\$7.72	-\$17.48
Upper (5%)	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
----- Sugarbeets -----						
Lower (5%)	-\$2.95	-\$62.96	-\$54.79	-\$66.46	-\$39.63	-\$57.93
Average	-\$0.51	-\$22.36	-\$20.76	-\$28.08	-\$16.80	-\$38.12
Upper (5%)	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
----- Soybeans -----						
Lower (5%)	-\$2.95	-\$0.29	-\$0.37	-\$1.12	-\$0.50	-\$5.64
Average	-\$0.51	-\$0.01	-\$0.02	-\$0.06	-\$0.03	-\$0.45
Upper (5%)	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Note: Lower ranking refers to the lowest 5 percent of the 10,000 observations (500 replications with the largest per-acre losses). Upper ranking refers to the highest 5 percent of the 10,000 observations with the lowest per-acre losses. Five percent average of minimum and maximum observations controls for low probability events. Average values were estimated from all 10,000 observations in the analysis.						

Range of Per-Acre Crop Losses Observed in the Study, Storage Areas that Now Flood (new flooding)						
	10-year	25-year	50-year	100-year	500-year	1997-Like
----- Corn -----						
Least (5%)	-\$29.32	-\$46.93	-\$47.66	-\$55.92	-\$65.15	-\$89.33
Average	-\$2.86	-\$6.26	-\$6.51	-\$8.53	-\$10.82	-\$18.65
Max (5%)	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
----- Wheat -----						
Least (5%)	-\$50.32	-\$74.62	-\$72.07	-\$82.66	-\$91.71	-\$108.46
Average	-\$5.55	-\$12.12	-\$11.64	-\$15.31	-\$18.63	-\$28.36
Max (5%)	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
----- Sugarbeets -----						
Least (5%)	-\$19.69	-\$159.25	-\$154.37	-\$177.06	-\$195.21	-\$231.84
Average	-\$2.07	-\$25.72	-\$24.70	-\$32.67	-\$39.70	-\$60.27
Max (5%)	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
----- Soybeans -----						
Least (5%)	\$0.00	-\$0.04	-\$0.06	-\$0.13	-\$0.22	-\$1.62
Average	\$0.00	\$0.00	\$0.00	-\$0.01	-\$0.01	-\$0.09
Max (5%)	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00

When only losses due to the operation of the Diversion were evaluated, the average loss per acre for corn ranged from \$6.26/acre in the 25-year event to \$10.82 per acre in the 500-year event, excluding losses from the 10-year event. Per-acre losses for soybeans averaged less than \$0.10 for all flood event sizes. Excluding the 10-year flood event, the average loss per acre for wheat ranged from \$12.12/acre in the 25-year event to \$18.63 per acre in the 500-year event. Sugarbeets had the largest average per acre loss, ranging from \$26 per acre in the 25-year event to nearly \$40 per acre in the 500-year event. The per-acre losses reflect averaging of all storage areas in Groups 3 and 5, and included only replications when the operation of the Diversion produced revenue losses.

The collective revenue losses, for any single flood-event size examined in this study, when examined over all 10,000 replications for all 175 storage areas, ranged from \$0 in the best-case situations to slightly over \$3 million in the worst-case situations. Those estimates did not include any Federal crop insurance indemnities associated with delayed planting.

Conclusions

Overall, the economic impact of Diversion Operations on crop production in the 175 storage areas was modest. In evaluating the historical data and expected differences in flooding created by the Diversion, several reasons underpin this conclusion.

There are no recorded flows on the Red River due to rain that would have triggered the use of the Diversion. Historically, the Diversion would have never been needed to protect against a summer flood. The Diversion is not expected to create losses after spring planting season.

Spring snow melt and runoff, in most cases, occur early relative to the regional planting season. During much of the flood-event, no planting occurs due to snow melt and overall wet conditions. The historical data suggest there was limited overlap between spring runoff and planting.

The engineering data indicate that the combined capacity of the Red River and the Diversion channel, once the community is protected with dikes, will move extensive amounts of water around the community. The exact amount and timing will not be known until the Diversion Operating Manual is finalized by the U.S. Corps of Engineers, but the preliminary indications are that the Red River will handle 17,000 cfs through the community and the Diversion channel will handle an additional 22,000 cfs around the community. However, despite the stated capacities, the timing and flow of flood waters also will be based on the characteristics of the flood-event, and all floods are unique (e.g., compare the 1997 flood event to the 2009 flood event). The combined flow capacity of 39,000 cfs clearly exceeds the largest flow in Fargo of 29,800 cfs observed in 2009. Both the stated design capacity of the Diversion and the current hydrology data suggest that water will not be retained in the staging area for extensive periods, and it is highly likely that those lands will be planted in a flood year.

In the more modest flood events (e.g., 25-year and 50-year events), many storage areas are not adversely affected by the Diversion. A substantial portion of the 175 storage areas, most lying in relatively low elevations, would experience flooding Without the Diversion. Current hydrology modeling suggests that the majority of lands that would flood Without the Diversion will experience 1 to 7 days of additional time for the effects of flooding to be gone (Group 3). For those lands, the Diversion may contribute to a delayed planting but is not responsible for all of the delayed planting. Most lands that will experience new flooding With the Diversion (Group 5) would require up to 25 days from the date when the staging area is activated until the effects of flooding are gone. However, not all of those days translate directly into planting delays. For much of that period, general weather conditions, such as temperature and normal dry-down from snow melt, prevent spring planting.

The impacts of planting delays from Diversion operations on corn, wheat, and sugarbeets are likely to be substantially different than soybeans. Soybeans had the lowest frequency and magnitude of revenue loss of the four crops. Soybeans also have the lowest relative yield decline of the four crops when planted beyond the optimal period. Over the planting periods evaluated in this study, planting delays have less relative impact on soybeans than corn, wheat, or sugarbeets. Soybeans also are planted later in the spring, reducing the likelihood of planting delays due to the use of the staging area. This combination of factors is why soybeans have the lowest per-acre revenue losses. Soybeans also comprise the largest share of crops grown in the staging area, which further reduces the average revenue losses when all crop losses are combined within an entire storage area.

Operation of the Diversion creates a high likelihood of modest planting delays and subsequent revenue loss

Due to the complexity of the hydrology, which varies by storage area for the flood events evaluated, generalized statements about how producers will be individually affected are difficult. Revenue losses across all acres and crops within a storage area and by hydrology group measures the potential cumulative losses in the staging area and identifies general risk. However, care should be exercised that generalities and averages mask substantial differences for individual crops and storage areas. The economic impacts on some agricultural producers are likely to be considerably different from the average values within the hydrology groups.

Per-acre losses and cumulative losses would be larger if expected Federal crop insurance indemnities were included. Several uncertainties exist with how Federal crop insurance would be administered in the cases where the Diversion adds to existing flooding but the land would have flooded in the absence of the Diversion. Also in cases where the Diversion is modeled to have no adverse effect, questions remain if the use of the Diversion affects the eligibility of Federal crop insurance to assist in mitigating planting delays on those lands. To what degree Federal crop insurance coverage will be impacted as a result of Diversion operations is unknown. This study only estimated the revenue losses associated with delayed planting that was due to operation of the Diversion. Including the potential value of lost insurance on all lands experiencing a planting delay (regardless if the planting delays was due to the Diversion) would increase the losses to producers and perhaps substantially increase losses Calculated in this study.

Total losses in this study were based on the assumption that if any portion of a storage area was inundated, all land within that storage area was equally affected. Given the lack of available data to refine that assumption, developing estimates using all acreage was the best approach. However, overall losses due to the use of the Diversion would be sensitive to that assumption. Finally, including the value of lost insurance indemnities would increase total losses.

This study represents an expanded geographic assessment to address potential effects of temporary water storage on spring planting resulting from the use of the Diversion. As a result of this effort, insights were gained on a broad geographic region of how the flooding effects vary by location and elevation of land, and how the effects also are influenced by the size of flood event. Examining when the effects of flooding may be gone and when regional planting typically begins, suggests a high likelihood of relatively short planting delays. These conclusions are extremely helpful in advancing the discussion of how agricultural production might be affected, but a number of additional issues remain unquantified. While this project was not able to address all production-related issues, this study, along with its methodology, lays a strong foundation from which additional production questions can be addressed.

Recommendations

-) Insurance Implications

Evaluate the potential loss of insurance indemnities during flood years and potential effects of reduced yields in flood years on adjustments to a producer's annual production history. Implications associated with effects on federal crop insurance could be substantial.

-) **Improve upon Key Assumptions**

Study results are sensitive to dry-down assumptions. The days required for dry-down and clean-up was a static assumption, but should be re-examined to evaluate if dry-down periods can be statistically linked to planting rates or related to weather differences generally observed between the months of April and May.

Refinement in general agricultural data may require cooperation from producers operating within the staging area or cooperation from government agencies (e.g., Risk Management Service). County- or state-level information for crop yields, planting periods, planting rates and other agricultural factors were used in this assessment. More refined data, specific to the general staging area, would provide more precise estimates of the economic effects.

Inclusion of updated hydrology data also will be necessary as engineers continue to improve and refine the hydrology modeling and as an operating manual for the diversion project is developed.

-) **Variability of Effects at Producer Level Highlight Need for a Fair, Flexible, and Comprehensive Compensation Policy**

This study demonstrates the complexity of framing and measuring the impacts of temporary water storage on agricultural producers. The FM Diversion Authority should continue to evaluate alternative compensation adjustments and mitigation strategies. Potential elements could include relieving risk to tenant producers, not just landowners. A compensation plan addressing full damages and including all affected parties would help alleviate the risk and financial concerns associated with temporary water storage.

Expanded Geographic Assessment of the Agricultural Risk of Temporary Water Storage for FM Diversion

The proposed Fargo/Moorhead Area Diversion (FM Diversion) is intended to reduce the flood risk for Fargo, North Dakota, Moorhead, Minnesota and other communities in Cass County, North Dakota and Clay County, Minnesota. The project is being pursued by the Flood Diversion Board of Authority (Diversion Authority) in collaboration with the U.S. Army Corps of Engineers (Corps).² The FM Diversion is comprised of a water storage embankment and tie-back levies upstream of Fargo, flood protection dikes in the Fargo/Moorhead communities, and a Diversion channel to route water around the Fargo/Moorhead/West Fargo metro area. The embankment, tie back levies, and natural rise in the Red River basin will create a staging area in which water will be temporarily collected during times of high flow during spring flood events.³

Current design of the FM Diversion is that temporary water storage will occur during spring flood events when the predicted flow of the Red River is expected to exceed 17,000 cubic feet per second (cfs) in Fargo. Ten flood events since 1969, all occurring in the spring, would have triggered use of the FM Diversion using that criterion. The flow of the Red River at Fargo has not exceeded 17,000 cfs more than once within a year's time.

Researchers in the Department of Agribusiness & Applied Economics at North Dakota State University prepared an initial assessment in 2015 of the risk and economic effects on spring planting resulting from the proposed temporary water storage during spring flood events (Bangsund et al. 2015)⁴. Following completion of the initial agricultural risk assessment in 2015 and with a mandate from the North Dakota 2015 Legislature, engineers reviewed and refined hydrology data to ensure all agricultural lands affected by 6 inches or more of inundation during temporary water storage associated with the FM Diversion were identified and evaluated (Figure 1).

Following refinement of the engineering data, researchers in the Department of Agribusiness & Applied Economics conducted this economic analysis based on the updated hydrology data.

² Additional information is available on the FM Diversion web site <http://www.fmDiversion.com/authority.php>

³ Additional materials and information on the physical dimensions and placement of key elements of the FM Diversion can be found on the FM Diversion web site http://www.fmDiversion.com/pdf/StructureFeatures20140401_1117.pdf

⁴ Report is available at: <http://ageconsearch.umn.edu/bitstream/211469/2/AAE745.pdf>

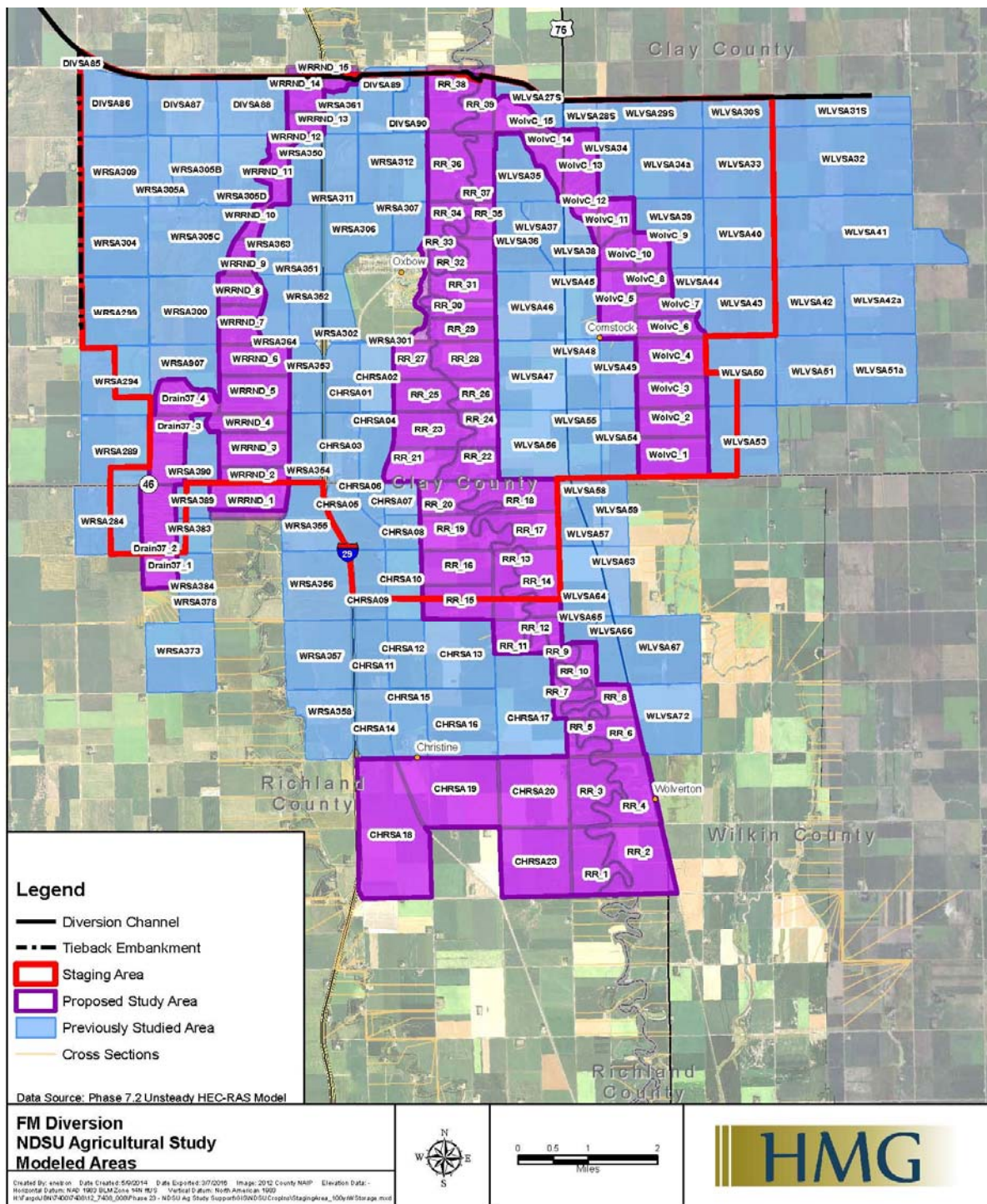


Figure 1. Storage Areas Associated With FM Diversion Staging Area, 2016
Source: Houston-Moore Group (2016).

Implications for Agricultural Production

The implications of temporary water storage raise a number of questions, such as the effects of inundation on public infrastructure (e.g., roads, bridges), cultural landmarks (e.g., cemeteries), residential and commercial structures, delivery of public services (e.g., fire and rescue), and agricultural lands. This study expands the geographic scope of evaluating how temporary water storage may influence agricultural production.

The following points underpin the analysis:

- Net Impact - The impact of the proposed Diversion on production agriculture in the staging area is the difference between:
 - 1) the gross revenues from production agriculture in the staging area WITHOUT the Diversion
 - 2) the gross revenues from production agriculture in the staging area WITH the Diversion.

Note: The measure of damage created by the FM Diversion should not to be confused with the difference between gross revenues in a flood year and gross revenues in a non-flood year⁵.
- Flood Event Size - The staging area would be filled to capacity only in case of an extremely large (but also low probability) flood event (e.g., 100-year and 500-year events). Smaller flood events, even though their flow exceeds 17,000 cfs and would require water storage, are not likely to fill the staging area. Thus, the higher elevations in the staging area, such as 925 feet above mean sea level (msl), may rarely be impacted by the operation of the Diversion. The study needs to consider how acreage of land inundated will vary among flood event sizes based on general field elevation and volume of water associated with different flood events as opposed to peak or crest flow rate.
- Hydrology and Inundation - FM Diversion staging area primarily affects agricultural lands by either:
 - 1) Retaining water longer than would otherwise occur. In these circumstances, the lands would have flooded even Without the Diversion. Many of those areas are in lower relative elevations, and often experience spring flooding. The impact of the Diversion on these agricultural lands would result from the additional time the land remains inundated. The time required to clear debris and time necessary to dry out is NOT an impact of the Diversion because the land would have been inundated even Without the Diversion.
 - 2) Land that now floods that would not otherwise be inundated. These lands could potentially be impacted by the time that water is on the land and the time required for the lands to dry-down and to remove debris.
 - In both cases, the duration of inundation is a critical component of the analysis, and must be considered over a range of flood event sizes for land throughout the staging area.

⁵ This study only examines the effects of temporary water storage associated with spring flood events. The Diversion is expected to only be needed to protect against spring-time rain and snowmelt. Based on historical records, the Diversion would have never been needed to protect against a summer flood.

- Flood Start Dates - Converting water storage duration and dry-down periods into planting delays must account for when a flood event occurs and how long the flood event lasts. Flood events do not occur on the same calendar date(s), nor do they always have the same duration. Therefore, the effects on agricultural producers can vary based on both the start date of the flood event and how long the flood event lasts.
- Spring Planting Dates - Spring planting does not start on the same date(s) every year. Planting conditions vary considerably; therefore, planting delays due to the Diversion cannot be estimated without also knowing when producers can typically begin planting.
- Planting Rates - Spring planting conditions are not always constant during a planting season, nor are they necessarily consistent among years. Therefore, conditions during the spring planting season also must be included in the analysis to account for how long it takes to plant a crop.
- Agronomic Factors - Agronomic considerations include crop rotations, yields, and time periods when planting delays result in yield losses.
- Crop Prices - Crop prices are an important part of farm revenue, yet prices vary almost annually and are unlikely to be the same for all flood years.
- Insurance Eligibility - There are repercussions of a man-made versus natural flood event for crop insurance eligibility. Producers stand to lose potential revenues from crop insurance during years when the staging area is used if similar insurance provisions or mechanisms are not available to them.

The economic impact of storing water in the staging area is the difference between the economic value of agricultural crop production in the staging area Without the Diversion and the economic value of agricultural crop production in the staging area when the Diversion is operated. A number of potential factors may affect a producer as a result of the Diversion, such as soil productivity changes resulting from erosion⁶, additional costs to travel in and out of the region if farmsteads are moved/relocated outside the staging area, reduction in yield due to planting delays, reduction in revenues if crops cannot be planted, potential costs of post-flood cleanup, and potential effects on crop quality (e.g., sugar content in sugarbeets). Theoretically, the potential loss of value to agricultural land in the staging area arising from a restriction or abatement on future residential or commercial development should be mitigated through Federal easements. While a number of effects may warrant consideration from an agricultural producer's perspective, this study focuses only on the economic effects of planting delays on yields and producer revenues.

The following sections describe the data that were gathered to address the key study points and the analytical approaches, assumptions, and methods used to evaluate the key issues. Additional detail is contained in several appendices, and as well as throughout the report.

⁶ Erosion has occurred in previous large flood events, such as the 1997 flood. Based on hydrographs showing the rate of water inundation and rate of water out-flow between the Without Diversion conditions and With Diversion conditions, erosion may occur in the staging area on the in-fill or out-flow phases of operation. The issue of potential erosion of crop land has not been specifically addressed in the current hydrology modeling.

Data and Methods

A combination of factors needs to be considered in evaluating the impacts of temporary water storage on agricultural production in the staging area with respect to spring planting conditions. The key *physical* factors would include timing of flood events, frequency of flood events, duration of flood events, length of time land is inundated, dry-down period, planting start dates, and planting progress rates. Key *economic* factors include agronomically optimal planting periods, reductions in crop yields for acreage planted after optimal planting window, switch dates to stop planting a crop and shift remaining acreage to another crop, crop yields, prevent planting date on which planting for the season will stop and acreage will remain unplanted, and crop prices.

A Monte Carlo simulation was used in the previous study, and that modeling process was retained in its entirety in this study. Monte Carlo simulation addresses risk when the conditions or issues (i.e., potential planting delays) require evaluation over a wide range of potential possibilities. In this study, historical data were assumed to be sufficient to represent a reasonable range of potential future outcomes. The accuracy of the Monte Carlo simulation is limited to the predictive capacity of the underlining data.

Historical data were used to determine a distribution or range of likely flood event start dates, planting start dates, and planting rates. A Monte Carlo simulation of 10,000 combinations of flood event start dates, planting start dates, and planting rates were used to represent spring planting conditions. Each of the 10,000 combinations was applied to six flood events and the two conditions of Without and With the Diversion for each of the 175 storage areas. Crop share, yields (including a decline in yields for late planting), and prices were included in the simulation to calculate the economic impact of staging water. Each of the key components of study data and methods are briefly acknowledged in the following sections. *For an in-depth description of this study's data and analytical methods see pages 8-54 in Bangsund et al. (2015)*⁷.

A few differences between the initial (2015) report and this expanded geographic study include the following

- Hydrology data for fewer than 15 storage areas from the 2015 study were refined to reflect an updated understanding of representative field elevations; the adjustments generally reduced the duration of inundation about one day.
- The economic model was refined so that the Monte Carlo simulation could not use overlapping distributions of corn/wheat/sugarbeet regional planting start dates and regional planting start dates for soybeans. This adjustment affected about 0.4 percent of the 10,000 replications.
- An additional 77 storage areas, comprising about 20,100 acres, were added to this study. The goal of adding storage areas was to ensure that all agricultural lands affected by 6 inches or more of inundation during temporary water storage associated with the FM Diversion were identified and evaluated for effects associated with potential planting delays.

An additional year of observable data was available to this study, but comparisons to previous study parameters revealed little difference would result in updating the model for 2015 data (Table 1).

⁷ Report can be obtained at: <http://ageconsearch.umn.edu/bitstream/211469/2/AAE745.pdf>

Table 1: Comparison of Agricultural Parameters with and without 2015 Data					
	Measurement	Initial Parameters ^a	Parameters with Inclusion of 2015 Data		
Crop Prices	7-year Olympic Average	2008 to 2014	2009 to 2015		
Corn	\$/bu	4.36	4.25		
Wheat	\$/bu	6.87	6.38		
Soybeans	\$/bu	10.88	10.79		
Sugarbeets	\$/ton	55.54	54.18		
Crop Yields	3-year Average	Clay County	Wilkin County	Cass County	Richland County
2011 to 2013					
Corn	bu/planted acre	128.1	139.3	118.3	127.4
Wheat	bu/planted acre	49.2	47.3	44.6	45.3
Soybeans	bu/planted acre	36.4	35.8	32.1	35.2
Sugarbeets	ton/planted acre	22.1	23.0	18.4	20.5
2013 to 2015					
Corn	bu/planted acre	132.8	143.0	126.8	134.1
Wheat	bu/planted acre	51.2	51.2	52.6	51.5
Soybeans	bu/planted acre	36.2	36.2	34.1	35.2
Sugarbeets	ton/planted acre	21.7	22.6	18.4	21.7
Crop Share	3-year Average	Clay County	Wilkin County	Cass County	Richland County
2011 to 2013					
Corn	Percentage of acreage allocated to the four crops	31.6	26.5	34.7	44.3
Wheat		16.7	21.5	8.9	6.9
Soybeans		40.9	39.0	54.3	44.4
Sugarbeets		10.8	13.1	2.1	4.5
2013 to 2015					
Corn	Percentage of acreage allocated to the four crops	32.0	26.9	31.3	40.9
Wheat		9.7	18.6	10.5	7.7
Soybeans		47.2	41.7	56.3	47.2
Sugarbeets		11.1	12.8	1.9	4.2
^a Existing parameters represent the data used in both this updated study and were use in the 2015 study. Target yields used in the analysis are larger than the yields reported by National Agricultural Statistics Service (Bangsund et al. 2015).					

Flood Start Dates

U.S. Geological Survey (USGS) daily water flow data for Fargo for period of record was originally examined to produce a statistical distribution of flood event start dates based on dates when river flows peaked. Due to high variability with the flow data in non-flood years and difficulty in correlating the calendar dates of peak flows in non-flood years, actual calendar dates when the Red River equaled or exceeded 17,000 cfs were used instead of USGS daily flow data over the period of record to produce a distribution of flood event start dates.

Planting Start Dates

Planting start dates for wheat, corn, and sugarbeets were based on National Agricultural Statistics Service (NASS) planting progress data for sugarbeets in North Dakota. Sugarbeets in North Dakota were considered the best proxy for planting start dates for corn and wheat since the progress data for sugarbeets was largely influenced by conditions in the Red River Valley, and producers traditionally begin planting wheat and corn at nearly the same time as sugarbeets. The distribution of planting start dates for soybeans was based on NASS planting progress data for soybeans in North Dakota.

Planting Rates

National Agricultural Statistics Service data from 2000 through 2014, based on the rate of acreage planted per day from 20 percent to 80 percent of planting progress, were used to estimate the annual variability in planting rates. Separate estimates were generated for wheat, corn, sugarbeets and soybeans using planting progress data for North Dakota.

The typical time required to plant a crop was based on information gathered from agricultural producers. Producers indicated that increases in planting capacity have occurred in recent years, which may suggest that the planting rates for regional crops may exceed historical observations. Even though the regional rate of planting progress was adjusted to reflect current production capacities, the variability from year to year was retained when creating the distributions. The annual variability in the planting rates was considered to be reflective of the annual planting conditions (i.e., moisture, temperature) over the 2000 to 2014 period.

Crop Share

Storage areas in the staging area are assigned the percentage of wheat, corn, soybeans, and sugarbeets grown in the respective county. A three-year average (2012-2014) was used to estimate the crop shares. By assigning some wheat, corn, soybean, and sugarbeet acreage to each storage area, the analysis does not have to distinguish among which crops would be raised on the storage area in any given year. The process also treats planting activities equally among all the storage areas, and does not suggest that storage areas close to the river or prone to flooding will only raise one crop and all the storage areas at higher elevations will only raise another crop.

Crop Prices

NASS crop prices represent statewide marketing-year average prices. A 7-year olympic average of North Dakota prices from 2008 through 2014 was used to represent commodity prices in the four-county study region. Statewide prices received in North Dakota were used for storage areas in Minnesota and North Dakota.

Yield Losses

Crops generally have an optimal planting period based on typical agronomic growing conditions throughout the year. If a crop is planted within that period, the producer generally has the best opportunity to realize maximum potential yields. Yields are assumed to be relative to the spring planting conditions, meaning that the yield obtained when planting after the optimal period will be less

than the yield that would have been obtained had the crop been planted during the optimal period. However, even with optimal planting conditions, yields are not likely to achieve maximum potential unless other factors throughout the growing season also remain favorable.

During non-optimal planting periods, the analysis uses a daily yield reduction over the spring planting period. For example, if a crop is likely to have a 1 percent yield loss for each day of planting after the optimal period, yield on the first day following the last optimal planting date for acres planted that day would be 1 percent less than the target yield. Acres planted on the second day following the optimal planting window would receive a yield 2 percent less than the target yield. The analysis continues with daily yield reductions until planting for that crop is completed, switched, or results in prevent plant. *For details on agronomically optimal planting dates, switch dates to move unplanted acreage from one crop to another crop due to delays in planting, and prevent plant dates see page 45 in Bangsund et al. (2015)⁸.*

Hydrology Data

Houston-Moore Group working with the U.S. Army Corps of Engineers provided hydrology data for storage areas (i.e., tracks of land defined by man-made and natural boundaries) within the staging area both for existing conditions (Without Diversion) and conditions anticipated With Diversion. The primary criterion for geographic scope was that all areas expected to receive 6 inches or more of inundation as a result of the FM Diversion was included in this study. Note that the 6 inch criterion only needs to occur in any one of the flood events modeled and does not suggest that those storage areas would have to experience 6 inches or more of inundation in all flood events.

The hydrology modeling was based on 10-year, 25-year, 50-year, 100-year, and 500-year synthetic flood events that are not necessarily reflective of a specific past flood. The flood event sizes represent the annual probability or likelihood of a spring flood event reaching a certain size (e.g., crest height, volume of water flow). For example, a 100-year flood event has a 1 percent probability of occurring in any given year, and is a larger flood than a 25-year or 50-year flood event, which have a probability of occurring 4 percent and 2 percent in any given year, respectively.

In addition to the five probability-defined flood events, a 1997-like flood event also was modeled. The 1997 flood event had high flow rates for a longer period than any other documented previous flood event with flows exceeding 17,000 cfs in Fargo for 20 consecutive days. The long duration of the 1997 flood event provides a valuable contrast to the 2009 flood event which had 10 days with flows exceeding 17,000 cfs but resulted in a record crest height on the Red River in Fargo.

Hydrology modeling was provided for 175 storage areas within the staging area⁹. The 175 storage areas totaled 64,422 acres and exceed acreage of the USACE-defined staging area. Data for each storage area included location, approximate elevation, size (acreage), water elevation over the course of a flood event, duration of water inundation (days), and time (days) for inundation to occur from when staging is initiated¹⁰.

⁸ Report is available at: <http://ageconsearch.umn.edu/bitstream/211469/2/AAE745.pdf>

⁹ The U.S. Army Corps of Engineers' staging area is the portion of the upstream inundation area that contains the additional storage volume needed for project operation, but does not include all lands potentially inundated from temporary water storage.

¹⁰ Hydrology data provided by U.S. Corps of Engineers with cooperation from Houston-Moore Group represents HEC-RAS 7.2 modeling (Hydrologic Engineering Center - River Analysis System, modeling version 7.2).

The riverine reaches included in this expanded study were represented as cross sections in the hydrology modeling provided in the first study (see Figure 1 for identification of riverine reaches). The unsteady HEC-RAS model utilizes cross sections to simulate flooding in the immediate river channels and utilizes storage areas to represent overland flooding on land away from the channels. For 2015 NDSU study, the initial set of hydrology data provided by Houston-Moore Group estimated the staging area flooding characteristics using storage areas and did not reference the modeled channel cross sections.

The omission of the cross sections were largely because the storage areas had a spatial extent (polygon) to associate the flooding depth and duration with a location on the ground, and the cross sections were not modeled with those characteristics. Therefore, the initial analysis did not include the areas of land that are represented by the channels. The revised analysis did not represent new modeling per se, but rather data from the model were extracted to allow the cross sections to be approximated as storage areas. The extracted data were used to create new storage areas for the cross section domain.

Near the embankment, each storage area extends approximately one mile – north/south. However, as the river profiles extend upstream, the storage area density increased to generally maintain a water surface that is +/- 3 inches of the modeled water surface profile. In areas away from the dam, the storage areas typically represent one-half mile of length along the river profile. Additionally, the storage areas were split along the Red River centerline to account for ground elevation differences on either side of the river. Lastly, an original modeled cross section was chosen to represent the spatial extent of each of the defined channel storage areas. A unique field elevation was identified for each storage area using LiDAR and aerial imagery to best represent the field elevation from which flooding can be measured. The model output produced the inundation data for each storage area which was then compared to the field elevation in the given storage area (Houston-Moore Group 2016).

Storage Area versus Land Inundated

Land associated with the FM Diversion can be measured by acreage actually flooded and acreage affected by flooding. In this study, *flooded acreage* represents land that will be submerged or inundated with temporary water and *affected acreage* represents the size of the storage area that contains flooded land. This study assumes any flooding within a storage area results in the entire storage area being affected. While this overall assumption results in a conservative estimate of the acreage affected by temporary water storage, data to refine these assumptions were not available.

Dry-down Period

Inundated land needs time to dry after the water recedes. Although the time necessary for dry-down will vary based on temperature, wind, precipitation, soil type, fall tillage, and cloud cover, the study assumes that dry-down and clean-up (e.g., remove or disperse debris) will take 10 days after the water leaves the land. Ten days are added to all storage areas that have inundation for either the Without Diversion or With Diversion conditions. The additional 10-days of dry-down can only be attributed to the Diversion when temporary water storage results in land flooding that would otherwise not flood with existing conditions. Lands that would flood naturally Without the Diversion also will require a dry-down period before planting, but the dry-down period is not an impact attributable to the Diversion. For example, if a storage area floods for 8 days With the Diversion and floods for 8 days Without the Diversion, the 10 days of dry-down would have occurred in the absence of the Diversion. Even in situations when the Diversion results in inundation that extends beyond inundation with existing conditions, the Diversion would be responsible for the additional days for the water to leave the land, but not the 10-day dry-down period.

By placing the hydrology data into a timeline and adding time required for the land to dry out, the study can begin to assess potential planting delays. *Total days* represents the sum of days for the land to become inundated, days the land is inundated, and a dry-down period. *Potential days of delay* in this study are defined as the difference between total days Without the Diversion and total days With the Diversion.

Three important issues with respect to understanding how the hydrology data are measured, used and discussed in this study include:

- *Total days* for a storage area is not equal to the days that the storage area is inundated. Total days is the measure from when the staging area is activated to when the effects of flooding are gone. Total days includes the time it takes for the land to be inundated after the staging area is activated as well as a dry-down period for all storage areas that have any flooding.
- The difference in Total Days between Without and With Diversion conditions represents the *potential days of delay*. However, it is important to understand that potential days of delay do not necessarily equal actual planting delays.
- The metrics used to describe the hydrology effects in this study will not match the metrics used in previous reports by the USACE and FM Diversion Authority. The differences are that this study needed to create a timeline whereas previous public reports and presentations by the USACE and FM Diversion Authority discussed the duration of flooding.

Planting Framework

A modeling process was developed that chronologically traces key activities during the spring planting season for each of the 175 storage areas and works by estimating the number of days between activation of the staging area and when planting can occur (Figure 2). The potential time (i.e., days) from activation of the staging area to when planting can occur will vary based on size of flood event and location/elevation of the storage area. Planting start dates for storage areas that are not inundated with flood water (either With or Without the Diversion) are not restricted by the timeline in Figure 2, but are estimated using regional planting start dates.

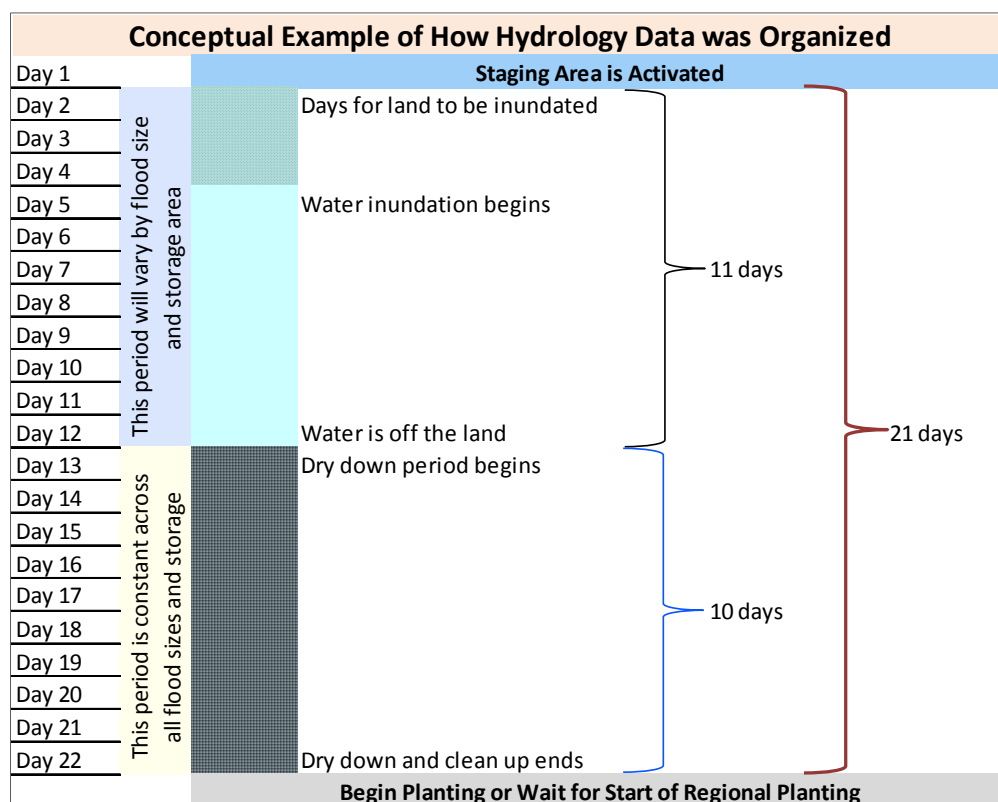


Figure 2. Example of the Analytical Framework of the Time Line from Activation of Staging Area to When Planting can Occur for Storage Areas having Spring Flooding.

Study Limitations

Combining weather and producer behavior is difficult, and the study was not able to include all factors that may affect spring planting, yield loss, or reductions in producer incomes in the staging area. If all of the potential subjects or issues could be adequately incorporated into future studies, they would refine the magnitude of losses and further articulate producer-level effects. However, aside from perhaps the largest omission (e.g., farm insurance), the study's current data and methodology could potentially draw similar conclusions even if the omitted factors were addressed. This is due to the general relationship between when the staging area would be activated and when producers are expected to be able to begin planting. Unless the hydrology effects were to substantially change, those fundamental relationships would remain present in an expanded study. *See Bangsund et al. (2015) for a complete listing and discussion of limitations and key assumptions; those limitations and assumptions were not alleviated or addressed in this study.*

Results

This study examined several important issues related to how temporary water storage in the FM Diversion staging area might affect spring planting. Below is an outline of study findings.

Hydrology in the Staging Area: This section describes the basic breakout of acreage among the various hydrology groups and discusses how the affected acreage with the staging area changes based on flood size.

Evaluation of Potential Planting Delays: This section examines the length of time needed for the effects of flooding to be gone and matches that information with planting progress data to estimate the probability of incurring planting delays.

Evaluation of 10-year, 25-year, 50-year, 100-year, and 500-year Flood Events: Estimates of the frequency of revenue losses are presented by hydrology group and size of flood event. Gross revenues per acre are provided by hydrology group for flood years with existing conditions (Without Diversion) and conditions With the Diversion. The gross revenues represent a combined average of all four crops with all storages areas within the hydrology groups across the entire range of conditions generated in the Monte Carlo simulation.

Estimation of Gross Revenues Only in Years With Losses: Gross revenues are presented for only conditions that produce a revenue loss. Conditions when planting delays were not observed were removed to provide a more accurate estimate of the value of the revenue loss if there was a planting delay.

Estimation of Potential Revenue Losses by Crop: The difference in per-acre revenues between existing conditions and With the Diversion are provided by crop and size of flood event. The estimates would be analogous to the per acre revenue losses if only a single crop comprised the entire acreage with a storage area.

Distribution of Total Revenue Losses: Total revenue losses are presented graphically to view the magnitude of potential liabilities in the staging area.

Hydrology in the Staging Area

The 175 storage areas in this study were grouped into five categories. Each category represents a different set of conditions between current hydrology and hydrology created by the FM Diversion with respect to spring flooding (Table 2).

- **Hydrology Group 1:** Storage areas that will not be flooded/inundated if the Diversion is operated. This outcome is due to land at a relatively high elevation in the staging area (*Does Not Flood*).
- **Hydrology Group 2:** Storage areas that will be flooded/inundated for the same duration whether or not the Diversion is operated; usually the lowest land in the staging area (*Floods the Same*).
- **Hydrology Group 3:** Land that will be flooded/inundated longer as a result of operating the Diversion (*Floods Longer*).
- **Hydrology Group 4:** Storage areas that will be flooded/inundated a shorter duration as a result of operating the Diversion because the features of the Diversion will drain the water away more quickly; however, the shortened storage time often is no more than a day (*Floods Shorter*).
- **Hydrology Group 5:** Storage areas that do not flood, but will be flooded/inundated With the Diversion (*New Flooding*).

The 175 storage areas will not necessarily be in the same hydrology group for all five flood event sizes. A storage area with a relatively low elevation (e.g., 909 ft msl) may be in Group 3 for most flood events, meaning it would flood With or Without the Diversion but floods longer With the Diversion. A storage area with a relatively high elevation (e.g., 925 ft msl) may be in Group 1 for most flood events, meaning that it would not be inundated regardless of the Diversion. A storage area with a mid-elevation (e.g., 919 ft msl) may be in Group 3 during a large flood event, Group 5 in a moderate flood event, and Group 1 during a small flood event.

Relating to the timing of spring planting, land contained within Hydrology Groups 3 and 5 are the only storage areas that incur adverse economic effects from the operation of the Diversion staging area and are likely to receive the greatest attention during policy discussions and debates. For most practical purposes dealing with spring planting, storage areas in Groups 1, 2 and 4 are not meaningfully impacted by the operation of the Diversion.

Table 2. Description of General Hydrology Conditions for Storage Areas Within the FM Diversion Staging Area

Hydrology Group	Description With Existing Conditions	Effects of the FM Diversion ^a
1	Does not flood	Does not flood
2	Already floods	Flood duration is unchanged
3	Already floods	Flood duration is longer
4	Already floods	Flood duration is shorter
5	Does not flood	Will now flood With Diversion
^a The flooding effects of operating the Diversion do not necessarily imply all acreage within that storage area is inundated.		

Current hydrology data suggests little additional flooding occurs within the staging area for a 10-year event With the Diversion. However, for the other flood events, flooded acreage With the Diversion varies from about 26,100 acres for the 25-year event to 48,700 acres for the 500-year event (Table 3). By contrast, under existing conditions about 12,200 acres would be naturally flooded with a 25-year event and 35,500 acres would be flooded with a 500-year event. The total affected acreage is larger than the inundated acreage when using the overall size of the affected storage areas (Table 4).

Table 3. Acreage Inundated by Spring Flood Events, by Flood Frequency, With and Without FM Diversion Staging Area				
Flood Event	Estimated Acreage of Land Inundated ^a		Percentage of Acreage Inundated ^b	
	With Use of FM Diversion Staging Area	With Existing Conditions (no Diversion)	With Use of FM Diversion Staging Area	With Existing Conditions (no Diversion)
10-Yr	6,716	6,578	10.9	10.2
25-Yr	26,124	12,184	42.3	18.9
50-Yr	31,633	15,677	51.2	24.3
100-Yr	39,262	20,120	63.5	31.2
500-Yr	48,660	35,526	78.7	55.1
^a Only acreage submerged by water.				
^b Based on acreage of 61,812 for the project conditions and 64,422 for the existing conditions.				
Source: Houston-Moore Group (2016).				

Table 4. Total Acreage of Storage Areas affected by Spring Flood Events, by Flood Frequency, With and Without FM Diversion Staging Area				
Flood Event	Acreage of Storage Areas having Some Spring Flooding		Percentage of Acreage Affected ^a	
	With Use of FM Diversion Staging Area	With Existing Conditions (no Diversion)	With Use of FM Diversion Staging Area	With Existing Conditions (no Diversion)
10-Yr	16,394	15,551	25.4	24.1
25-Yr	46,084	28,820	71.5	44.7
50-Yr	54,267	35,803	84.2	55.6
100-Yr	60,504	42,067	93.9	65.3
500-Yr	63,040	52,239	97.9	81.1
^a Based on 175 storage areas encompassing 64,422 acres. Storage acreage not adjusted for With Diversion conditions (e.g., dikes, levees, embankments). Not all acres within storage areas will be inundated. Acreage of the 175 storage areas used in this study will not match acreage of the USACE-defined staging area.				
Source: Houston-Moore Group (2016).				

With a 25-year event With the Diversion, hydrology data estimate that 28,500 acres would be affected by longer inundation and 17,300 acres (i.e., total acreage of affected storage areas) would be inundated that otherwise would not store water (Table 5). With a 50-year event, the Diversion would cause 35,800 acres to be affected by longer inundation and 18,500 acres would store water that would not otherwise be inundated.

Hydrology data also reveal whether the *duration* of flooding changes for storage areas inside the staging area. The 10-year event had little difference in the duration of flooding based on acreage of affected storage areas inside the staging area; however, about 40,000 acres associated with storage areas would flood longer with use of the staging area in the 100-year and 500-year events (Table 5). In some cases, the duration of flooding would be less with use of the staging area due primarily to improved water flow as a result of the Diversion channel, modified culverts, or other drainage enhancements. About 2,300 acres with the 10-year event and about 9,000 acres with the 500-year event would experience a shorter flood inundation With the Diversion (Table 5).

Table 5. Difference in Storage Areas Acreage affected by Spring Flood Events, by Flood Frequency, With and Without FM Diversion Staging Area				
Flood Event	Acreage of Storage Areas Flooded Due to Use of Staging Area ^b (Group 5)	Change in the Duration of Water Inundation ^a		
		Storage Areas where Inundation is the SAME with Use of Staging Area (Group 2)	Storage Areas where Inundation is LONGER with Use of Staging Area (Group 3)	Storage Areas where Inundation is SHORTER with Use of Staging Area (Group 4)
		----- acres -----		
10-Yr	843	11,863	1,467	2,221
25-Yr	17,264	364	28,456	0
50-Yr	18,464	0	35,803	0
100-Yr	18,437	202	41,865	0
500-Yr	10,801	4,231	39,163	8,845
^a Based on how many days flood water remains on the land. ^b Only acreage of the 175 storage areas. Additional acreage is defined as the difference between total acreage inundated with the use of the staging area less acreage inundated naturally with Existing Conditions. Not all acres within storage areas will be inundated. Acreage of the 175 storage areas used in this study will not match acreage of the USACE-defined staging area. Source: Houston-Moore Group (2016).				

The timing and duration of water inundation varies considerably among the storage areas for each of the five flood event sizes. In the 10-year flood event, nearly 75 percent of the acreage in the 175 storage areas is not inundated, whereas in the 500-year flood event only 2 percent of the acreage is unaffected (Table 6). Storage areas that either flood the same duration or flood with less duration With the FM Diversion (Hydrology Groups 2 and 4, respectively) comprise a minority of acres in all five flood event sizes. Storage areas in Hydrology Groups 3 and 5 (lands that are inundated longer or lands that flood as a result of the Diversion) comprise about 3.5 percent of the staging area in a 10-year flood but comprise nearly 94 percent of the acreage in a 100-year event. (See Appendix A for detailed information on the hydrology groups for the five flood events).

Table 6. Acreage of Hydrology Groups, by Size of Flood, Operation of the FM Diversion Staging Area										
	10-year Event		25-year Event		50-year Event		100-year Event		500-year Event	
Group	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
1 ^a	48,027	69.7	18,338	28.0	10,155	15.8	3,918	6.1	1,382	2.2
2 ^a	11,863	22.3	364	0.6	0	0	202	0.3	4,231	6.6
3 ^a	1,467	1.7	28,456	49.7	35,803	55.6	41,865	65.0	39,163	60.8
4 ^a	2,221	5.2	0	0	0	0	0	0	8,845	13.7
5 ^a	843	1.1	17,264	21.7	18,464	28.6	18,437	28.6	10,801	16.7
Total ^b	64,422		64,422		64,422		64,422		64,181	

^aGroup 1 represents land that does not flood either in existing conditions or With the Diversion. Group 2 represents land that floods for the same duration. Group 3 represents lands that flood longer With the Diversion. Group 4 represents lands where inundation is shorter With the Diversion. Group 5 represents lands that now flood With Diversion but would otherwise not flood. Not all acres within storage areas for Groups 2, 3, 4, and 5 will be inundated.

^bBased on total acreage of the 175 storage areas. Acreage of the 175 storage areas used in this study will not match acreage of the USACE-defined staging area.

Source: Houston-Moore Group (2016).

The length of time from activation of the staging area until water leaves a storage area varies among the hydrology groups for any particular flood event, and also varies across the five flood event sizes for each of the hydrology groups (Table 7). For example, the average length of time from activation of the staging area until water leaves storage areas in Hydrology Group 2 (flood duration is the same) ranges from 4.5 days in a 25-year flood event to 17 days in a 100-year flood event.

Table 7. Days from Staging Activation until Water Leaves the Storage Area, Average of All Storage Areas Within Each Hydrology Group for Each Flood Event										
Hydrology Group	10-year Event		25-year Event		50-year Event		100-year Event		500-year Event	
	WO	W	WO	W	WO	W	WO	W	WO	W
	----- days -----									
1	0	0	0	0	0	0	0	0	0	0
2	7.1	7.1	4.5	4.5	na	na	17.0	17.0	14.5	14.5
3	6.2	6.8	4.1	4.1	9.4	12.7	10.4	14.4	11.5	13.6
4	7.2	6.7	na	na	na	na	na	na	21.4	20.0
5	0	6.0	0	0.2	0	8.7	0	10.0	0	11.1
WO = Without Diversion and W = With Diversion.										
Source: Houston-Moore Group (2016).										

The difference between the Without Diversion and With Diversion conditions, averaged across all storage areas within the hydrology group, varies from 0.2 days for Hydrology Group 5 in a 25-year event to 11.1 days for Hydrology Group 5 in a 500-year event (Table 7). In Hydrology Group 3, the net difference in time for water to leave the land ranges from 0.6 days in a 10-year flood event to 4 days in a 100-year flood event. The Diversion is expected to add between 2 days to 4 days for water to leave the land for Hydrology Group 3 in the 50-year, 100-year, and 500-year flood events. Hydrology Group 5 has the largest difference, with storage areas ranging from no flooding to having 6 to 11 days from staging area activation until water leaves the land in four of the five flood events (Table 7). Table 7 represents the average of all storage areas within each of the five hydrology groups for each of the flood event

sizes; some storage areas will experience longer periods for flood waters to leave while others within the same hydrology group will experience shorter periods.

******* An important clarification is that some storage areas within certain hydrology groups will be inundated longer than storage areas in other hydrology groups, and that the classification of the storage areas is based on the type of flooding effects created by the Diversion, not based on how long the water is on the land or how long it takes for the water to leave the land. For example, a storage area in Hydrology Group 2 that floods the same duration (e.g., 12 days Without and 12 days With Diversion) may be inundated for a longer period than a storage area in Hydrology Group 3 that now floods longer With the Diversion (e.g., from 8 days of inundation Without Diversion to 10 days of inundation With Diversion). ******* See Appendix A for detailed hydrology for all 175 storage areas.

The distribution of acres affected within the staging area varies between Minnesota and North Dakota, both in terms of hydrology impacts and flood event size (Table 8). A disproportionate share of acreage in Hydrology Group 5 (does not flood but floods With the Diversion) lies along the Minnesota side of the staging area. By contrast, a disproportionate share of acreage in Hydrology Group 3 (floods longer) lies on the North Dakota side of the staging area (Table 8). Additional information on acreage of storage areas, by county and duration of inundation, are detailed in Appendix A.

Table 8. Distribution of Storage Areas, by State, Size of Flood Event, and Hydrology Group					
State and Hydrology Group	Flood Event Size				
	10-year	25-year	50-year	100-year	500-year
Minnesota ----- Total Acreage of All Storage Areas in Hydrology Group -----					
1 No flooding	25,034	28,370	5,547	1,276	0
2 Floods Same	2,868	364	0	0	134
3 Floods Longer	237	5,911	8,539	12,906	17,724
4 Floods Shorter	0	0	0	0	644
5 No Flood, Now Floods	186	10,897	14,513	14,372	10,248
North Dakota					
1 No flooding	22,993	7,254	4,608	2,642	1,382
2 Floods Same	8,995	0	0	202	4,097
3 Floods Longer	1,230	22,545	27,264	28,959	21,439
4 Floods Shorter	2,221	0	0	0	8,201
5 No Flood, Now Floods	613	6,254	4,181	4,249	933
Source: Houston-Moore Group (2016).					

Evaluation of Potential Planting Delays

Two key factors in assessing the likelihood of planting delays included 1) how much time flooded lands require for the effects of flooding to be gone and 2) how long after a flood event until general planting begins. Data on flood start dates (i.e., when the Diversion staging area would be activated), historical data on regional planting progress, and hydrology data on the duration of flooding Within the Diversion staging area were evaluated and used in the Monte Carlo simulations.

The follow section examines the number of days from when the staging area is activated to when the effects of flooding would be gone and compares that to the number of days from flood start (i.e., staging area activation) to when regional planting begins. Flooding results in delayed planting when inundated lands require more time for the effects of flooding to be gone than the time from flood start to when regional planting begins. Stated alternatively, if regional planting begins before the effects of flooding are over for inundated lands, those lands will experience delayed planting. However, the analysis focuses on 1) the additional time the Diversion adds to when the effects of flooding are gone, and 2) how often those additional days result in planting delays.

Flood Dates and Planting Dates for Wheat, Corn, and Sugarbeets

Key factors in the study include when the Diversion staging area would be activated and when planting begins in the region. Knowing the date when the staging area is activated is critical because that starts the countdown to when the effects of flooding will be gone. Likewise, when producers are able to begin planting, based on general spring conditions, is critical since that provides a date that can be used to estimate potential planting delays.

Historical dates when the Red River first reached 17,000 cfs was compared to historical dates when planting began for North Dakota sugarbeets (Figure 3). The reason for examining the date when the Red River reaches 17,000 cfs is because that date corresponds to when the staging area would be activated¹¹. Dates when the Red River has reached 17,000 cfs in Fargo have ranged from March 19, 2010 to April 12th, 2001. The average date the flood events reached 17,000 cfs was March 31st. The hydrology modeling provided by the Houston-Moore Group working with the U.S. Corps of Engineers uses the Diversion activation date as the time from which the water flow is evaluated, and the Diversion activation date for this study is when the Red River reaches 17,000 cfs in Fargo.

The number of days from when the Red River in Fargo reached 17,000 cfs to the start of spring planting ranged from 9 days in 2001 to 25 days in 2009 (Figure 3). The average number of days between the Red River reaching 17,000 cfs and the start of spring planting (i.e., first date reported) was 18 days. If the 20 percent of planting completion threshold is used (see Bangsund et al. 2015 for more discussion), the average number of days increases to 29 days. This study used a 20 percent threshold to estimate when most producers are actively planting. The historical data suggest a range from 19 to 38 days from when the Red River in Fargo reaches 17,000 cfs until spring planting reaches 20 percent completion. The average is 29 days (Table 9).

¹¹ Operation of the staging area is expected to use gauge information upstream of Fargo; however, those details will be finalized when the operational plan for the staging area is completed. This study used Fargo gauge dates as a point in time when the staging area would be activated.

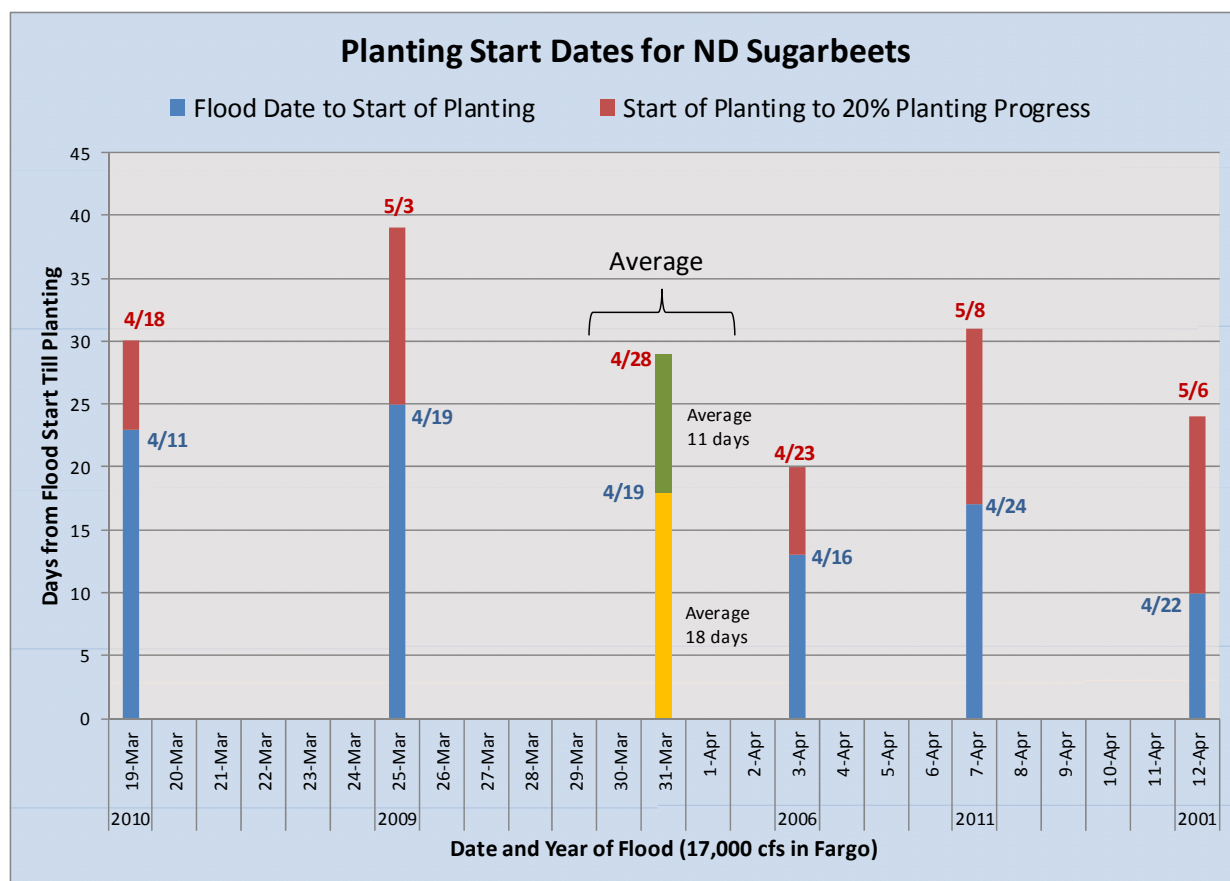


Figure 3. Historical Planting Start Dates for North Dakota Sugarbeets and Dates when Red River Reached 17,000 cfs in Fargo, 2000 through 2014.

Source: National Agricultural Statistics Service (2015); U.S. Geological Survey (2105).

Figure 3 and Table 9 identify the difference in regional planting start dates and the dates when the Red River reached 17,000 cfs in Fargo. Another element of the planting data is to compare planting start dates for years *without* major flood events to the planting start dates *with* major flood events. The data indicate that a major flood event does not always lead to a later spring planting start date (Figure 4). In recent years (e.g., 2013 & 2014), spring planting start dates have been later than the planting start dates in flood years 2006, 2009, and 2010. If a 20 percent threshold is used to evaluate planting start dates, the start date in 2014 exceeds the same metric in all years with a major flood event (Figure 5). Also in 5 of the last 15 years, regional planting dates to reach 20 percent completion in non-flood years are later than the planting dates in two of the five flood years. The historical data suggest that a major flood event is not always going to result in regional planting dates being later than dates for non-flood years (Figure 5).

Table 9. Historical Dates, Red River Reaches 17,000 cfs in Fargo, Regional Planting Start Dates for Sugarbeets in North Dakota, 2000 through 2014

Major Flood Events ^a		Regional Planting Start Date ^a			
Year	Date when Red River Reaches 17,000 cfs in Fargo	0 Percent Completion	20 Percent Completion	Days Between Flood Start and Start of Spring Planting	Days Between Flood Start and 20% Completion of Spring Planting
2010	March 19	April 11	April 18	23	29
2009	March 25	April 19	May 3	25	38
2006	April 3	April 16	April 23	13	19
2011	April 7	April 24	May 8	17	30
2001	April 12	April 22	May 6	10	23
Average	March 31	April 18	April 29	18	29

^aPlanting progress data for flood years 1997, 1989, 1979, and 1969 were not available.

^bData for North Dakota sugarbeet planting progress.

Source: National Agricultural Statistics Service (2015); U.S. Geological Survey (2015).

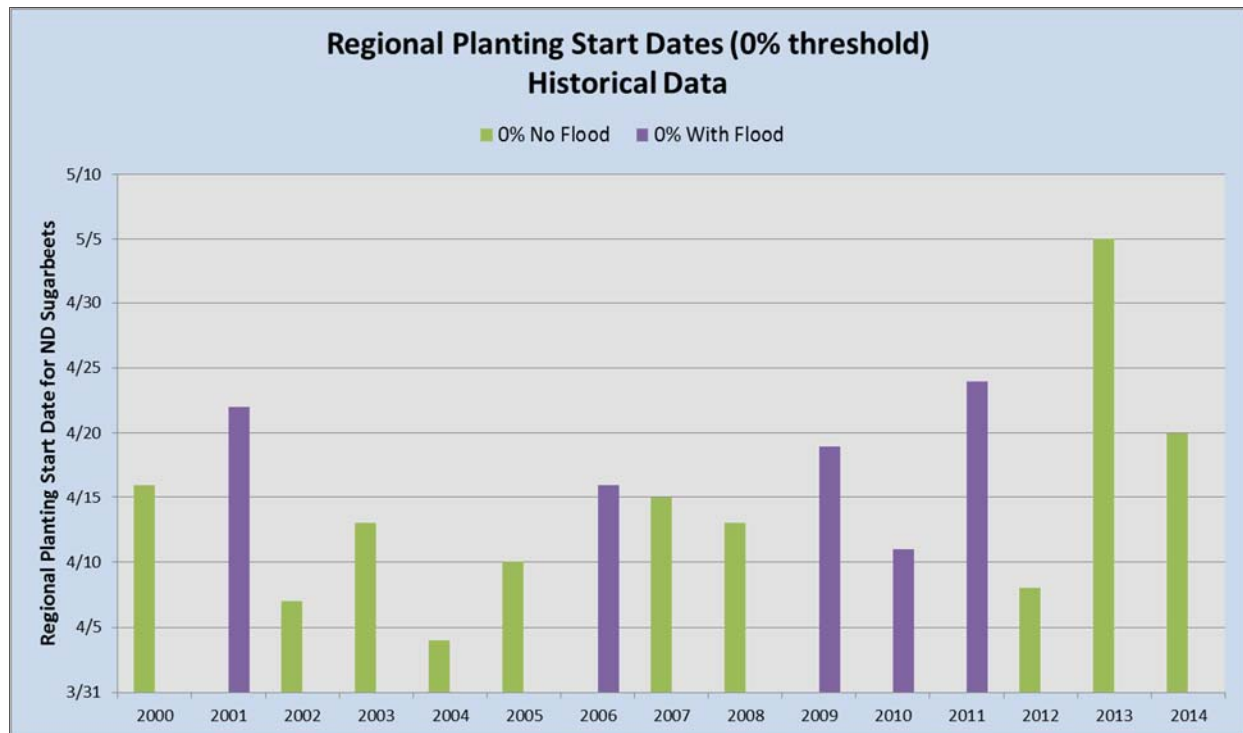


Figure 4. Comparison of Planting Start Dates for North Dakota Sugarbeets in Flood and Non-flood Years, 2000 through 2014.

Source: National Agricultural Statistics Service (2015).

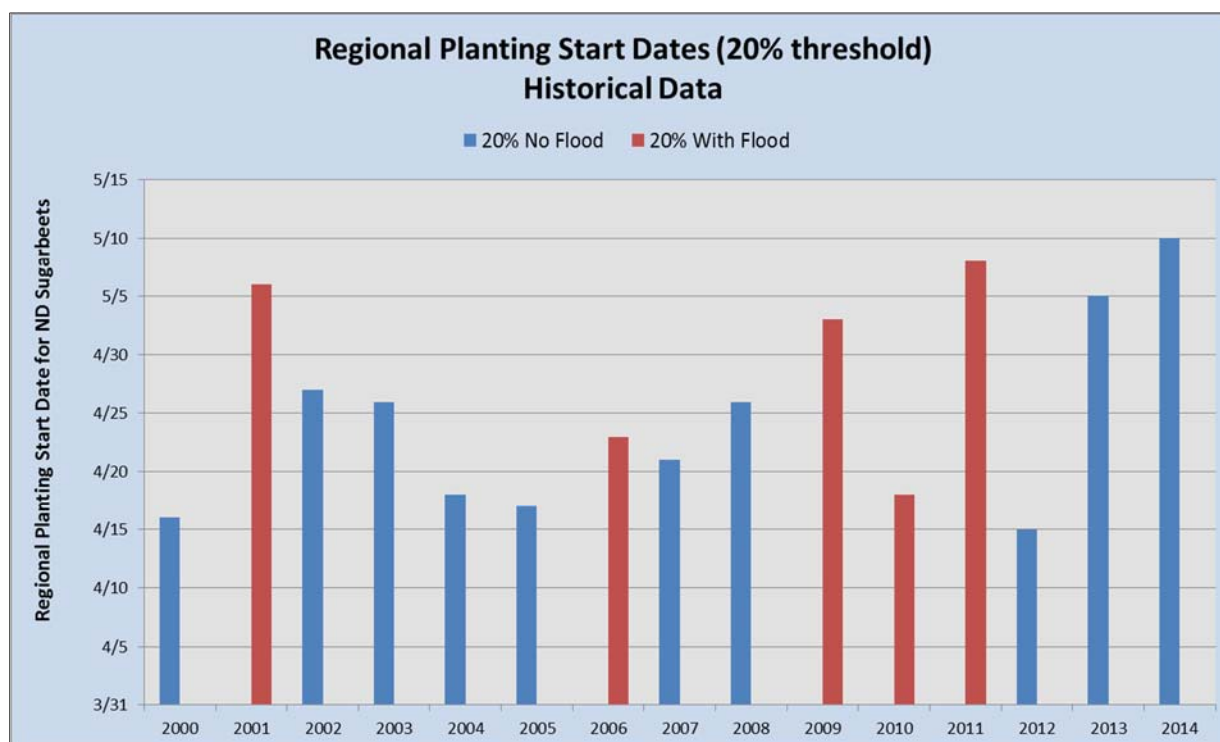


Figure 5. Comparison of Dates for 20 Percent Planting Completion for North Dakota Sugarbeets in Flood and Non-flood years, 2000 through 2014.

Source: National Agricultural Statistics Service (2015).

Historical data on when the Red River has reached 17,000 cfs were used to produce a distribution of dates that are likely given the ability of the historical data to predict future flood dates. [The range of flood dates used in the simulation is discussed by Bangsund et al. (2015)]. A statistical analysis of the data provided both a range of calendar dates and the future likelihood (i.e., probability) of the staging area being triggered on those dates. While the distribution developed for this study limits flood event start dates from March 19 to April 18 (Figure 6), the distribution should not be interpreted as suggesting there is zero probability of a flood event start date falling outside of that range. While the likelihood may be extremely low, that possibility still exists.

Historical data on when regional planting has reached 20 percent completion were used to produce a range and future probability for those dates. However, unlike the flood start dates, the historical planting completion data suggested that a nearly equal chance exists in any given year that planting of sugarbeets in North Dakota will fall between April 14 and May 10.

Combining the distribution of dates for regional planting and dates for activation of the staging area can illustrate the number of days between the triggering of the staging area (17,000 cfs in Fargo) to when regional planting completion has reached 20 percent (Figure 7). Statistics used to produce the distributions indicate that those dates actually overlap in a small number of potential combinations; however, the analysis eliminated any situations where a regional planting date precedes a flood start date.

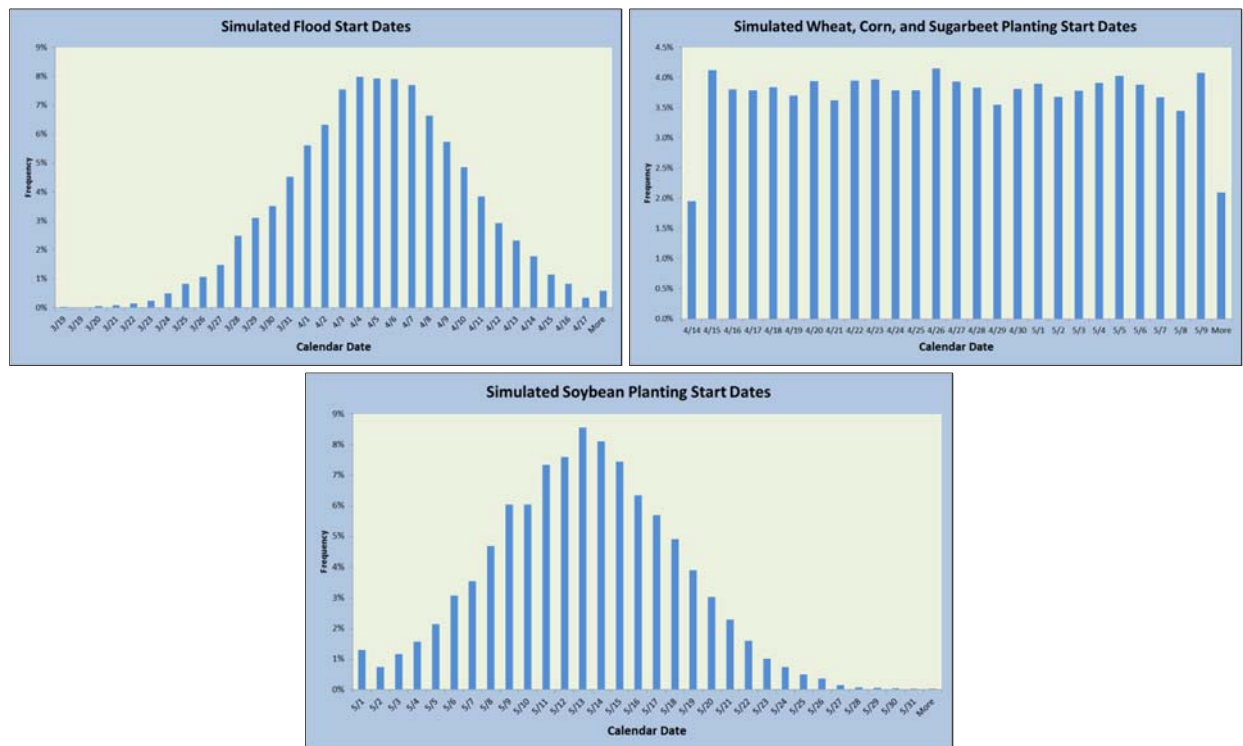


Figure 6. Distributions of the Dates for Staging Area Activation, Corn, Wheat, Sugarbeets, and Soybean Planting Dates Corresponding With 20 Percent Completion.

The statistical distributions not only can show the range of days between staging activation date and regional planting dates, but also can illustrate the frequency or probability of that range. Figure 4 and Table 9 already illustrate that the historical data show a range of 10 to 25 days from when the Red River reaches 17,000 cfs in Fargo and when planting activity is first reported by NASS. Also, the historical data show a range of 19 to 38 days from when the staging area would be triggered to when planting progress reaches 20 percent completion. Over the 10,000 replications, the difference (in days) between staging area activation and when regional planting reaches 20 percent completion varied from 0 days to 49 days (Figure 7). While the simulation produced a range larger than observed with existing data, the chance of the difference exceeding 40 days or being less than 10 days is about 12 percent (Table 10). About 70 percent of the replications in the simulation suggest that the difference between the staging area activation date and when regional planting may reach 20 percent completion falls between 11 and 30 days. Alternatively, the difference between the staging area activation date and regional planting date will be 11 to 30 days over 70 percent of the time (Table 10).

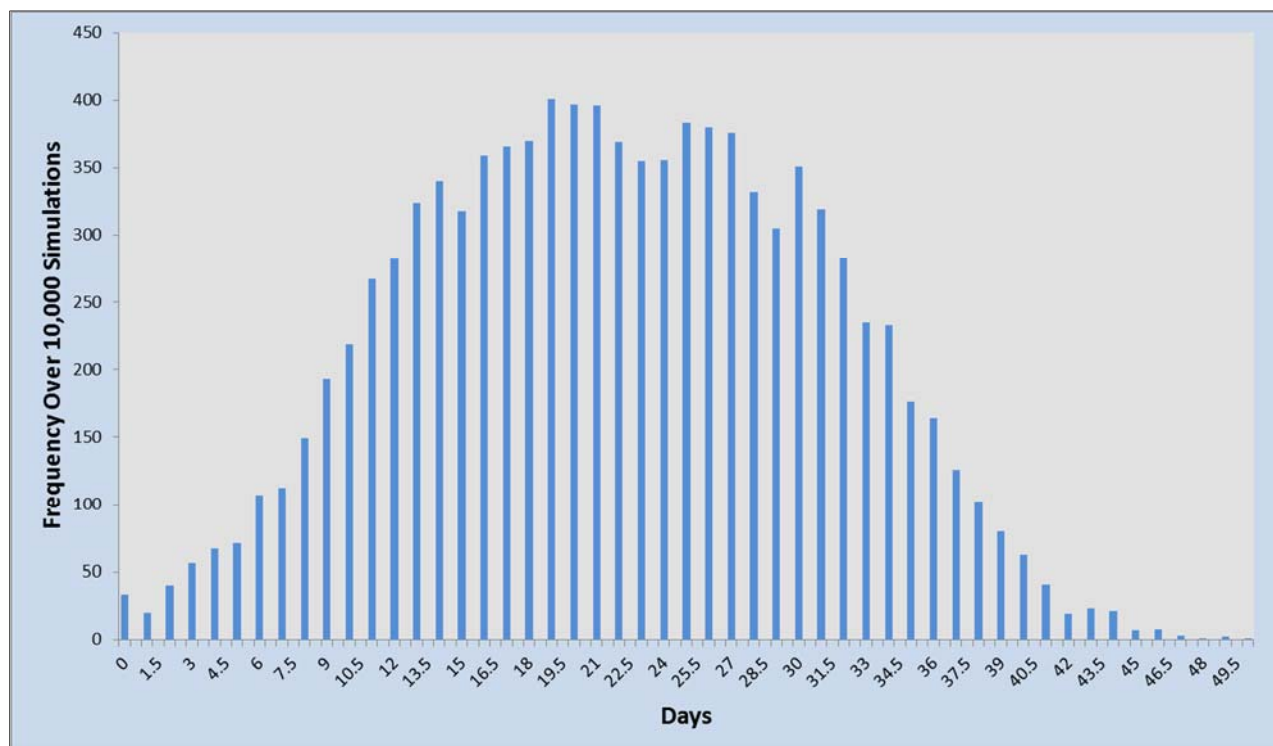


Figure 7. Monte Carlo Simulation, Difference in Days between Staging Area Activation and Regional Planting Reaching 20 percent Completion, Sugarbeets, Corn, and Wheat.

Table 10. Monte Carlo Simulation, Distribution of the Difference in Days between Staging Area Activation and Regional Planting Reaching 20 percent Completion for Sugarbeets, Corn, and Wheat

Days ^a	Number of Replications	Percent of Monte Carlo Simulation
0	21	0.2
1 to 15	2,259	22.6
16 to 20	1,814	18.1
21 to 25	1,873	18.7
26 to 30	2,127	21.3
31 to 35	1,070	10.7
36 to 40	648	6.5
41 to 45	166	1.7
>45	22	0.2

^a Days were estimated by subtracting the flood start date (date when staging area is activated) from the regional planting start date (20% threshold). Days therefore represent the time required for the effects of flooding to be gone without incurring a planting delay due to a spring flood event.

Flood Start Dates and Planting Dates for Soybeans

Historical dates when the Red River first reached 17,000 cfs were compared to historical dates when planting began for North Dakota soybeans (Figure 8). The number of days from when the Red River in Fargo reached 17,000 cfs to the start of spring planting of soybeans ranged from 24 days in 2001 to 54 days in 2009 (Figure 8). The average number of days between the Red River reaching 17,000 cfs and the start of spring planting for soybeans was 35 days. If the number of days required to reach 20 percent of planting completion is included, the average number of days increases to 45 days. This study used a 20 percent threshold to estimate when most producers are actively planting. The historical data suggest a range from 31 to 58 days from when the Red River in Fargo reaches 17,000 cfs until spring planting for soybeans reaches 20 percent completion. The average is 45 days (Table 11).

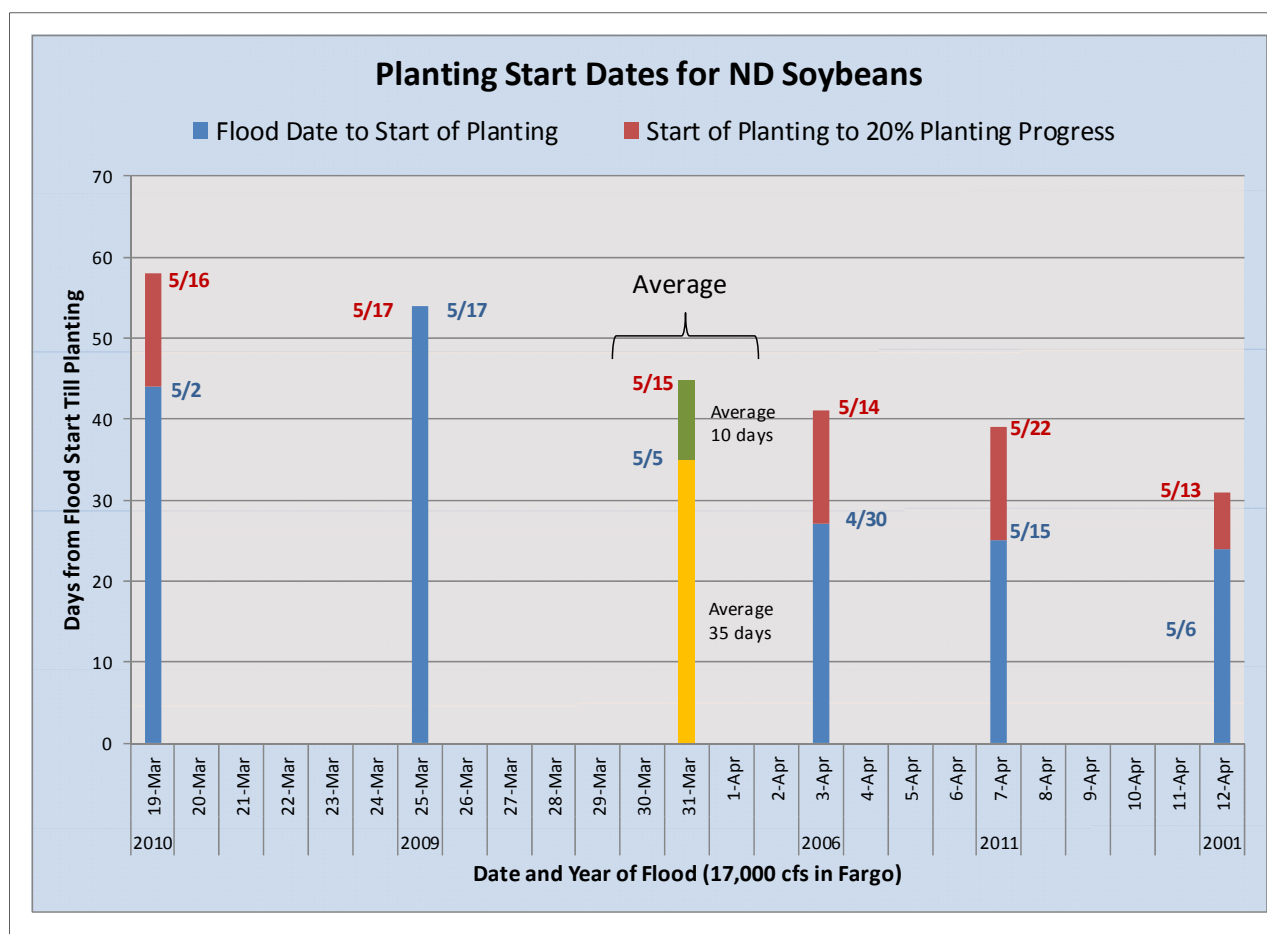


Figure 8. Historical Planting Start Dates for North Dakota Soybeans and Dates when Red River Reached 17,000 cfs in Fargo, 2000 through 2014.

Source: National Agricultural Statistics Service (2015); U.S. Geological Survey (2105).

Figure 8 and Table 11 identify the difference in regional planting start dates for soybeans and the dates when the Red River reached 17,000 cfs in Fargo. Another element of the planting data is to compare planting start dates for years *without* major flood events to the planting start dates *with* major flood events. The data indicate that a major flood event does not always lead to a later spring planting start date for soybeans (Figure 9). Aside from flood years 2009 and 2011, spring planting start dates between flood years and non-flood years are similar. If a 20 percent threshold is used to evaluate

planting start dates, the start date in 2003 exceeds the same metric in all years with a major flood event (Figure 10). Also in 10 of the last 15 years, regional planting dates for four flood years and six non-flood years have started approximately in the same week. The historical data suggest that a major flood event is not always going to result in regional planting dates for soybeans being later than dates for non-flood years (Figure 10).

Table 11. Historical Dates, Red River Reaches 17,000 cfs in Fargo, Regional Planting Start Dates for Soybeans in North Dakota, 2000 through 2014					
Major Flood Events ^a		Regional Planting Start Date ^a			
Year	Date when Red River Reached 17,000 cfs in Fargo	0 Percent Completion	20 Percent Completion	Days Between Flood Reaching 17,000 cfs in Fargo and Start of Spring Planting	Days Between Flood Reaching 17,000 cfs in Fargo and 20% Completion of Spring Planting
2010	March 19	May 2	May 16	44	58
2009	March 25	May 18	May 17	54	54
2006	April 3	April 30	May 14	27	41
2011	April 7	May 15	May 22	25	39
2001	April 12	May 6	May 13	24	31
Average	March 31	May 5	May 15	35	45
^a Planting progress data for flood years 1997, 1989, 1979, and 1969 for North Dakota for corn, soybeans, and sugarbeets were not available. Spring wheat, barley and oats planting progress data were available for 1997, but not available for 1989, 1979, and 1969. ^b Data for North Dakota Sugarbeet planting progress. Source: National Agricultural Statistics Service (2015); U.S. Geological Survey (2015).					

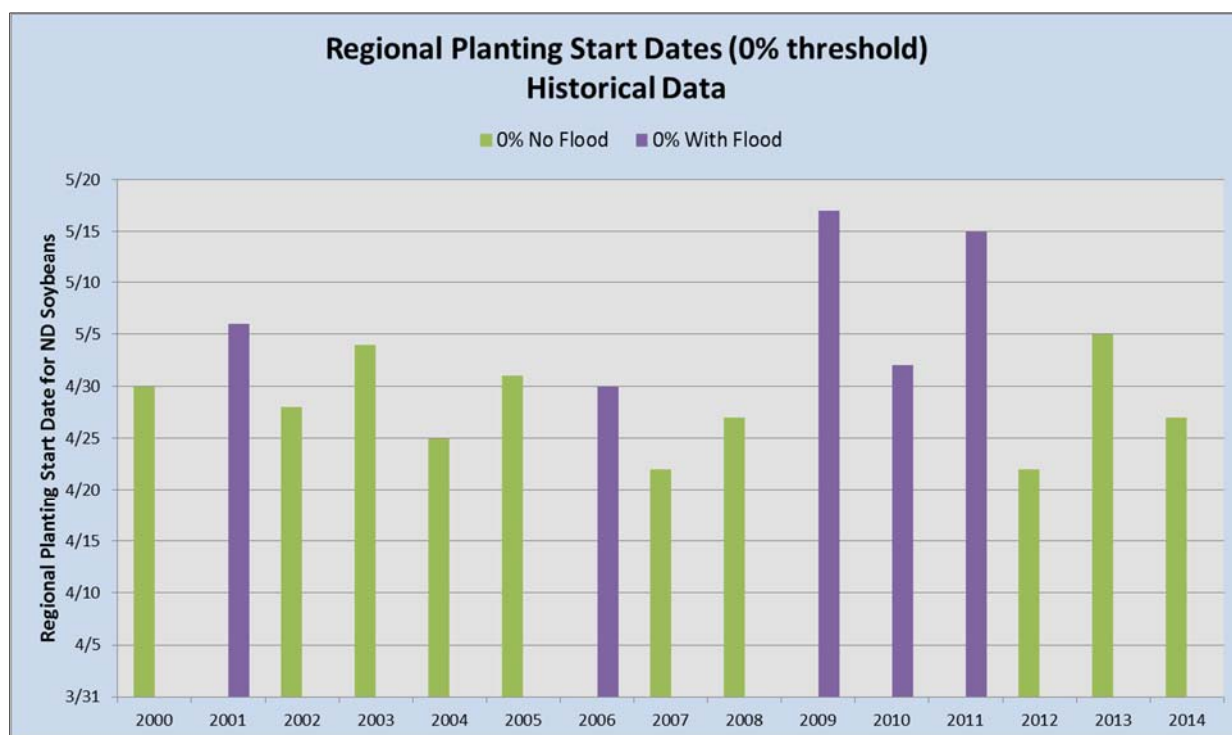


Figure 9. Comparison of Planting Start Dates for North Dakota Soybeans in Flood and Non-flood Years, 2000 through 2014.

Source: National Agricultural Statistics Service (2015).

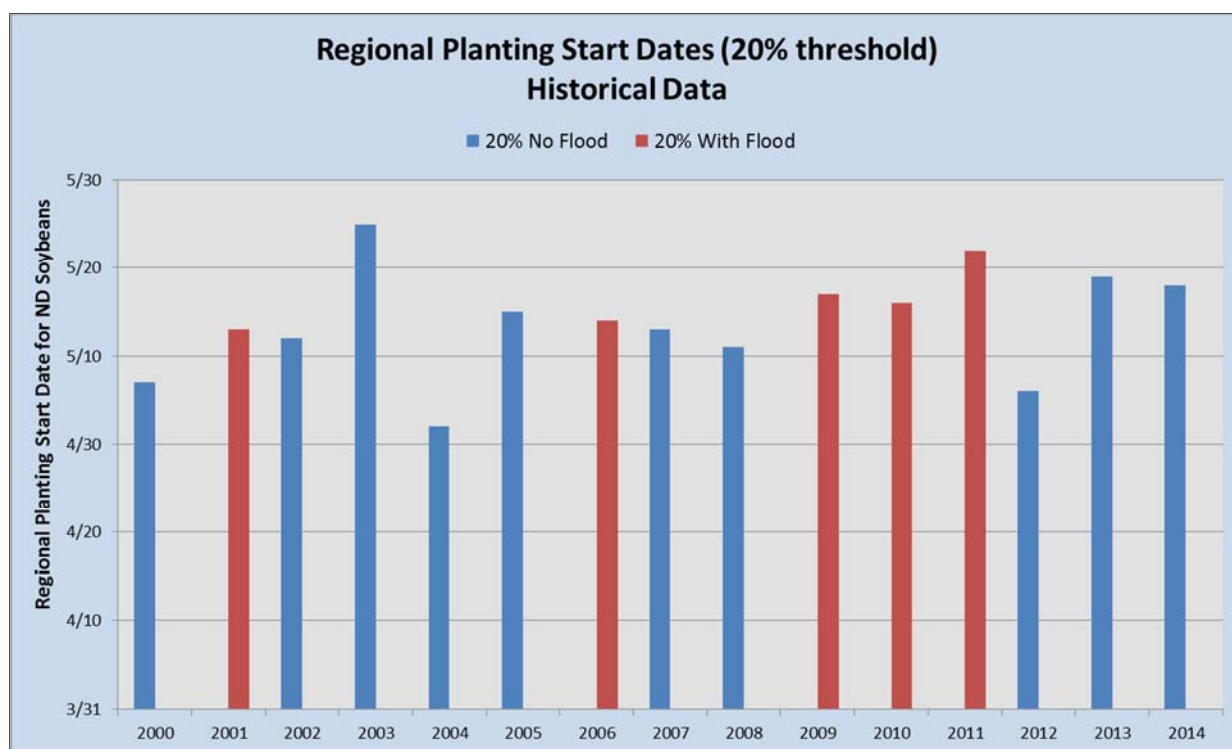


Figure 10. Comparison of Dates for 20 Percent Planting Completion for North Dakota Soybeans in Flood and Non-flood Years, 2000 through 2014.

Source: National Agricultural Statistics Service (2015).

Historical data on when regional planting for soybeans has reached 20 percent completion were used to produce a range and future probability for those dates. The historical planting completion data suggested that planting of soybeans in North Dakota will fall between May 1 and May 31, with an average start date around May 13. [The range of spring planting start dates used in the simulation for soybeans is discussed by Bangsund et al. (2015)].

Combining the distribution of dates for regional planting and dates for activation of the staging area can illustrate the number of days between the triggering of the staging area (17,000 cfs in Fargo) to when regional planting completion for soybeans has reached 20 percent (Figure 11).

The statistical distributions not only can show the range of days between staging activation date and regional planting dates, but also can illustrate the frequency or probability of that range. Figure 8 and Table 11 already illustrate that the historical data show a range of 24 to 54 days from when the Red River reaches 17,000 cfs in Fargo and when planting activity for soybeans is first reported by NASS. Also, the historical data show a range of 31 to 58 days from when the staging area would be triggered to when planting progress reaches 20 percent completion. Over the 10,000 replications, the difference (in days) between staging area activation and when regional planting reaches 20 percent completion varied from 10 days to 61 days (Figure 11). While the simulation produced a range larger than observed with existing data, the chance of the difference exceeding 50 days or being less than 15 days is about 4 percent (Table 12). About 80 percent of the replications in the simulation suggest that the difference between the staging area activation date and when regional planting may reach 20 percent completion falls between 30 and 50 days. Alternatively, the difference between the staging area activation date and regional planting date will be 30 to 50 days over 80 percent of the time (Table 12).

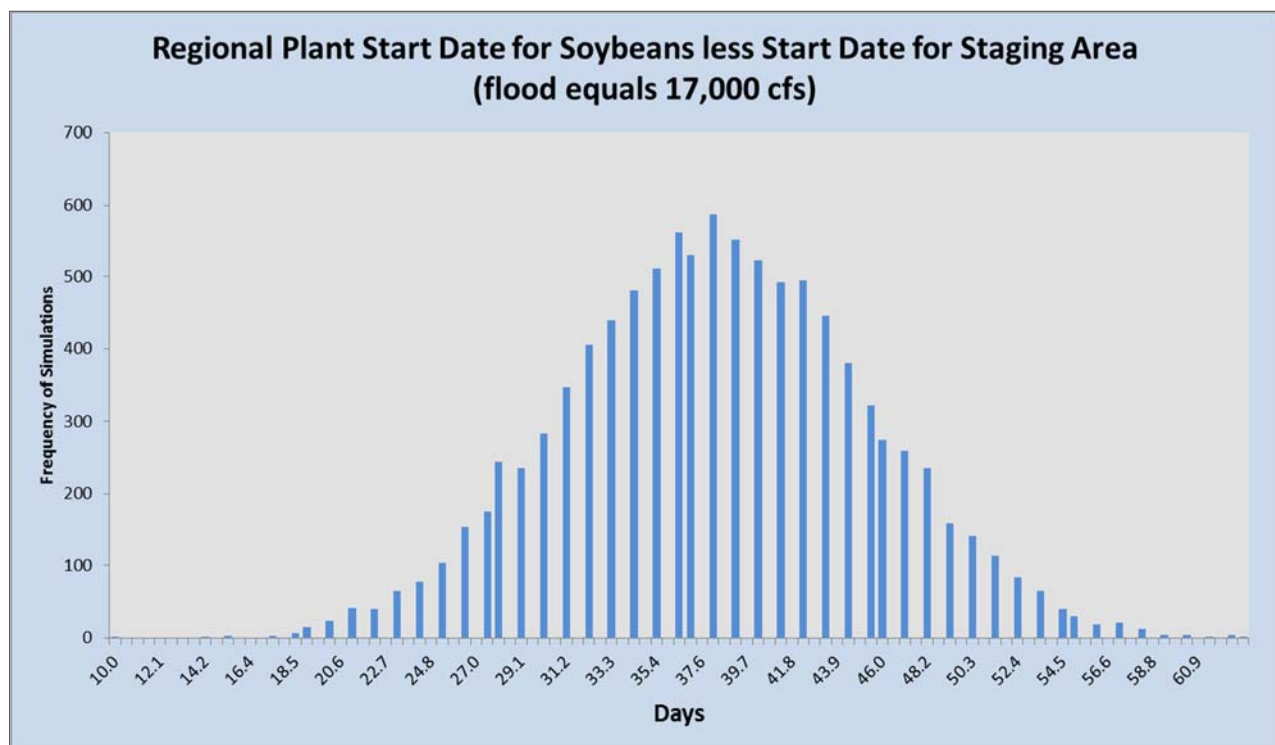


Figure 11. Monte Carlo Simulation, Difference in Days between Staging Area Activation and Regional Planting Reaching 20 percent Completion for Soybeans.

Table 12. Monte Carlo Simulation, Distribution of the Difference in Days between Staging Area Activation and Regional Planting Reaching 20 percent Completion for Soybeans

Days ^a	Number of Replications	Percent of Monte Carlo Simulation
0-15	3	0.0
16-20	27	0.3
21-25	246	2.5
26-30	1,193	11.9
31-35	1,672	16.7
36-40	3,265	32.7
41-45	1,811	18.1
46-50	1,388	13.9
>50	395	4.0

^a Days were estimated by subtracting the flood start date (date when staging area is activated) from the regional planting start date (20% threshold). Days therefore represent the time required for the effects of flooding to be gone without incurring a planting delay due to a spring flood event.

Time Required for Effects of Planting to be gone During Flood Years

A critical element in evaluating the potential agricultural implications of short-term water storage on farmlands in the FM Diversion staging area relates to the duration or absence of water storage within the staging area. Understanding the differences in water storage between the Without Diversion and With Diversion conditions forms the basis to evaluating the potential effects on spring field work.

In all flood event sizes except the 10-year event, the majority of acres in the staging area have 16 to 25 days from activation of staging area until the effects of flooding are gone (Table 13). Acreage associated with more than 25 days until the effects of flooding are over is relatively small in the 25-year and 50-year events, but increases in the 100-year and 500-year events. For example, the number of acres that would require 25 or more days for the effects of flooding to be over ranges from around 2,800 acres in the 25-year event to 23,400 acres in the 500-year event. As would be expected, as the size of the flood event increases, more acres require a longer period for the effects of flooding to be gone (Table 13).

Table 13. Total Days from Staging Area Activation until the Effects of Flooding are gone, With and Without Diversion, by Size of Flood Event										
Total Days ^a	Size of Flood Event									
	10-year		25-year		50-year		100-year		500-year	
	W	WO	W	WO	W	WO	W	WO	W	WO
	----- acres of storage areas -----									
0	48,027	48,874	18,338	35,602	10,155	28,619	3,918	22,355	1,382	12,183
1-15	510	364	364	4,685	907	364	792	1,684	0	0
16-20	15,885	15,188	19,076	14,888	21,087	21,784	16,925	21,737	9,049	15,473
21-25	0	0	23,805	9,247	27,181	13,655	23,570	14,208	30,575	20,871
25-30	0	0	2,839	0	5,092	0	19,217	3,808	19,674	9,865
31-35	0	0	0	0	0	0	0	631	3,742	5,398
36-40	0	0	0	0	0	0	0	0	0	631
>40	0	0	0	0	0	0	0	0	0	0
Total	64,422	64,422	64,422	64,422	64,422	64,422	64,422	64,422	64,422	64,422
W=With Diversion, WO=Without Diversion.										
^a Total days are equal to the sum of days for land to become inundated, days of inundation, and 10-day dry-down period.										
Total days until the effects of flood are gone are NOT equivalent to planting delays.										

Another way to examine how the staging area may create planting delays is to examine the difference in days (i.e., days from activation until regional planting starts) between the two conditions. The difference between With and Without Diversion conditions represents the additional time that the land requires for the effects of flooding to be gone due to the Diversion. The extra days attributable to the Diversion may not result in planting delays because planting delays will depend upon when the flood event occurs, duration of the flood event, and when regional planting activity begins. However, the difference in time required for the effects of flooding to be gone between existing conditions and With the Diversion helps to clarify the magnitude of *potential* delays (Table 14).

In a 10-year event, only a relatively small amount of land would experience a longer period for the effects of flooding to be gone due to the Diversion (Table 14, Figure 12). In a 25-year event, the difference in time required for the effects of flooding to be gone due to the Diversion varies from 1 day

to 23 days (Table 14, Figure 13). The difference in the time for the effects of flooding to be over varies from 0.5 day to 23.5 days in a 50-year event (Table 14, Figure 14). Similarly, in a 100-year event the difference in when the effects of flooding are over ranges from -0.5 days to 24.5 days (Table 14, Figure 15). The 500-year event has storage areas that have a potential for the effects of flooding to be over 3 days sooner With the Diversion to 24.5 days later With the Diversion (Table 14, Figure 16). Data presented in Table 14 and Figures 12 to 16 represent the difference in the time required for the effects of flooding to be gone, but do not represent planting delays.

Table 14. Difference in Days Required for Effects of Flooding to be gone between Existing Conditions and With the Diversion					
Difference in	Size of Flood Event				
Total Days ^a	10-Year	25-Year	50-Year	100-Year	500-Year
	----- acres of storage areas-----				
- days ^b	2,221	0	0	0	8,845
0	59,890	18,702	10,155	4,120	5,613
1 to 5	1,467	21,783	32,360	31,652	37,573
6 to 10	0	6,674	3,444	10,214	1,590
11 to 15	0	0	907	1,385	0
16 to 20	843	11,200	11,307	8,190	2,728
21 to 25	0	6,064	6,250	8,862	8,073
>25	0	0	0	0	0
Total	64,442	64,442	64,442	64,442	64,442
^a Total days for the effects of flooding to be over With the Diversion less the total days for the effects of flooding to be gone Without the Diversion. Total days are equal to the sum of days for land to become inundated, days of inundation, and 10-day dry-down period.					
^b Situations where total days are fewer With the Diversion than Without the Diversion.					

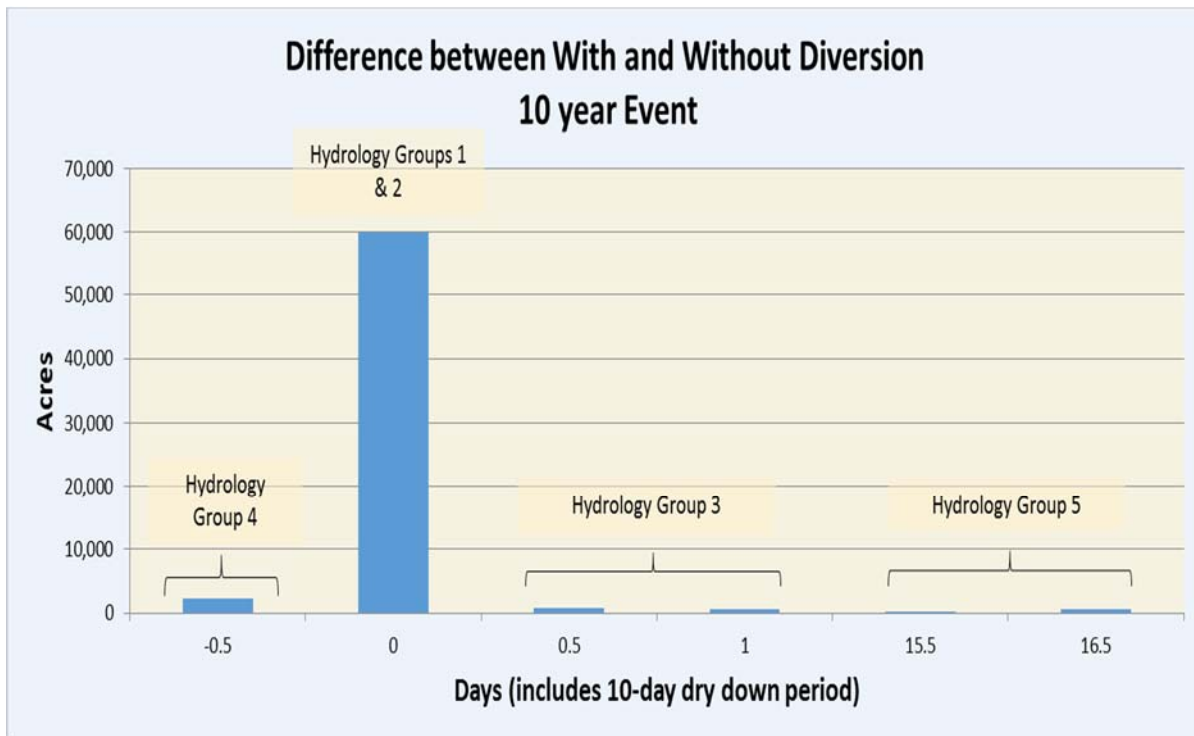


Figure 12. Extra Days needed for the Effects of Flooding to be gone due to the Diversion, 10-year Event

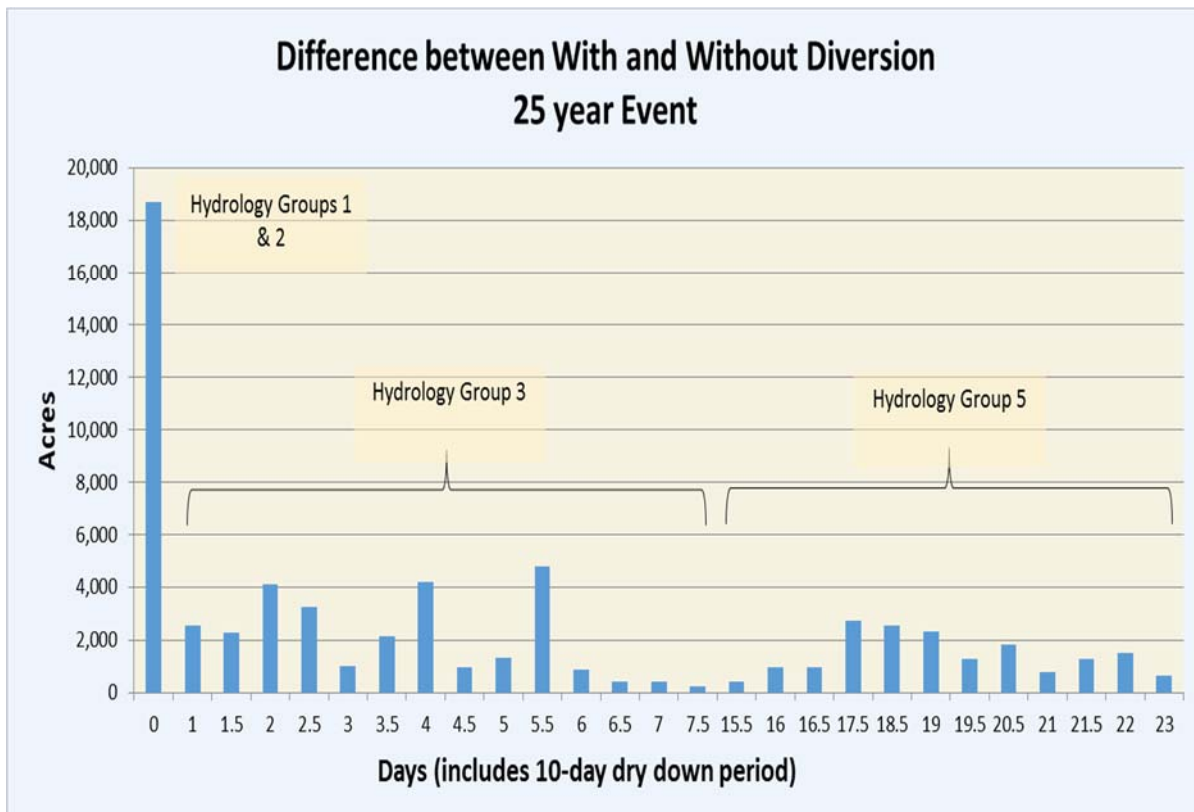


Figure 13. Extra Days needed for the Effects of Flooding to be gone due to the Diversion, 25-year Event

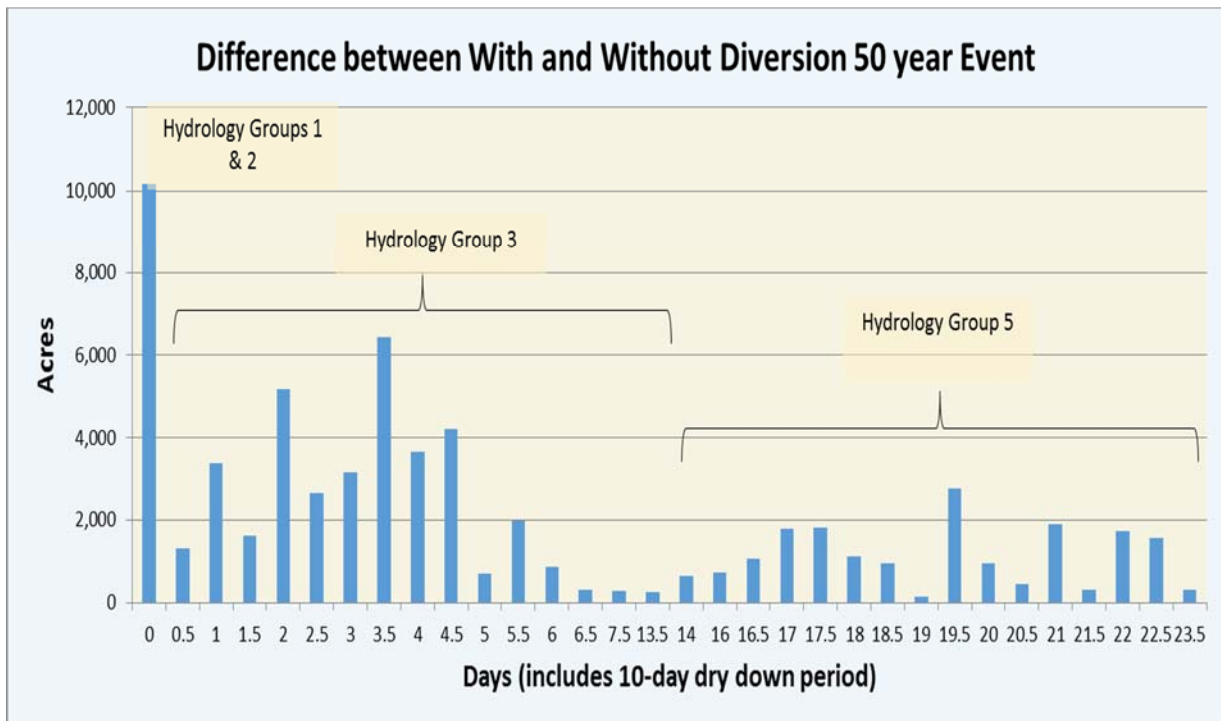


Figure 14. Extra Days needed for the Effects of Flooding to be gone due to the Diversion, 50-year Event

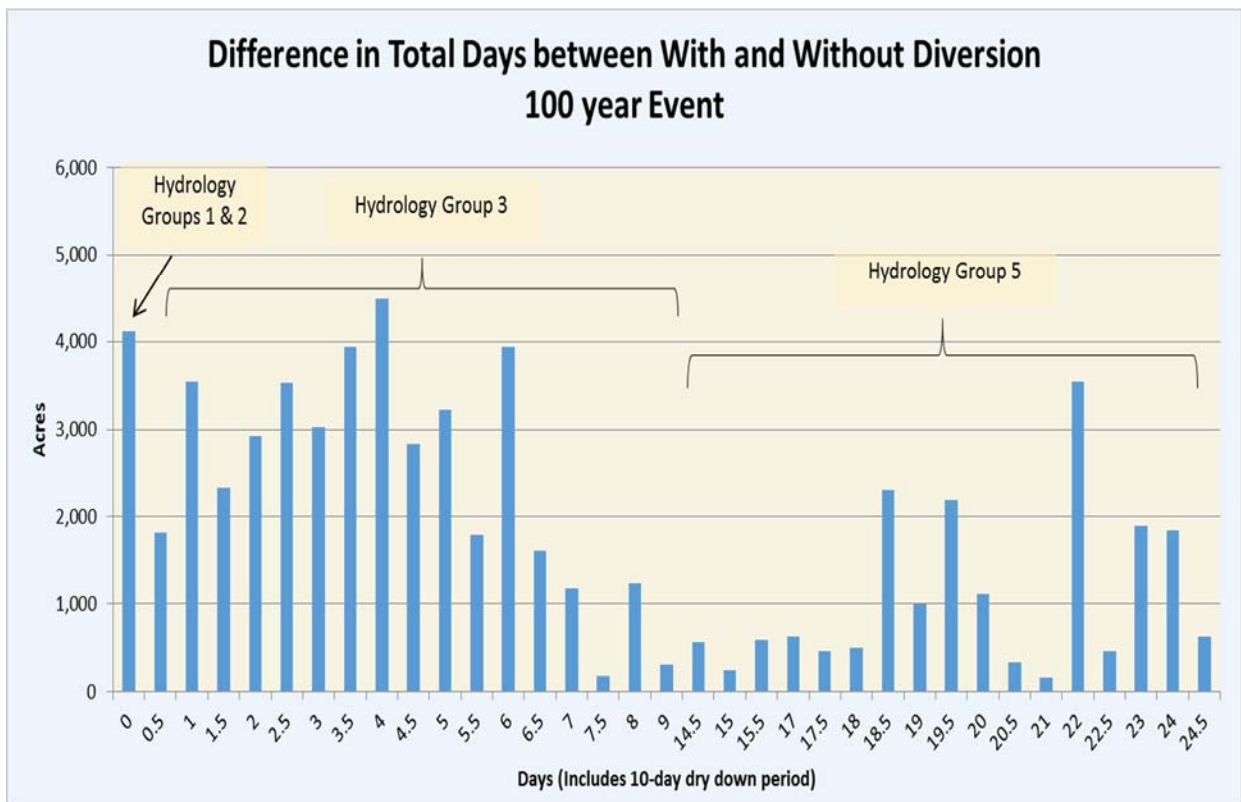


Figure 15. Extra Days needed for the Effects of Flooding to be gone due to the Diversion, 100-year Event

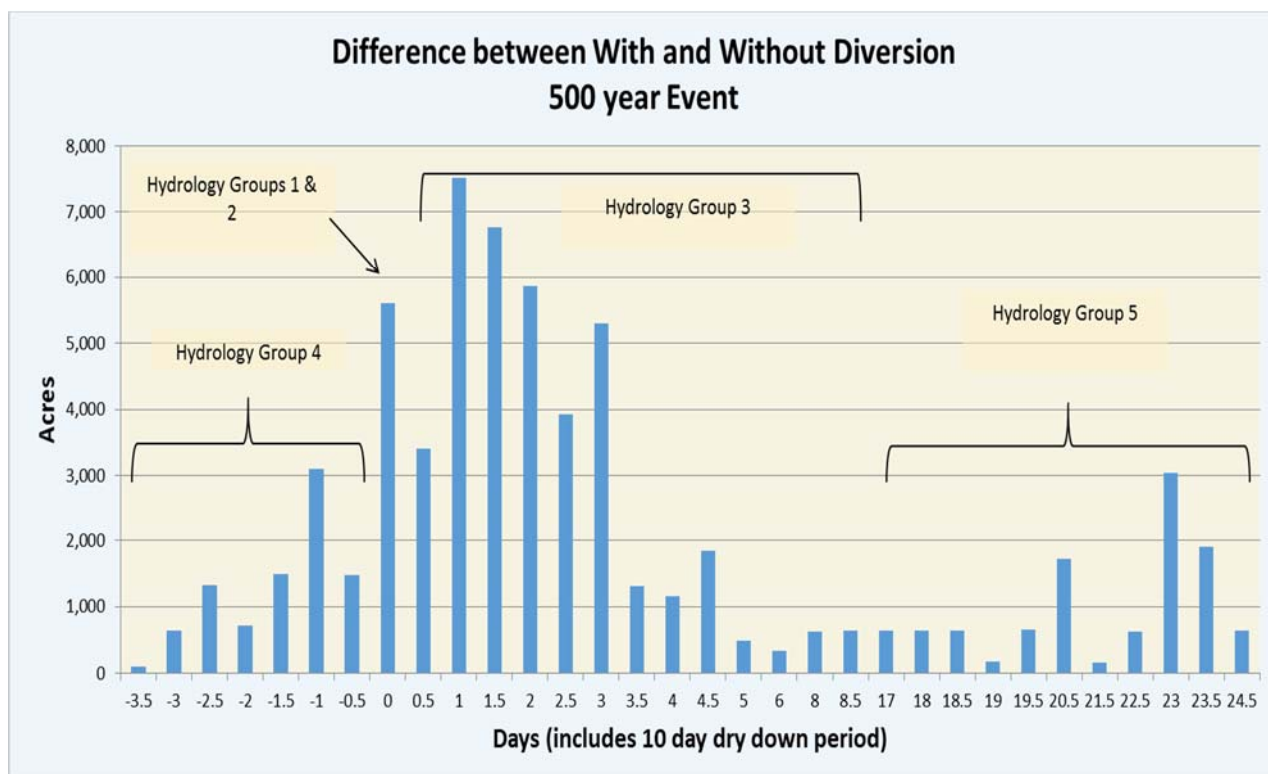


Figure 16. Extra Days needed for the Effects of Flooding to be gone due to the Diversion, 500-year Event

The time required for the effects of flooding to be gone in the staging area, With or Without the Diversion, varies from 0 days to more than 40 days during a flood event (see Table 13). Essentially, lands in the staging area would experience a wide range of days for the effects of flooding to be gone in either condition. This suggests that natural flooding would affect a substantial amount of acreage within the staging area. Also, the general time required for the effects of flooding to be gone and the acreages affected increases with flood event size for both existing conditions and With the Diversion (see Table 13).

Comparing the results in Table 13 with the results in Table 15, it is clear that during flood years a high probability exists that lands in the staging area will experience delayed planting for sugarbeets, corn, and wheat. For example, in Table 13, nearly 48,200 acres will require 16 to 25 days for the effects of flooding to be gone in a 50-year flood event With the Diversion and nearly 35,400 acres will require the same period for the effects of flooding to be gone with existing conditions. Correspondingly, in Table 15, a period of 16 to 20 days would result in a planting delay 40 percent of the time and a period of 21 to 25 days would result in planting delays nearly 60 percent of the time. In a 50-year flood event, the majority of acres (either Without or With the Diversion) would have a 40 to 60 percent chance of experiencing a planting delay. The probability of a planting delay increases with the size of the flood event, both for existing conditions and With the Diversion. Therefore, modeling based off of the existing data suggests that planting delays are highly probable for the majority of acres in the staging area. However, it must be stressed that the analysis is focused solely on the degree of planting delays caused by the Diversion.

In Table 16, lands that would require 40 or more days for the effects of flooding to be gone would experience a planting delay 64 percent of the time. However, the majority of land will require 25 or fewer days for the effects of flooding to be gone With the Diversion or with existing conditions (Table

13), which suggests a low probability of planting delays for soybeans (Table 16). If the time for the effects of flooding to be over is 25 or fewer days after the staging area is triggered, the chance of planting delays for soybeans is around 3 percent. Table 16 indicates that lands would need to have 35 or more days for the effects of flooding to be over after staging area activation to have a greater than 50 percent chance for planting delays for soybeans.

Table 15. Comparing the Days until the Effects of Flooding are Over with the Days from Staging Activation until Regional Planting Reaches 20 Percent Completion for Sugarbeets in North Dakota		
Total Days From Staging Activation until Effects of Flooding are over ^a	Annual Chance that Regional Planting Start Date would occur Prior to When Effects of Flooding are over ^b	Annual Chance that Effects of Flooding are over before Regional Plant Date ^b
----- days -----	----- percent -----	
0	0	100
1-15	22.6	77.4
16-20	40.8	59.2
21-25	59.6	40.4
25-30	80.9	19.1
31-35	91.6	8.4
36-40	98.1	1.9
41-45	99.8	0.2
>45	100	0
^a Total days are equal to days for land to become inundated, days of inundation, and 10-day dry-down period. Total days until the effects of flooding are over are NOT equivalent to planting delays. ^b Based on the 10,000 replications from the Monte Carlo simulation. Regional planting start date is when regional planting has reached 20 percent completion.		

Table 16. Comparing the Days until the Effects of Flooding are over to the Days from Staging Activation until Regional Planting Reaches 20 Percent Completion for Soybeans in North Dakota		
Total Days From Staging Activation until Effects of Flooding are over ^a	Annual Chance that Regional Planting Start Date would occur Prior to When the Effects of Flooding are over ^b	Annual Chance that Effects of Flooding are over before Regional Plant Date ^b
----- days -----	----- percent -----	
0-15	0	100
16-20	0.3	99.7
21-25	2.7	97.3
26-30	14.7	85.3
31-35	31.4	68.6
36-40	64.0	36.0
41-45	82.1	17.9
46-50	96.0	4.0
>50	100	0
^a Total days are equal to days for land to become inundated, days of inundation, and 10-day dry-down period. Total days until the effects of flooding are over are NOT equivalent to planting delays. ^b Based on the 10,000 replications from the Monte Carlo simulation. Regional planting start date is when regional planting has reached 20 percent completion.		

Summary of Planting Dates, Flood Start Dates, and Time Required for Effects of Flooding to be Gone

Inundated lands require a certain amount of time for the effects of flooding to be gone (i.e., water must leave the land and then it must dry-down). On the other end of the spectrum, there is a certain amount of time between when a flood event starts (i.e., 17,000 cfs in Fargo) to when regional planting typically begins. This section examined the number of days from when the staging area is activated to when the effects of flooding are over and compared that period to the number of days from flood event start (i.e., staging area activation) to when regional planting begins. Flood events result in delayed planting when inundated lands require more time for the effects of flooding to be gone than the time from flood event start to when regional planting begins. Stated alternatively, if regional planting begins before the effects of flooding are over for inundated lands, those lands will experience delayed planting. However, the analysis focused on 1) the additional time the Diversion adds to the time required for the effects of flooding to be gone, and 2) how often those additional days are likely to result in planting delays. The following points below highlight the evaluation of flood start dates, time for effects of flooding to be over, and planting start dates.

-) Historical data suggest flood years do not necessarily result in a later planting start date than non-flood years for sugarbeets, corn, or wheat. Planting start dates for soybeans also show that planting start dates are nearly the same between flood years and non-flood years. Therefore, a flood year does not guarantee a later regional planting date than a non-flood year.
-) Historical data reveal that regional planting for sugarbeets, corn, and wheat has reached 20 percent completion between 19 to 38 days after Red River first reaches 17,000 cfs in Fargo. This is the range of days under which inundated lands have time for the effects of flooding to be gone before planting sugarbeets, corn, and wheat without incurring planting delays.
-) Historical data reveal that regional planting for soybeans has reached 20 percent completion between 31 to 58 days after the Red River first reaches 17,000 cfs in Fargo. This is the range of days under which inundated lands have time for the effects of flooding to be gone before planting soybeans without incurring planting delays.
-) Using historical data for corn, sugarbeets, and wheat, the Monte Carlo simulation revealed:
 -) a 40 percent annual chance that regional planting would begin within 20 days of the Red River reaching 17,000 cfs in Fargo
 -) a 40 percent annual chance that regional planting would begin between 21 to 30 days after Red River reached 17,000 cfs in Fargo
 -) 20 percent annual chance that regional planting would begin 30 or more days after the Red River reached 17,000 cfs in Fargo
-) Using historical data for soybeans, the Monte Carlo simulation revealed:
 -) a 37 percent annual chance that regional planting would begin within 35 days of the Red River reaching 17,000 cfs in Fargo
 -) a 37 percent annual chance that regional planting would begin between 36 to 42 days after Red River reached 17,000 cfs in Fargo
 -) 26 percent annual chance that regional planting would begin 43 or more days after the Red River reached 17,000 cfs in Fargo

-) Combining a dry-down period with the hydrology data revealed:
 -) A majority of acres within the staging area will require 16 to 25 days for the effects of flooding to be over after activation of the staging area, even though some storage areas will require over 30 days for the effects to be gone (Table 13)
 -) A majority of land in the staging area will flood Without the Diversion, and the Diversion will add 1 to 7 days of additional time for the effects of flooding to be over on those lands (Figures 12 to 16 and Table 14)
 -) Between 10,000 to 13,000 acres (depending upon flood event size) within the staging area will flood due to the diversion that would not otherwise flood, and the time for the effects of flooding to be over on those lands varies from 16 to 25 days after the activation of the staging area (Figures 12 to 16 and Table 14).

-) Examining the Monte Carlo distribution of regional planting start dates and distribution of flood event start dates reveals
 -) 60 percent annual chance that regional planting date for corn, soybeans, and wheat will be 21 or more days after the staging area is activated (Figure 7)
 -) 40 percent annual chance that regional planting date for corn, sugarbeets, and wheat will be 20 or fewer days after the staging area is activated (Figure 7)
 -) Annual probability ranges from 40 to 60 percent that the majority of acreage in the staging area, either with existing conditions or With the Diversion, would experience some planting delay for corn, sugarbeets, and wheat in a flood year (i.e., flood year of sufficient size to activate the staging area)
 -) 64 percent annual chance that regional planting date for soybeans will be more than 35 days after the staging area is activated.
 -) 31 percent annual chance that regional planting date for soybeans will be less than 35 days after the staging area is activated
 -) annual probability is less than 15 percent that the majority of acreage in the staging area would experience some planting delays for soybeans in a flood year
 -) The range of time needed for lands in the staging area to be ready for planting is similar to the amount of time between when the staging area is activated and when regional planting would start for corn, wheat, and sugarbeets, implying
 -) High probability of some planting delays for corn, wheat, and sugarbeets
 -) Low probability of large planting delays for corn, wheat, and sugarbeets
 -) The range of time needed for lands in the staging area to be ready for planting is shorter than the time between when the staging area is activated and when regional planting would start for soybeans, implying
 -) Low probability of planting delays for soybeans

Evaluation of 10-year, 25-year, 50-year, 100-year, and 500-year Flood Events

Two key elements to the analysis are 1) how likely are damages to occur during a flood year and 2) what is the dollar value of those losses. The following results combine the elements discussed in the previous two sections; how the time for the effects of flooding to be gone overlaps with when regional planting will begin and how the delayed planting results in revenue losses.

Probability of Losses During a Flood Event

No two flood events are the same nor are spring planting conditions homogeneous across years. Therefore, it becomes difficult to predict a point estimate of the potential effects of water storage on planting operations, which is precisely the reason for conducting a simulation over a range of different conditions. The analysis estimates how frequent revenues losses occur over the range of different flood event start dates, planting start dates, and planting rates for each storage area in the five flood events. Storage areas that do not flood or flood the same duration would not be impacted by the staging area, so the emphasis on estimating flood-related revenue losses can be focused on those storage areas that flood longer With the Diversion (Group 3) and those storage areas that now flood with use of the staging area but would not otherwise experience a spring flood event (Group 5).

-) 10-year Flood Event

In a 10-year event, storage areas that are inundated longer With the Diversion have a 33 percent annual probability of incurring planting delays that result in revenue declines (Tables 17 and 18). Not all planting delays result in revenue losses (see Table 16), so the annual probability of experiencing a planting delay is greater than the annual chance of experiencing a revenue loss. Hydrology Group 3 storage areas have a 66 percent annual chance of experiencing no losses associated With the Diversion in a 10-year event. Similarly, Hydrology Group 5 storage areas have a 29 percent annual chance of incurring revenues losses associated with operation of the staging area in a 10-year event. Alternatively, about 70 percent of the time Hydrology Group 5 storage areas would not experience revenues losses in a 10-year event. Storage areas that are modeled to have reduced periods of inundation (Hydrology Group 4) resulting from the Diversion have a 33 percent annual probability of improved revenues associated with earlier planting start dates. While the results show no revenue losses for storage areas in Hydrology Group 2, the revenue losses being measured are those created by the Diversion. Results should be interpreted carefully, as the model does not imply that Hydrology Group 2 storage areas have no revenue losses from delay planting—rather, since the flood duration is the same, the Diversion did not create additional revenue losses.

For storage areas in Groups 3 and 5, the average per-acre losses are expected to range from \$1 to \$25 in nearly all situations that produce a revenue loss from delayed planting (Table 17). Losses greater than \$25 per acre are possible, just less likely. In an attempt to more accurately portray the average revenue reductions, Hydrology Groups 3 and 5 were further delineated into sub-groups based on the difference between existing conditions and With Diversion conditions for the days required for the effects of flooding to be gone (Table 18). Proper interpretation of the revenue losses must consider that all storage areas within a particular hydrology group (and sub-group) are averaged, and all acres within each individual storage area also are averaged. Averaging within the model results in storage areas with low losses being combined with storage areas having higher losses. For example, a storage area in Hydrology Group 3 that requires one additional day for the effects of flooding to be over would be averaged with a storage area that requires five additional days for the effects of flooding to be gone. The average revenue loss reported therefore would be higher than the storage area with 1 day of delay and lower than the storage area with 5 days of delay.

-) 25-year Flood Event

Only three hydrology groups are represented in a 25-year event. Hydrology Group 3 (floods longer) had a revenue loss in 64 percent of the replications. Storage areas in Hydrology Group 5 (now floods with Diversion) have over a 50 percent annual chance of experiencing revenue losses (Table 19). Nearly all of the losses for storage areas in Hydrology Group 3 ranged from \$1 to \$25 per acre. Storage areas that now flood With the Diversion that would not normally flood had average damages greater than \$25 per acre in about 7 percent of the replications, with the remainder of the potential revenue losses in the \$1 to \$25 per acre range. Storage areas in Hydrology Group 5 that had over 20 days of additional time required for the effects of flooding to be over experienced losses greater than \$50 per acre in about 2 percent of the replications (Table 20).

-) 50-year Flood Event

Results for the 50-year event for storage areas in Hydrology Groups 3 and 5 were similar to those for the 25-year event (Table 21). Hydrology Group 3 experienced revenue losses ranging from \$1 to \$25 per acre in 67 percent of the replications. Revenue losses occurred in 56 percent of the replications for Hydrology Group 5, with nearly 8 percent over \$25 per acre. When Groups 3 and 5 were delineated by days, the results became more sensitive to the length of time required for the effects of flooding to be over. One storage area in Hydrology Group 5, requiring 14 additional days from activation of the staging area to when the effects of flooding would be gone, only had revenue losses in 19 percent of the replications (Table 22). Storage areas requiring more than 20 days for the effects of flooding to be gone experienced revenue losses in 56 percent of the replications. The contrast in frequency of revenue losses between the storage areas with less than 14 days and more than 20 days is consistent with the results discussed in the [Evaluation of Potential Planting Delays](#) section.

-) 100-year Flood Event

In a 100-year flood event, storage areas in Hydrology Group 3 had revenue losses due to the Diversion in about 75 percent of the replications (Table 23). However, nearly all of the revenues losses for Hydrology Group 3 ranged from \$1 to \$25 per acre. Storage areas in Hydrology Group 5 had revenue losses in 60 percent of the replications. As was observed with the 50-year flood, storage areas having greater than 20 days difference in the time required for the effects of flooding to be gone experienced revenue losses considerably more often than storage areas requiring 16 to 20 days for the effects of flooding to be gone (Table 24). Longer periods for the effects of flooding to be gone (Group 5) also increased the likelihood of larger per-acre losses. Average losses in excess of \$25 per acre occurred in 18 percent of the replications for storage areas with 20 or more additional days for the effects of flooding to be over compared to revenue losses in about 5 percent of the replications for storage areas requiring 16-20 additional days for the effects of flooding to be over.

-) 500-year Flood Event

The likelihood of revenue losses for Hydrology Groups 3 and 5 for a 500-year event were similar to those for a 100-year event. Seventy-five percent of the replications produced revenue losses for storage areas that now flood longer With the Diversion, and nearly all of those losses ranged from \$1 to \$25 per acre (Table 25). Storage areas in Hydrology Group 5 exhibited revenue losses in 60 percent of the replications—nearly identical to the frequency of losses in the 100-year event. Hydrology modeling revealed reduced water inundation periods for several storage areas in a 500-year event. Those storages areas (Hydrology Group 4) experienced revenue gains in 94 percent of the replications. The

likelihood of greater revenue losses increased in the 500-year event over those observed in the other flood events. In Hydrology Group 3, those storage areas with 6 to 10 additional days for the effects of flooding to be over had a 25 percent change of revenue losses exceeding \$25 per acre. The percentage for replications producing losses of the same magnitude for the storage areas with similar hydrology in the 100-year event was 18 percent. The 500-year event produced some situations where the average per-acre losses within the storage areas exceeded \$75 per acre (Table 26).

Table 17. Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 10-year Flood Event

Hydrology Groups	No Loss	\$0 to \$25/acre ^a Loss	\$26 to \$50/acre ^a Loss	\$51 to \$75/acre ^a Loss	\$76 to \$100/acre ^a Loss	Positive Impact per Acre	Any Loss	Acres
----- Based on 10,000 replications from Monte Carlo Simulation -----								
(1) Does not flood	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	48,027
(2) Floods Same Duration	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11,863
(3) Floods Longer Duration	66.8%	33.2%	0.0%	0.0%	0.0%	0.0%	33.2%	1,467
(4) Floods Shorter Duration	66.8%	0.0%	0.0%	0.0%	0.0%	33.2%	0.0%	2,221
(5) Now Floods With Diversion	70.5%	28.6%	0.9%	0.0%	0.0%	0.0%	29.5%	843

^a The range of losses per acre represent an average of all storage areas with the hydrology group.

Table 18. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 10-year Flood Event

Time from Activation of Staging Area until Effects of Flooding are Over ^a										
Hydrology Group	Without Diversion	With Diversion	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	Any Loss	Acres
----- days -----				----- Based on 10,000 replications from Monte Carlo Simulation -----						
3	16.2	16.8	1 to 5	66.8%	33.2%	0.0%	0.0%	0.0%	33.2%	1,467
3	na	na	6 to 10	na	na	na	na	na	na	na
5	na	na	11 to 15	na	na	na	na	na	na	na
5	0	16	15 to 20	70.5%	28.6%	0.9%	0.0%	0.0%	29.5%	843
5	na	na	Over 20	na	na	na	na	na	na	na

Na=not applicable. There were no storage areas in those categories.

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood with existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas within the groups.

Table 19. Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 25-year Flood Event

Hydrology Groups	No Loss	\$0 to	\$26 to	\$51 to	\$76 to	Positive	Any Loss	Acres
		\$25/acre ^a	\$50/acre ^a	\$75/acre ^a	\$100/acre ^a	Impact per		
		Loss	Loss	Loss	Loss	Acre		
		----- Based on 10,000 replications from Monte Carlo Simulation -----						
(1) Does not flood	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	18,338
(2) Floods Same Duration	na	na	na	na	na	na	na	na
(3) Floods Longer Duration	36.3%	63.7%	0.0%	0.0%	0.0%	0.0%	63.7%	28,456
(4) Floods Shorter Duration	na	na	na	na	na	na	na	na
(5) Now Floods With Diversion	47.4%	46.0%	5.9%	0.6%	0.0%	0.0%	52.6%	17,264

Na=not applicable. There were no storage areas in those hydrology groups.

^a The range of losses per acre represent an average of all storage areas with the hydrology group.

Table 20. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 25-year Flood Event

Time from Activation of Staging Area until Effects of Flooding are Over ^a										
Hydrology Group	Without Diversion	With Diversion	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	Any Loss	Acres
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----						
3	19	21.9	1 to 5	36.3%	63.7%	0.0%	0.0%	0.0%	63.7%	21,783
3	16.9	22.7	6 to 10	40.2%	57.3%	2.5%	0.0%	0.0%	59.8%	6,674
5	na	na	11 to 15	na	na	na	na	na	na	na
5	0	18.1	16 to 20	59.1%	36.8%	3.7%	0.4%	0.0%	40.9%	11,200
5	0	21.4	Over 20	47.4%	40.2%	10.6%	1.6%	0.1%	52.6%	6,064

Na=not applicable. There were no storage areas in those categories.

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood with existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas within the groups.

Table 21. Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 50-year Flood Event

Hydrology Groups	No Loss	\$0 to \$25/acre ^a Loss	\$26 to \$50/acre ^a Loss	\$51 to \$75/acre ^a Loss	\$76 to \$100/acre ^a Loss	Positive Impact per Acre	Any Loss	Acres
----- Based on 10,000 replications from Monte Carlo Simulation -----								
(1) Does not flood	100%	0%	0%	0%	0%	0%	0%	10,155
(2) Floods Same Duration	na	na	na	na	na	na	na	Na
(3) Floods Longer Duration	32.5%	67.5%	0%	0%	0%	0%	67.5%	35,803
(4) Floods Shorter Duration	na	na	na	na	na	na	na	na
(5) Now Floods With Diversion	43.9%	48.9%	6.5%	0.7%	0.1%	0.0%	56.1%	18,464

Na=not applicable. There were no storage areas in those hydrology groups.
^a The range of losses per acre represent an average of all storage areas with the hydrology group.

Table 22. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 50-year Flood Event

Time from Activation of Staging Area until Effects of Flooding are Over ^a										
Hydrology Group	Without Diversion	With Diversion	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	Any Loss	Acres
----- days -----				----- Based on 10,000 replications from Monte Carlo Simulation -----						
3	20.3	23.3	1 to 5	32.6%	67.4%	0.0%	0.0%	0.0%	67.4%	19,086
3	17.2	23.2	6 to 10	43.8%	53.7%	2.4%	0.0%	0.0%	56.2%	1,906
5	0	14.0	11 to 15	80.7%	18.2%	1.1%	0.0%	0.0%	19.3%	638
5	0	17.8	16 to 20	59.1%	36.0%	4.5%	0.5%	0.0%	40.9%	8,215
5	0	22.2	Over 20	43.9%	40.6%	13.1%	2.2%	0.2%	56.1%	4,641

Na=not applicable. There were no storage areas in those categories.

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood with existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas within the groups.

Table 23. Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 100-year Flood Event

Hydrology Groups	No Loss	\$0 to	\$26 to	\$51 to	\$76 to	Positive	Any Loss	Acres
		\$25/acre ^a	\$50/acre ^a	\$75/acre ^a	\$100/acre ^a	Impact per		
		Loss	Loss	Loss	Loss	Acre		
		----- Based on 10,000 replications from Monte Carlo Simulation -----						
(1) Does not flood	100%	0%	0%	0%	0%	0%	0%	3,918
(2) Floods Same Duration	100%	0%	0%	0%	0%	0%	0%	626
(3) Floods Longer Duration	25.3%	74.5%	0.3%	0%	0%	0%	74.7%	24,446
(4) Floods Shorter Duration ^b	100%	0%	0%	0%	0%	0%	0%	808
(5) Now Floods With Diversion	40.3%	48.3%	9.8%	1.5%	0.1%	0%	59.8%	14,487

Na=not applicable. There were no storage areas in those hydrology groups.

^a The range of losses per acre represent an average of all storage areas with the hydrology group.

^b The one storage area having a 0.5 day improvement in flood duration did not produce positive economic effects due to rounding to whole days within the model.

Table 24. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 100-year Flood Event

Hydrology Group	Time from Activation of Staging Area until Effects of Flooding are Over ^a			No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	Any Loss	Acres
	Without Diversion	With Diversion	Difference in Total Days							
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----						
3	20.5	23.8	1 to 5	25.3%	74.7%	0.0%	0.0%	0.0%	74.7%	31,651
3	19.9	26.3	6 to 10	28.7%	53.0%	18.3%	0.1%	0.0%	71.3%	10,214
5	0	14.8	11 to 15	77.3%	26.7	0.9%	0.0%	0.0%	22.7%	792
5	0	18.6	16 to 20	59.1%	35.4%	5.0%	0.6%	0.0%	40.9%	8,783
5	0	22.9	Over 20	40.2%	41.2%	15.2%	2.9%	0.5%	59.8%	8,862

Na=not applicable. There were no storage areas in those categories.

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood with existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas within the groups.

Table 25. Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 500-year Flood Event

Hydrology Groups	No Loss	\$0 to	\$26 to	\$51 to	\$76 to	Positive	Any Loss	Acres
		\$25/acre ^a	\$50/acre ^a	\$75/acre ^a	\$100/acre ^a	Impact per		
		Loss	Loss	Loss	Loss	Acre		
		----- Based on 10,000 replications from Monte Carlo Simulation -----						
(1) Does not flood	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1,382
(2) Floods Same Duration	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4,231
(3) Floods Longer Duration	25.3%	74.5%	0.0%	0.0%	0.0%	0.0%	74.6%	39,163
(4) Floods Shorter Duration ^b	4.7%	0.0%	0.0%	0.0%	0.0%	95.3%	0.0%	8,845
(5) Now Floods With Diversion	40.2%	44.2%	13.0%	2.2%	0.3%	0.0%	59.8%	10,801

Na=not applicable. There were no storage areas in those hydrology groups.

^a The range of losses per acre represent an average of all storage areas with the hydrology group.

^b The one storage area having a 0.5 day improvement in flood duration did not produce positive economic effects due to rounding to whole days within the model.

Table 26. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 500-year Flood Event

Hydrology Group	Time from Activation of Staging Area until Effects of Flooding are Over ^a			No Loss	\$0 to	\$26 to	\$51 to	\$76 to	Any Loss	Acres
	Without Diversion	With Diversion	Difference in Total Days		\$25/acre ^b Loss	\$50/acre ^b Loss	\$75/acre ^b Loss	\$100/acre ^b Loss		
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----						
3	21.6	23.6	1 to 5	25.3%	74.5%	0.0%	0.0%	0.0%	74.7%	37,573
3	16.5	24	6 to 10	40.2%	34.8%	24.6%	0.4%	0.0%	59.8%	1,590
5	na	na	11 to 15	na	na	na	na	na	na	na
5	0	18.4	16 to 20	59.1%	36.4%	4.1%	0.4%	0.0%	40.9%	2,728
5	0	22.1	Over 20	40.2%	39.5%	16.2%	3.4%	0.6%	59.8%	8,073

Na=not applicable. There were no storage areas in those categories.

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood with existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas within the groups.

Gross Revenues per Acre With and Without Diversion

The gross revenues per acre were averaged over all 10,000 replications for the five hydrology groups for each of the 5 flood events. In addition to average revenues, the minimum and maximum observed gross revenues were included to provide some perspective on the potential range of observed revenues for the different hydrology groups. The gross revenues are subject to the price and target yield assumptions, and the yield decline functions used in the model.

-) 10-year Flood Event

The average gross revenue for Hydrology Groups 3, 4, and 5 for the Without and With Diversion conditions are nearly identical in the 10-year event (Table 27). Storage areas that do not flood averaged \$588 of gross revenue per acre, which represents all of the combinations of early and late spring planting conditions but does not include any effects from either natural flooding or Diversion-related flooding. An overall average of \$588 per acre is a direct function of the target yields, prices, crop rotation, distribution of planting start dates and associated yield decline functions.

Hydrology Groups 2, 3, and 4 can be compared to Hydrology Group 1 to indicate the effects of natural flooding, as storage areas in Hydrology Groups 2, 3, and 4 are inundated with spring water Without the Diversion. The average revenues for those groups are lower than the average revenues for the storage areas that do not flood, demonstrating that natural spring flooding does create revenue losses through delayed planting when evaluated over a wide range of potential planting conditions. The average gross revenue among those three groups is not equal because the duration of water inundation (natural flooding) varies among the groups (see Appendix A).

The difference in gross revenues between With and Without Diversion for the hydrology groups affected by flooding is small, suggesting the overall effects of the Diversion in a 10-year event are minimal (Tables 27 and 28). As was highlighted in the previous section, the percentage of replications in a 10-year event that resulted in no revenue loss ranged from 67 percent to 71 percent for Hydrology Groups 3 and 5, respectively. Part of the reason for the small differences between the With and Without Diversion conditions is the high number of no-loss replications.

-) 25-year Flood Event

In the 25-year flood event Without the Diversion, the average gross revenue for Hydrology Group 3 (\$534) was lower than Hydrology Group 5 (\$591) (Table 29). The difference clearly highlights that natural flooding creates revenue losses due to delay planting. The difference in gross revenue between Hydrology Groups 1 and 5 (both groups do not currently flood), Without the Diversion, are the result of different composition of acres among the four counties in the staging area. Revenues among the four counties are different, due to different yields and crop shares.

The difference in gross revenues for storage areas in Hydrology Group 3 having 1 to 5 days additional delay compared to storage areas with 6 to 10 days additional delay is attributable to the overall time required for the effects of flooding to be over in those storage areas. For example, Without the Diversion, the total days required for the effects of flooding to be gone for Hydrology Group 3 that has 1 to 5 days of delay is 3 days longer than the requirements for storage areas in Hydrology Group 3 that have 6 to 10 days of additional delay (see Table 20). The difference in average gross revenue between the two sub-groups in Hydrology Group 3 is partially due to the difference in total time required for the effects of flooding to be over, and that the group with 6 to 10 days is heavily weighted by acreage in Clay County, which has higher relative gross revenues per acre than Cass County.

-) 50-year Flood Event

Only three hydrology groups are represented in a 50-year event. Hydrology Group 3 (floods longer) had average revenue loss around \$4 per acre when all replications were averaged (i.e., an average of no losses were included). Storage areas in Hydrology Group 5 (floods With Diversion) had average revenue loss around \$6 per acre (\$604 per acre Without Diversion compared to \$598 per acre With Diversion) when all replications were averaged (Table 31). For Hydrology Group 3, the storage areas with 6 to 10 days of additional delay had average revenue losses over all simulated conditions of \$8.5 per acre compared to around \$3.50 for storage areas with 1 to 5 days of additional delay. Similarly, the average losses per acre over all possible combination in the simulation for storage areas in Hydrology Group 5 ranged from \$1.60 to \$9.50 per acre (Table 32).

-) 100-year Flood Event

All five hydrology groups are represented in a 100-year event. The average gross revenue for storage areas that flood the same duration With and Without the Diversion were nearly \$110 per acre less than storage areas that do not flood (Table 33). While the lower revenues of \$110 per acre cannot be attributed to the Diversion, it does demonstrate the potential revenue losses associated with planting delays (see Appendix A for average days water is on the land for Hydrology Group 2). Similarly, storage areas that are expected to flood shorter With the Diversion (Group 4) also demonstrated revenue differences when compared to storage areas that do not flood (Group 1), which is due to the reduced duration of water inundation on those areas (see Appendix A).

Storage areas in Hydrology Group 3 (1 to 5 additional days) had average gross revenues \$4 less With the Diversion and those storage areas with 6 to 10 additional days had average gross revenues that were \$12.50 lower With the Diversion. In Hydrology Group 5, gross revenues ranged from \$5 lower for storage areas with 16-20 days for the effects of flooding to be gone after staging area activation to \$11.70 lower With the Diversion for those areas that require more than 20 days for the effects of flooding to be over after activation of the staging area (Table 34).

-) 500-year Flood Event

Although a 500-year event is expected to be considerably larger than the other flood events, estimated average gross revenues were similar to the 100-year event (Tables 35 and 36). Much of the reason for having similar gross revenues to the 100-year event is that the additional duration of water storage is actually lower for many storage areas in the 500-year event (see Appendix A).

Table 27. Gross Revenues, by Hydrology Group, With and Without Diversion, 10-year Flood Event				
Hydrology Group	Gross Revenues Per Acre ^a			
	Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)				
(1) Does not flood	587.72	437.96	618.71	25.09
(2) Floods Same Duration	523.79	378.10	551.50	20.25
(3) Floods Longer Duration	511.64	364.65	537.39	19.77
(4) Floods Shorter Duration	503.78	355.82	528.48	19.02
(5) Now Floods With Diversion	527.52	379.11	552.91	21.43
With Diversion				
(1) Does not flood	587.72	437.96	618.17	25.09
(2) Floods Same Duration	523.79	378.10	551.50	20.25
(3) Floods Longer Duration	511.13	364.44	537.39	19.63
(4) Floods Shorter Duration	504.06	356.85	528.48	19.09
(5) Now Floods With Diversion	525.44	379.11	552.91	20.53
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.				
^b Average of all 10,000 replications.				

Table 28. Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 10-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			
		Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)					
3	1 to 5	511.64	364.65	537.39	19.77
3	6 to 10	na	na	na	na
5	11 to 15	na	na	na	na
5	16 to 20	527.52	379.11	552.91	21.43
5	Over 20	na	na	na	na
With Diversion					
3	1 to 5	511.13	364.44	537.39	19.63
3	6 to 10	na	na	na	na
5	11 to 15	na	na	na	na
5	16 to 20	525.44	379.11	552.91	20.53
5	Over 20	na	na	na	na
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					
^b Average of all 10,000 replications.					

Table 29. Gross Revenues, by Hydrology Group, With and Without Diversion, 25-year Flood Event				
Hydrology Group	Gross Revenues Per Acre ^a			
	Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)				
(1) Does not flood	603.73	453.01	635.84	26.33
(2) Floods Same Duration	na	na	na	na
(3) Floods Longer Duration	534.08	390.64	563.22	20.34
(4) Floods Shorter Duration	na	na	na	na
(5) Now Floods With Diversion	590.67	441.87	621.80	25.52
With Diversion				
(1) Does not flood	603.67	453.01	635.84	26.33
(2) Floods Same Duration	na	na	na	na
(3) Floods Longer Duration	529.97	380.74	563.22	19.83
(4) Floods Shorter Duration	na	na	na	na
(5) Now Floods With Diversion	584.75	441.87	621.80	23.22
Na=not applicable. There were no storage areas in those hydrology groups.				
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.				
^b Average of all 10,000 replications.				

Table 30. Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 25-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			
		Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)					
3	1 to 5	520.97	374.87	548.63	19.48
3	6 to 10	576.88	433.10	610.84	23.60
5	11 to 15	na	na	na	na
5	16 to 20	592.20	442.15	623.10	25.42
5	Over 20	587.84	441.08	619.41	25.72
With Diversion					
3	1 to 5	517.89	367.33	548.63	19.17
3	6 to 10	569.43	417.06	610.84	22.34
5	11 to 15	na	na	na	na
5	16 to 20	587.81	442.15	623.10	23.54
5	Over 20	579.10	430.53	619.41	22.99
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					
^b Average of all 10,000 replications.					

Table 31. Gross Revenues, by Hydrology Group, With and Without Diversion, 50-year Flood Event				
Hydrology Group	Gross Revenues Per Acre ^a			
	Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)				
(1) Does not flood	597.42	446.58	628.70	25.74
(2) Floods Same Duration	na	na	na	na
(3) Floods Longer Duration	542.02	399.62	572.97	20.57
(4) Floods Shorter Duration	na	na	na	na
(5) Now Floods With Diversion	604.08	455.59	637	26.78
With Diversion				
(1) Does not flood	597.42	446.58	628.70	25.74
(2) Floods Same Duration	na	na	na	na
(3) Floods Longer Duration	537.94	389.59	572.97	20.22
(4) Floods Shorter Duration	na	na	na	na
(5) Now Floods With Diversion	597.84	455.59	637	24.22
Na=not applicable. There were no storage areas in those hydrology groups.				
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.				
^b Average of all 10,000 replications.				

Table 32. Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 50-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			
		Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)					
3	1 to 5	536.63	392.89	567	20.20
3	6 to 10	592.58	449.51	629.02	24.51
5	11 to 15	619.24	470.76	654.03	28.15
5	16 to 20	607.88	458.54	640.98	26.97
5	Over 20	595.01	448.06	627.32	26.26
With Diversion					
3	1 to 5	533.03	384.20	567	19.93
3	6 to 10	584.07	429.03	629.02	23.27
5	11 to 15	617.62	470.76	654.03	27.17
5	16 to 20	603.08	458.54	640.98	24.81
5	Over 20	585.50	435.76	627.32	23.35
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					
^b Average of all 10,000 replications.					

Table 33. Gross Revenues, by Hydrology Group, With and Without Diversion, 100-year Flood Event				
Hydrology Group	Gross Revenues Per Acre ^a			
	Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)				
(1) Does not flood	588.38	434.49	617.48	24.39
(2) Floods Same Duration	479.99	316.05	514.89	19.15
(3) Floods Longer Duration	550.46	408.96	583.96	20.95
(4) Floods Shorter Duration	601.37	453.05	634	26.57
(5) Now Floods With Diversion	567.11	423.13	600.01	22.16
With Diversion				
(1) Does not flood	588.38	434.49	617.48	24.39
(2) Floods Same Duration	479.99	316.05	514.89	19.15
(3) Floods Longer Duration	544.33	390.59	583.94	20.82
(4) Floods Shorter Duration	593.23	449.07	634	23.66
(5) Now Floods With Diversion	560.80	413.78	600.09	21.40
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.				
^b Average of all 10,000 replications.				

Table 34. Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 100-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			
		Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)					
3	1 to 5	\$538.08	\$394.33	\$570.04	\$20.16
3	6 to 10	\$588.83	\$447.46	\$627.10	\$23.69
5	11 to 15	\$594.74	\$441.19	\$624.76	\$25.01
5	16 to 20	\$596.79	\$448.31	\$628.80	\$26.13
5	Over 20	\$606.49	\$458.82	\$639.98	\$27.15
With Diversion					
3	1 to 5	\$534.01	\$383.14	\$570.02	\$20.17
3	6 to 10	\$576.33	\$413.68	\$627.09	\$23.42
5	11 to 15	\$593.01	\$441.19	\$624.76	\$24.09
5	16 to 20	\$591.64	\$448.31	\$628.80	\$23.97
5	Over 20	\$594.82	\$441.64	\$639.98	\$23.90
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					
^b Average of all 10,000 replications.					

Table 35. Gross Revenues, by Hydrology Group, With and Without Diversion, 500-year Flood Event				
Hydrology Group	Gross Revenues Per Acre ^a			
	Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)				
(1) Does not flood	\$531.56	\$380.03	\$567.64	\$19.95
(2) Floods Same Duration	\$571.15	\$426.70	\$609.02	\$22.03
(3) Floods Longer Duration	\$473.73	\$289.43	\$523.69	\$24.39
(4) Floods Shorter Duration	\$608.34	\$460.54	\$642.01	\$27.29
(5) Now Floods With Diversion	\$561.46	\$420.42	\$599.92	\$21.53
With Diversion				
(1) Does not flood	\$531.56	\$380.03	\$567.64	\$19.95
(2) Floods Same Duration	\$567.19	\$414.35	\$609.01	\$21.94
(3) Floods Longer Duration	\$479.03	\$301.08	\$524.41	\$22.34
(4) Floods Shorter Duration	\$597.92	\$448.28	\$642.01	\$23.98
(5) Now Floods With Diversion	\$558.03	\$403.69	\$600.01	\$21.66
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.				
^b Average of all 10,000 replications.				

Table 36. Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 500-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			
		Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)					
3	1 to 5	569.27	423.23	607.11	21.90
3	6 to 10	615.65	470.75	654.03	26.33
5	11 to 15	na	na	na	na
5	16 to 20	590.14	443.45	621.95	25.89
5	Over 20	614.49	466.30	648.79	27.77
With Diversion					
3	1 to 5	565.68	413.15	607.11	21.84
3	6 to 10	602.82	442.84	654.03	24.61
5	11 to 15	na	na	na	na
5	16 to 20	585.52	443.45	621.95	23.88
5	Over 20	602.11	448.23	648.79	24.33
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					
^b Average of all 10,000 replications.					

Estimation of Gross Revenues Only in Years When Diversion Creates Losses

Over the range of conditions evaluated in the Monte Carlo simulation, a number of combinations of planting start dates and flood event start dates do not result in revenue losses while a considerable number of situations result in revenue losses. When both outcomes are averaged, the values are useful in framing the magnitude of the potential revenue losses in the staging area from a policy perspective. But those revenue estimates do not accurately portray the average value when only losses are evaluated. In other words, if producers have a spring where planting delays actually occur, those potential revenue losses are likely to differ from values that have been combined with years when delays did not occur.

The estimated gross revenues for only the replications where a revenue loss was incurred due to delayed planting associated With the Diversion are presented in Tables 37 through 38. Gross revenues presented in Tables 37 through 41 cannot be compared to gross revenues in the previous section. Observations in the simulation where revenue losses were produced by the Diversion does not necessarily imply that gross revenues will be lower than the average of all replications. The reason is that the entire simulation includes situations where the Diversion does not create a planting delay (\$0 losses due to Diversion), but many of those situations are from late regional planting start dates. Having a late regional planting start date is much more likely to produce lower relative revenues than earlier plant start dates due to the use of the yield decline curves.

Table 37. Gross Revenues Only in Years with Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 10-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			Standard Deviation
		Mean	Minimum	Maximum	
With Existing Conditions (Without Diversion)					
3	1 to 5	521.71	366.36	537.39	14.95
3	6 to 10	na	na	na	na
5	11 to 15	na	na	na	na
5	16 to 20	542.75	385.92	552.91	13.58
5	Over 20	na	na	na	na
With Diversion					
3	1 to 5	520.16	364.44	537.38	15.35
3	6 to 10	na	na	na	na
5	11 to 15	na	na	na	na
5	16 to 20	535.71	383.01	552.80	15.34
5	Over 20	na	na	na	na
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					

Table 38. Gross Revenues Only in Years With Losses , Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 25-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			
		Mean	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)					
3	1 to 5	515.63	424.25	544.23	13.61
3	6 to 10	570.14	527.42	599.56	15.48
5	11 to 15	na	na	na	na
5	16 to 20	589.82	542.13	623.05	26.71
5	Over 20	590.40	536.86	619.41	24.79
With Diversion					
3	1 to 5	507.41	419.29	539.95	14.75
3	6 to 10	550.38	485.90	589.77	15.86
5	11 to 15	na	na	na	na
5	16 to 20	570.59	542.12	603.72	16.27
5	Over 20	558.87	510.91	592.95	15.88
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas Within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					

Table 39. Gross Revenues Only in Years With Losses , Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 50-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			
		Mean	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)					
3	1 to 5	534.04	392.89	566.90	17.38
3	6 to 10	603.91	458.88	629.02	18.46
5	11 to 15	644.21	527.11	654.03	12.04
5	16 to 20	627.35	485.80	640.98	14.86
5	Over 20	609.97	468.83	627.32	17.50
With Diversion					
3	1 to 5	537.70	384.20	566.63	18.58
3	6 to 10	589.68	429.03	628.66	21.96
5	11 to 15	635.84	499.07	653.87	15.05
5	16 to 20	615.62	468.31	640.88	18.01
5	Over 20	593.03	433.76	627.21	20.74
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas Within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					

Table 40. Gross Revenues Only in Years With Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 100-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			Standard Deviation
		Mean	Minimum	Maximum	
With Existing Conditions (Without Diversion)					
3	1 to 5	\$542.93	\$394.33	\$570.04	\$18.22
3	6 to 10	\$596.48	\$448.19	\$627.10	\$19.97
5	11 to 15	\$615.24	\$498.04	\$624.76	\$12.26
5	16 to 20	\$615.44	\$471.88	\$628.80	\$14.74
5	Over 20	\$621.04	\$482.95	\$639.98	\$18.57
With Diversion					
3	1 to 5	\$537.48	\$383.14	\$570.02	\$19.43
3	6 to 10	\$578.95	\$413.68	\$627.09	\$23.68
5	11 to 15	\$607.60	\$473.81	\$624.68	\$14.77
5	16 to 20	\$602.86	\$454.34	\$628.71	\$18.14
5	Over 20	\$601.52	\$441.64	\$639.74	\$21.95
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas Within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					

Table 41. Gross Revenues Only in Years With Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 500-year Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			
		Mean	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)					
3	1 to 5	574.52	424.23	607.11	19.92
3	6 to 10	628.49	485.19	654.03	19.12
5	11 to 15	na	na	na	na
5	16 to 20	608.55	462.86	621.95	14.82
5	Over 20	629.47	492.77	648.79	18.86
With Diversion					
3	1 to 5	569.72	413.15	607.11	20.93
3	6 to 10	607.03	442.84	653.10	24.19
5	11 to 15	na	na	na	na
5	16 to 20	597.26	448.43	621.88	17.76
5	Over 20	608.78	448.23	648.50	22.45
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas Within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					

Estimation of Potential Revenue Losses by Crop

Average revenues for storage areas can include situations where some crops experience a planting delay while other crops may not be delayed. This is most likely to occur when corn, wheat, or sugarbeets have planting delays but soybeans are not delayed. Identifying potential revenue losses by crop would be useful for producers. Data were not collected to identify the composition of land ownership Within the staging area (or Within individual storage areas). Information on how acreage Within each storage area was distributed among producers also was not collected. Most storage areas are not likely farmed by one producer, and therefore for any year during a major flood event, one producer may intend to plant a different crop on his share of the storage area than the crop another producer may intend to plant. The potential revenue losses between those two producers in a flood event could be considerably different than the average revenue values (and losses) reported for the entire storage area.

Soybeans have the lowest frequency of revenue loss among the four crops (the frequency of per-acre losses for all crops is presented in Appendix B). Soybeans also have the lowest relative yield decline of the four crops. In other words, over the planting periods evaluated in this study, planting delays have less relative impact on soybeans than corn, wheat, or sugarbeets. Soybeans also are planted later in the spring, reducing the likelihood of planting delays due to the use of the staging area. Those factors contribute to soybeans having the lowest per-acre revenue losses. Soybeans also comprise the largest share of crops grown in the staging area, which further acts to reduce the average revenue loss when all crops are combined Within an entire storage area.

Sugarbeets clearly have the largest average per-acre revenue losses of the four crops (Table 42). However, those losses occur on relatively few acres. The small percentage of acres planted to sugarbeets Within the staging area acts to limit the influence of revenues losses when all crops are included in average losses for a storage area. Averaged across all 10,000 replications, the revenue losses per acre for sugarbeets varied from a few dollars in a 10-year event to \$46 per acre in a 100-year event (Table 42).

Average per acre revenue losses for wheat generally exceeded the per acre losses for corn (Table 42). While corn has a larger overall gross revenue per acre, the relative price per bushel (\$4.35 for corn versus \$6.87 for wheat) and the difference in the relative rate of yield decline in the first week after optimal planting has ended suggest greater revenue losses for wheat. Of lesser importance, the last day of optimal planting for wheat was one day earlier than corn, providing a slightly longer period of non-optimal planting than corn since prevent plant and switch dates were modeled to be the same for each crop.

The average of a revenue loss (i.e., only losses were averaged) was estimated for each crop (Table 43). As would be expected, those estimates followed the overall pattern found in Table 42. If a loss was incurred due to planting delays, sugarbeets clearly had the largest per acre revenue decline, followed by wheat, corn, and soybeans. The distinction between the values in Tables 42 and Table 43 is important because not all flood situations will result in losses (Table 42); but if losses were to occur (Table 43), it is helpful to understand how the effects of averaging no losses influence the overall values.

Prices will play an important role the amount of revenue loss. With wheat yield declining about 1 bushel per day after the optimal planting window has ended, revenue losses will be proportional with respect to price changes. Similar observations can be made for the other crops, because yield losses due to planting delays were modeled to be linear for soybeans and sugarbeets. The yield decline for

corn was not linear; however, price changes will have similar effects on the revenue losses for corn as the other crops, especially in situations when delays result in planting near the end of the non-optimal period as that is when the largest yield declines for corn are observed.

Table 42. Revenue Loss Averaged Over Entire Monte Carlo Simulation, by Crop, between With and Without Diversion						
Crop and Hydrology Group			Potential Revenue Losses Per Acre ^a			
			10-Year	25-Year	50-Year	100-Year
Difference in Total Days ^b			----- average of 10,000 replications -----			
Corn						
3	1 to 5	-\$0.79	-\$4.88	-\$5.26	-\$6.59	-\$4.71
3	6 to 10	na	-\$8.96	-\$9.83	-\$15.50	-\$14.19
5	11 to 15	na	na	-\$1.39	-\$5.41	na
5	16 to 20	-\$2.86	-\$9.62	-\$4.84	-\$12.51	-\$12.88
5	Over 20	na	-\$7.02	-\$10.37	-\$1.89	-\$9.15
Soybeans						
3	1 to 5	\$0.00	-\$0.01	-\$0.02	-\$0.05	-\$0.03
3	6 to 10	na	-\$0.01	-\$0.02	-\$0.08	-\$0.03
5	11 to 15	na	na	\$0.00	\$0.00	na
5	16 to 20	\$0.00	\$0.00	\$0.00	\$0.00	-\$0.01
5	Over 20	na	-\$0.01	-\$0.01	-\$0.01	-\$0.02
Wheat						
3	1 to 5	-\$1.41	-\$8.04	-\$8.58	-\$8.56	-\$6.93
3	6 to 10	na	-\$14.33	-\$15.30	-\$21.90	-\$21.18
5	11 to 15	na	na	-\$2.96	-\$3.69	na
5	16 to 20	-\$5.50	-\$16.98	-\$8.93	-\$9.96	-\$21.54
5	Over 20	na	-\$12.12	-\$17.91	-\$20.89	-\$14.70
Sugarbeets						
3	1 to 5	-\$2.86	-\$16.22	-\$18.15	-\$16.55	-\$14.97
3	6 to 10	na	-\$30.67	-\$32.57	-\$46.29	-\$44.51
5	11 to 15	na	na	-\$6.35	-\$8.27	na
5	16 to 20	-\$11.04	-\$36.07	-\$19.40	-\$21.58	-\$45.48
5	Over 20	na	-\$25.65	-\$37.79	-\$43.95	-\$31.08
Na=not applicable. There were no storage areas in those hydrology groups.						
^a Represents an average of all storage areas Within the hydrology groups and includes replications With no revenue loss.						
^b Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.						

Table 43. Average Value of a Revenue Loss, by Crop, between With and Without Diversion, (excludes replications With zero losses)

Crop and Hydrology Group			Potential Revenue Losses Per Acre ^a				
			10-Year	25-Year	50-Year	100-Year	500-Year
Difference in Total Days ^b			----- average of a revenue loss -----				
Corn							
3	1 to 5		-\$2.42	-\$7.68	-\$7.82	-\$8.86	-\$6.33
3	6 to 10		na	-\$15.03	-\$16.49	-\$21.83	-\$23.82
5	11 to 15		na	na	-\$7.56	-\$8.73	na
5	16 to 20		-\$9.95	-\$18.39	-\$11.98	-\$13.39	-\$21.62
5	Over 20		na	-\$13.01	-\$18.53	-\$20.99	-\$15.65
Soybeans							
3	1 to 5		-\$0.48	-\$0.54	-\$0.45	-\$0.67	-\$0.31
3	6 to 10		na	-\$0.69	-\$0.93	-\$1.33	-\$1.86
5	11 to 15		na	na	-\$0.63	-\$0.13	na
5	16 to 20		-\$0.69	-\$0.59	-\$0.55	-\$0.79	-\$0.80
5	Over 20		na	-\$0.60	-\$0.59	-\$0.72	-\$0.63
Wheat							
3	1 to 5		-\$4.30	-\$12.67	-\$12.75	-\$11.51	-\$9.32
3	6 to 10		na	-\$24.04	-\$25.67	-\$30.82	-\$35.53
5	11 to 15		na	na	-\$15.83	-\$16.62	na
5	16 to 20		-\$19.06	-\$32.37	-\$22.00	-\$24.53	-\$36.12
5	Over 20		na	-\$22.42	-\$31.94	-\$35.04	-\$25.11
Sugarbeets							
3	1 to 5		-\$8.69	-\$25.56	-\$26.97	-\$22.26	-\$20.13
3	6 to 10		na	-\$51.43	-\$54.62	-\$65.15	-\$74.65
5	11 to 15		na	na	-\$33.89	-\$37.48	na
5	16 to 20		-\$37.92	-\$68.78	-\$47.73	-\$53.09	-\$76.27
5	Over 20		na	-\$47.46	-\$67.43	-\$73.70	-\$53.06

Na=not applicable. There were no storage areas in those hydrology groups.

^a Represents an average of all storage areas Within the hydrology groups and excludes replications With no revenue loss.

^b Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

Distribution of Revenue Losses

Revenue losses for all crops for all storage areas were summed, and sorted from lowest to highest over the 10,000 replications. The distribution of the revenue losses for storage areas in Hydrology Group 3 were compared among the five flood events (Figure 17). Across all flood events, except the 10-year flood event, Hydrology Group 3 is indicative of a relative high frequency of modest overall revenue losses. By comparison, overall revenue losses for storage areas in Hydrology Group 5 are slightly less frequent, but of greater magnitude (Figure 18). Overall revenue losses were higher in the 100-year event than in the 500-year event in both Hydrology Groups 3 and 5. The importance of the difference in revenue losses is that a 100-year flood event is likely to occur five times more frequently than a 500-year flood event (1% annual chance for a 100-year flood event versus 0.2% annual chance for a 500-year flood event).

Figures 17 through 19 show that in all flood event sizes, a number of spring planting conditions result in very low to no total revenue losses in the staging area. Revenue losses are not necessarily going to occur in every flood event. Contrasting that situation, a majority of the conditions evaluated did produce revenue losses for producers.

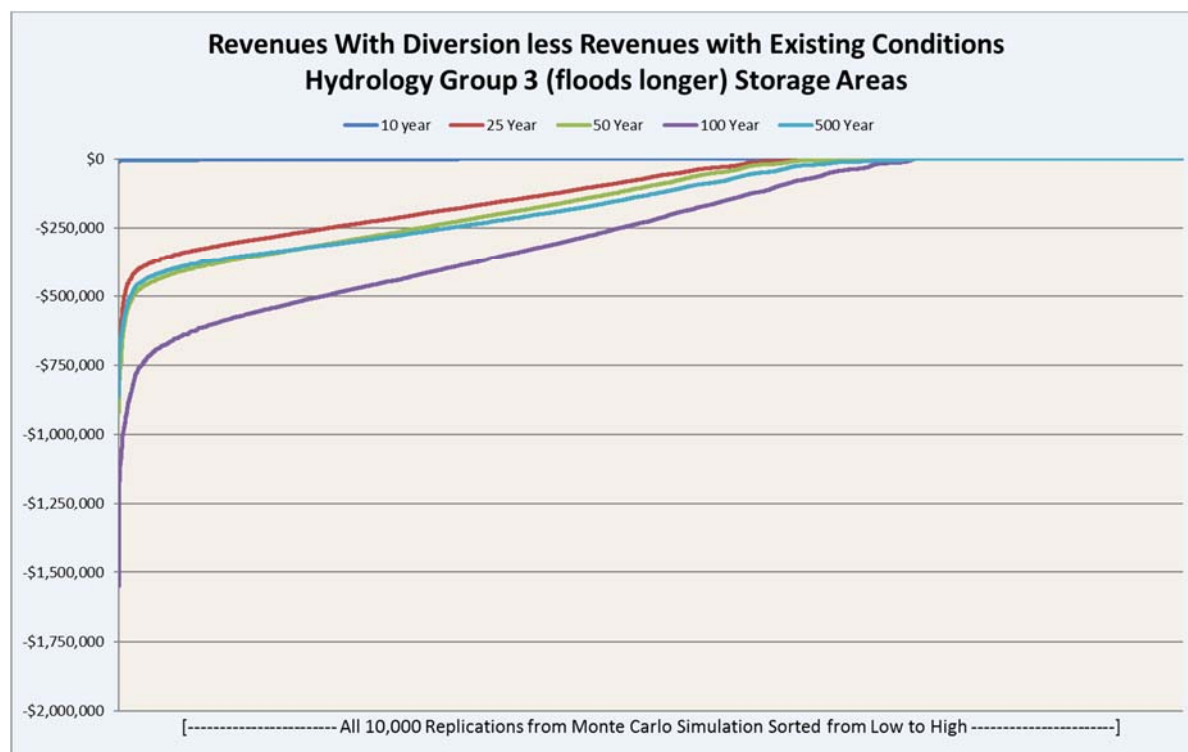


Figure 17. Sorted Distribution of Total Revenue Losses, Hydrology Group Three, All Flood Event Sizes, for All Monte Carlo Replications.

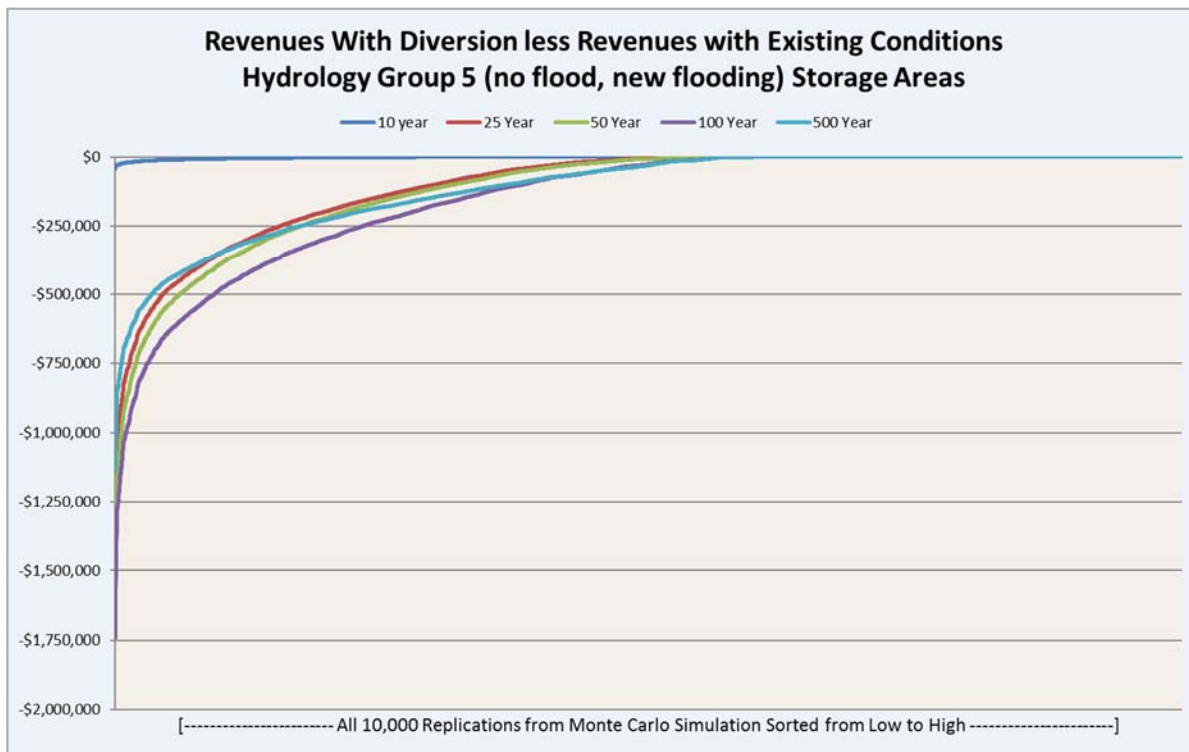


Figure 18. Sorted Distribution of Total Revenue Losses, Hydrology Group Five, All Flood Event Sizes, for All Monte Carlo Replications.

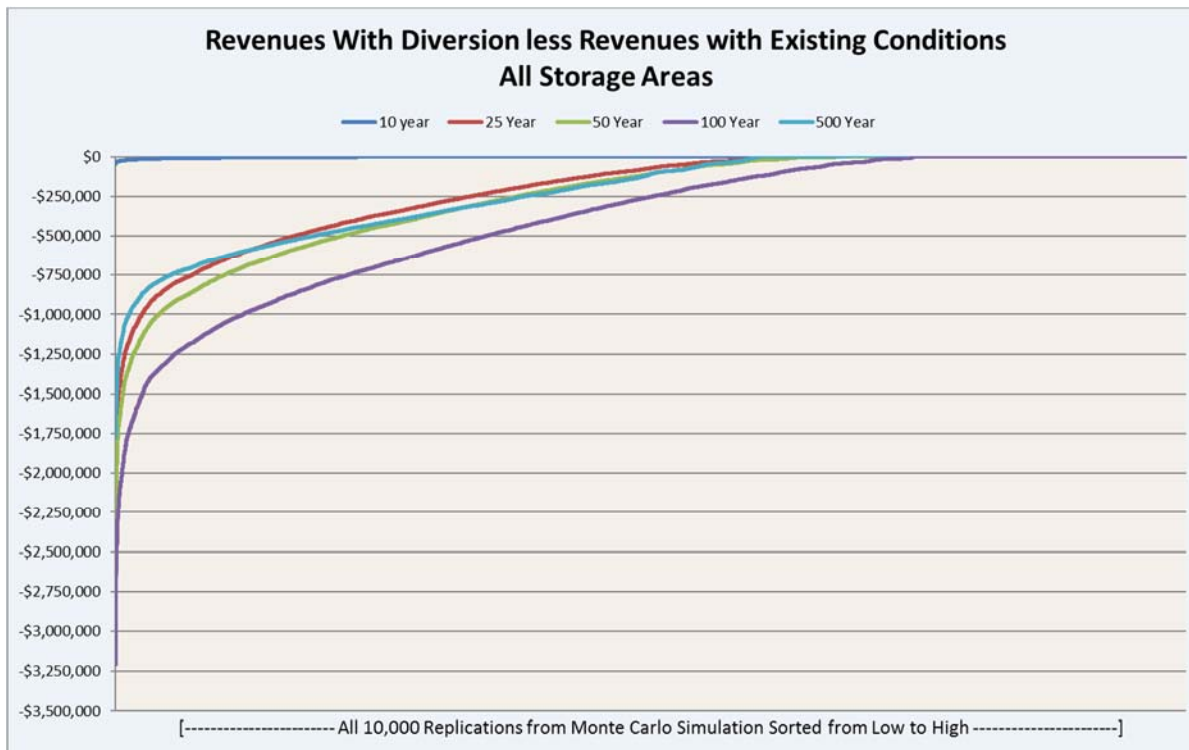


Figure 19. Sorted Distribution of Total Revenue Losses, All Hydrology Groups, All Flood Event Sizes, for All Monte Carlo Replications.

Sensitivity of Results to Key Parameters

Numerous factors will contribute to future potential revenue losses for producers Within the staging area. Key economic factors, such as future prices, yields, and crop mix are obvious. Other factors, largely related to weather, include timing of the flood event, duration of the flood event, timing of regional planting, and pace of planting. The study recognizes that all these factors will influence revenue losses associated with delayed planting within the staging area, even though sensitivity analysis was not conducted on those factors.

Another set of factors relate to hydrology and the ability to accurately predict the duration of water inundation. Duration of water inundation is critical, not because it is perceived to influence dry-down periods, but because those estimates are based on simulated analyses. The Diversion has not been built, so it remains unproven if water will accumulate and dissipate as planned. However, even if the hydrology modeling proves to be quite accurate, the duration of spring flood events is highly variable. To better gauge how sensitive planting delays might be to a change in the time from staging activation to when the effects of flooding would be gone, the dry-down period was decreased from 10 days to 6 days and increased from 10 to 14 days. Essentially, the adjustment adds and subtracts four days to the dates when the effects of flooding are over.

For lands that are inundated Without the Diversion (Hydrology Groups 2, 3, and 4), any adjustment in the dry-down period will have equal effects in both the Without and With Diversion conditions. If the dry-down period is extended for those hydrology groups, the degree of revenue loss from planting delays may increase, but those effects would not be the result of the Diversion. However, Hydrology Group 5 is directly affected by the dry-down period. In the absence of the Diversion, those storage areas would not flood and therefore would not have a dry-down period.

Hydrology Group 5 storage areas were evaluated for the 25-year event (Table 44). A 4-day decrease in the dry-down period resulted in situations with no planting delays increasing from 55 percent of the 10,000 replications to 70 percent. Conversely, adding 4 days to the dry-down period resulted in the number of situations with no planting delays going from 55 percent to 40 percent.

Table 44. Change in Days of Planting Delay With Adjustments to Dry-down Period, Hydrology Group Five, 25-year Flood Event			
Days of Planting Delay	Dry-down Period		
	6-day	10-day	14-day
	----- share of 10,000 replications -----		
0 (no delay)	70.4%	55.1%	40.3%
1	3.6%	4.0%	3.6%
2 to 5	12.6%	15.0%	15.2%
6 to 10	9.4%	15.3%	18.1%
11 to 15	3.4%	7.8%	14.3%
16 to 20	0.5%	2.5%	6.3%
20+	0.01%	0.5%	2.2%

Evaluation of 1997-type Flood Event

The 1997 flood event is characterized by high flow rates in Fargo which occurred for longer periods than other large flood events (see Table 1). Since the duration of water storage is a key factor affecting potential planting delays, the 1997 flood event would provide an important contrast to the simulated flood events (i.e., the five flood events used throughout this study) because of the duration of water flows. A flood event representing the 1997 flood was provided using the HEC-RAS version 7.2 modeling.

Probability of Losses During a Flood Event

About 27,150 acres would be inundated longer With the Diversion in a 1997-type flood event. Those storage areas (Hydrology Group 3) could expect a 93 percent annual chance of experiencing revenue losses based on planting delays due to the Diversion (Table 45). Similarly, about 18,000 acres would flood With the Diversion that would not flood with existing conditions. Hydrology Group 5 storage areas have a 80 percent annual chance of incurring revenue losses based on planting delays due to the Diversion.

Despite a high likelihood of incurring revenue losses in a 1997-like flood event, Hydrology Group 3 revenue losses due to the Diversion were expected to be \$25 or less per acre for storage areas With 1 to 7 additional days of delay (Table 45). For Hydrology Group 3 storage areas with 8 to 15 additional days of delay, a 1997-type flood event produced revenues losses of \$25 per acre or less in 52 percent of the replications, and produce revenue losses ranging from \$26 to \$50 per acre in 28 percent of the replications (Table 46). Hydrology Group 5 storage areas that have a difference of 25 or more days due to the Diversion have a 27 percent annual chance of incurring revenue losses ranging from \$26 to \$50 per acre, and a 11 percent annual chance of incurring revenue losses ranging from \$51 to \$75 per acre (Table 46).

Table 45. Probability of Losses Resulting from Use of the Staging Area, by Hydrology Group, 1997-type Flood Event

Hydrology Groups	No Loss	\$0 to \$25/acre ^a Loss	\$26 to \$50/acre ^a Loss	\$51 to \$75/acre ^a Loss	\$76 to \$100/acre ^a Loss	Positive Impact per Acre	Any Loss	Acres
----- Based on 10,000 replications from Monte Carlo Simulation -----								
(1) Does not flood	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11,674
(2) Floods Same Duration	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1,506
(3) Floods Longer Duration	6.5%	91.9%	1.6%	0.0%	0.0%	0.0%	93.5%	27,160
(4) Floods Shorter Duration	1.2%	0.0%	0.0%	0.0%	0.0%	98.8%	0%	6,104
(5) Now Floods With Diversion	18.8%	54.8%	20.8%	14.6%	1.0%	0.0%	81.2%	17,978

^a The range of losses per acre represent an average of all storage areas With the hydrology group.

Table 46. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 1997-type Flood Event

Time from Activation of Staging Area until Effects of Flooding are over ^a										
Hydrology Group	Without Diversion	With Diversion	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	Any Loss	Acres ^c
----- days -----				----- Based on 10,000 replications from Monte Carlo Simulation -----						
3	28.8	31.5	1 to 7	6.4%	93.2%	0.4%	0.0%	0.0%	93.6%	24,586
3	18.0	28.2	8 to 15	18.7%	52.2%	27.7%	1.4%	0.0%	81.3%	3,606
5	0	19.3	16 to 20	63.1%	34.1%	2.7%	0.2%	0.0%	36.9%	795
5	0	22.9	21 to 25	43.8%	38.3%	14.7%	2.8%	0.5%	56.2%	8,752
5	0	28.2	Over 25	18.7%	40.0%	27.2%	11.2%	2.8%	81.3%	7,794

Na=not applicable. There were no storage areas in those categories.

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas Within the groups.

^c Acreage in Hydrology Groups 3 and 5, delineated by days of delay, will not match the acreage in the Hydrology Groups 3 and 5 found in Table 45 due to one storage area moving from Group 5 in the standard grouping to Group 3 in the days of delay groupings.

Gross Revenues per Acre With and Without Diversion

The gross revenues per acre were averaged over all 10,000 replications for the five hydrology groups for the 1997-like flood event. In addition to average revenues, the minimum and maximum observed gross revenues were included to provide some perspective on the potential range of observed revenues for the different hydrology groups. The gross revenues are subject to the price and target yield assumptions, and the yield decline functions used in the model.

Storage areas that would not flood in a 1997-like event averaged \$600 per acre, which represents all of the combinations of early and late spring planting conditions but does not include any effects from either natural flooding or Diversion-related flooding (Table 47). The average gross revenue among Hydrology Groups 2, 3, and 4 is not equal because the duration of water inundation (natural flooding) varies among the groups (see Appendix B).

The difference in gross revenues between With and Without Diversion for the hydrology groups affected by flooding ranges from around \$8.60 per acre with storage areas that would require 1 to 7 additional days for the effects of flooding to be over With the Diversion to \$23.30 per acre for storage areas that require over 25 additional days for the effects of flooding to be over With the Diversion (Table 48).

Table 47. Gross Revenues, by Hydrology Group, With and Without Diversion, 1997-type Flood Event				
Hydrology Group	Gross Revenues Per Acre ^a			
	Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)				
(1) Does not flood	600.26	449.72	632.00	26.05
(2) Floods Same Duration	482.43	295.24	533.72	25.30
(3) Floods Longer Duration	540.47	376.25	586.99	22.06
(4) Floods Shorter Duration	446.55	237.49	510.23	32.27
(5) Now Floods With Diversion	600.47	451.91	632.91	26.45
With Diversion				
(1) Does not flood	600.26	449.72	632.00	26.05
(2) Floods Same Duration	482.43	295.24	533.72	25.30
(3) Floods Longer Duration	530.58	351.65	586.21	25.00
(4) Floods Shorter Duration	455.08	257.77	511.95	26.60
(5) Now Floods With Diversion	584.55	427.69	632.85	23.21
^a Represents an average of all storage areas Within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.				
^b Average of all 10,000 replications.				

Table 48. Gross Revenues, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 1997-type Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			
		Mean ^b	Minimum	Maximum	Standard Deviation
With Existing Conditions (Without Diversion)					
3	1 to 7	\$538.95	\$371.71	\$587.13	\$22.55
3	8 to 15	\$564.62	\$421.86	\$597.90	\$22.10
5	16 to 20	\$583.41	\$428.67	\$611.60	\$23.82
5	21 to 25	\$606.30	\$457.01	\$639.22	\$26.84
5	Over 25	\$594.13	\$447.02	\$626.28	\$26.15
With Diversion					
3	1 to 7	\$530.30	\$350.89	\$586.31	\$25.18
3	8 to 15	\$547.86	\$382.87	\$597.57	\$22.47
5	16 to 20	\$579.75	\$428.67	\$611.60	\$22.34
5	21 to 25	\$594.84	\$443.57	\$639.22	\$23.70
5	Over 25	\$570.78	\$401.82	\$626.13	\$24.15
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas Within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					
^b Average of all 10,000 replications.					

Estimation of Gross Revenues Only in Years When Diversion Creates Losses

Over the range of conditions evaluated in the Monte Carlo simulation for the 1997-like flood, relatively few combinations of planting start dates and flood event start dates did not result in revenue losses while a considerable number of situations did result in revenue losses. When both outcomes are averaged, the values are useful in framing the magnitude of the potential revenue losses in the staging area from a policy perspective. The estimated gross revenues for only the replications where a revenue loss was incurred due to delayed planting are presented in Table 49. Due to the relatively high number of replications with some planting delays resulting in revenue losses, the gross revenues when a loss was observed are similar to the gross revenues for the entire simulation (i.e., when non-loss observations are included in the averages).

Table 49. Gross Revenues Only in Years With Losses, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, 1997-type Flood Event					
Hydrology Group	Difference in Total Days	Gross Revenues Per Acre ^a			Standard Deviation
		Mean	Minimum	Maximum	
With Existing Conditions (Without Diversion)					
3	1 to 7	\$539.52	\$371.71	\$587.13	\$22.81
3	8 to 15	\$569.51	\$422.37	\$597.90	\$19.76
5	16 to 20	\$600.14	\$455.92	\$611.60	\$13.67
5	21 to 25	\$621.70	\$484.13	\$639.22	\$17.67
5	Over 25	\$600.78	\$447.66	\$626.28	\$22.70
With Diversion					
3	1 to 7	\$530.27	\$350.89	\$586.31	\$25.68
3	8 to 15	\$548.91	\$382.87	\$597.57	\$23.09
5	16 to 20	\$590.22	\$448.12	\$611.47	\$16.48
5	21 to 25	\$601.32	\$443.57	\$638.98	\$21.81
5	Over 25	\$572.04	\$401.82	\$626.13	\$24.88
Na=not applicable. There were no storage areas in those hydrology groups.					
^a Represents an average of all storage areas Within the hydrology group. Revenues represent potential income based on planting conditions. Effects of crop growing conditions throughout the remainder of the season were not included.					

Estimation of Potential Revenue Losses by Crop

The average of a revenue loss (i.e., only losses were averaged) was estimated for each crop (Table 50). If a loss was incurred due to planting delays, sugarbeets clearly had the largest per revenue decline, followed by wheat, corn, and soybeans.

Table 50. Average Value of a Revenue Loss, by Crop, between With and Without Diversion, (excludes replications With zero losses), 1997-Like Flood		
Crop and Hydrology Group		Potential Revenue Losses Per Acre ^a
		1997-Like
	Difference in Total Days ^b	----- average of a revenue loss -----
Corn		
3	1 to 7	-14.55
3	8 to 15	-31.73
5	16 to 20	-12.01
5	21 to 25	-22.76
5	Over 25	-35.48
Soybeans		
3	1 to 7	-1.31
3	8 to 15	-2.59
5	16 to 20	-0.62
5	21 to 25	-1.06
5	Over 25	-1.39
Wheat		
3	1 to 7	-15.74
3	8 to 15	-36.86
5	16 to 20	-23.57
5	21 to 25	-36.13
5	Over 25	-50.69
Sugarbeets		
3	1 to 7	-35.18
3	8 to 15	-71.85
5	16 to 20	-49.84
5	21 to 25	-79.21
5	Over 25	-107.26
Na=not applicable. There were no storage areas in those hydrology groups.		
^a Represents an average of all storage areas Within the hydrology groups and excludes replications With no revenue loss.		
^b Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.		

Distribution of Gross Revenues

Revenue losses for all crops for all storage areas were summed, and distributed over the 10,000 replications for the 1997-like flood event. In the 1997-like flood event, Hydrology Group 3 is indicative of a relative high frequency of modest overall revenue losses (Figure 20). By comparison, overall revenue losses for storage areas in Hydrology Group 5 are slightly less frequent, but of greater magnitude (Figure 21).

Figures 20 through 22 show that even in a 1997-like flood event, about 25 percent of the spring planting conditions result in low to no total revenue losses in the staging area. Contrasting that situation, in 75 percent of the conditions, the Diversion resulted in revenue losses for producers. The comparison of the distribution of the 1997-like event was similar in magnitude to the revenues losses observed in the 500-year event but less than the damages observed in the 100-year flood event. These results are consistent with the 1997-flood event being designated as a 50-year flood event. The big difference between the 1997-type flood event, being a 50-year flood event, and the 500-year flood event is that a 1997-like flood event is 10 times more likely to occur in any given year.

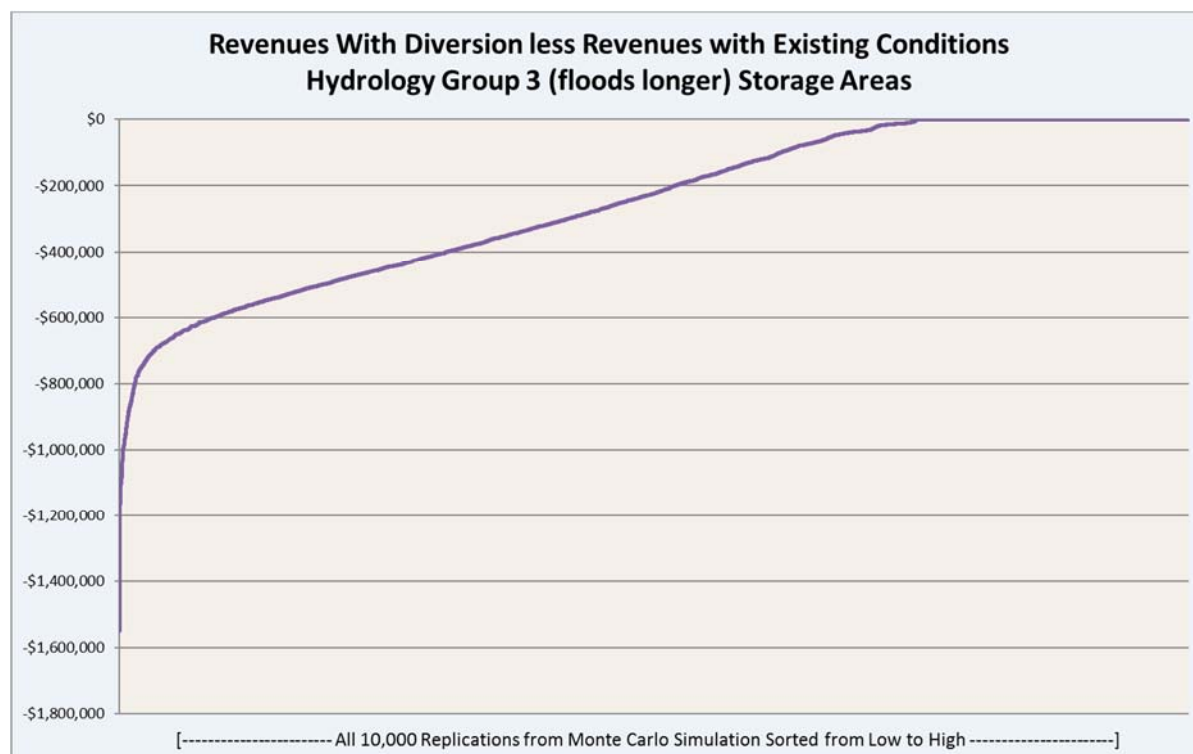


Figure 20. Sorted Distribution of Total Revenue Losses, Hydrology Group Three, 1997-like Flood Event, for All Monte Carlo Replications

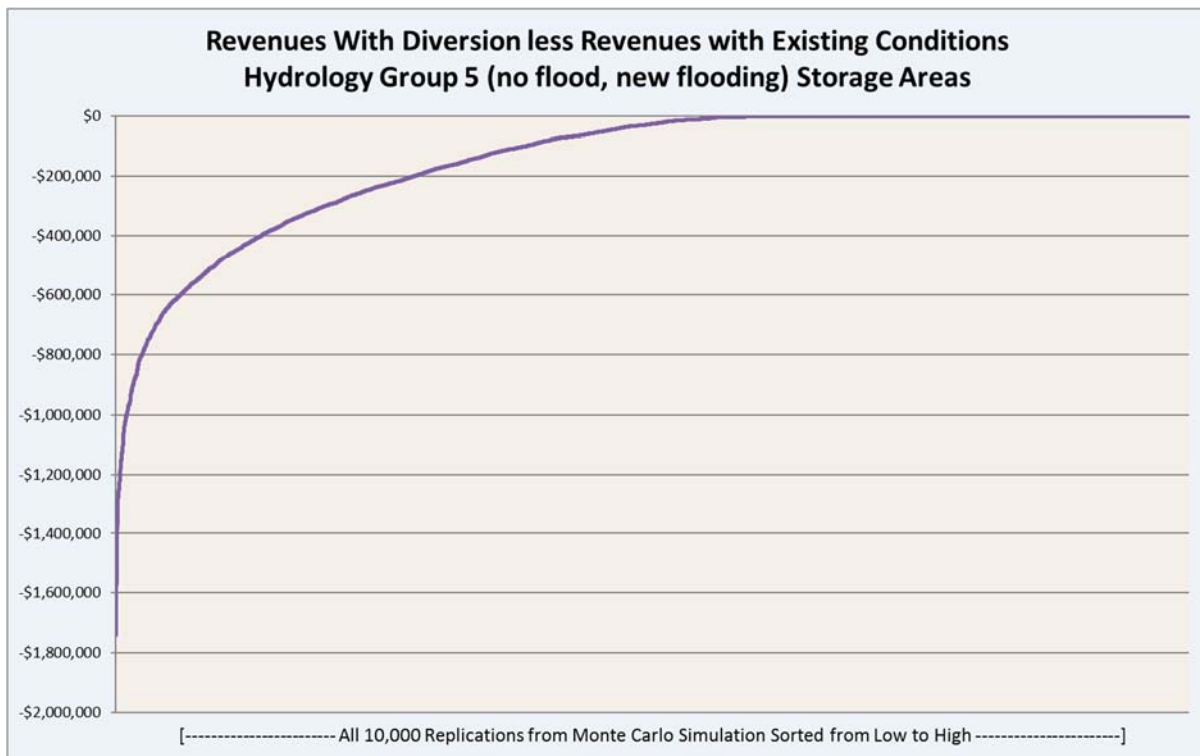


Figure 21. Sorted Distribution of Total Revenue Losses, Hydrology Group Five, 1997-like Flood Event, for All Monte Carlo Replications

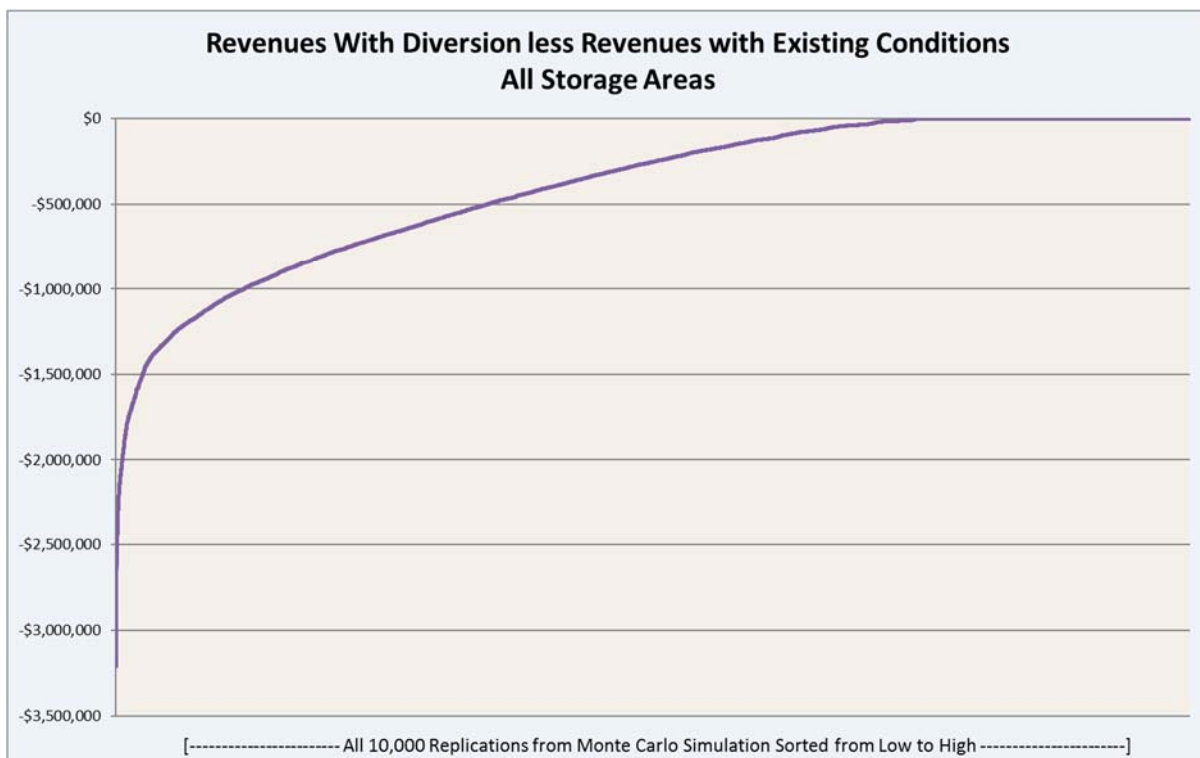


Figure 22. Sorted Distribution of Total Revenue Losses, All Hydrology Groups, 1997-like Flood Event, for All Monte Carlo Replications

Loss of Insurance Coverage

Destruction of a crop by a man-made event is not covered by Federal crop insurance. The Diversion Authority commissioned a study by Watts and Associates to evaluate the eligibility concerns and other issues pertaining to federal crop insurance¹². As discussed throughout this analysis, storage areas that now flood for longer duration (Group 3) and those storage areas that would flood with use of the staging area that would not otherwise flood (Group 5) will experience the greatest adverse impact of operating the proposed Diversion. Those storage areas, comprising a substantial acreage within the staging area for most flood events, will likely be ineligible for crop insurance to cover losses due to delayed planting. **For a more complete discussion of the implications of lost crop insurance see Bangsund et al. (2015).**

Converting Event-level Estimates into Annualized Values

Predicting the year(s) when a future flood will occur, or estimating the actual frequency of future floods is impossible. Therefore, any potential future flood damages are often measured and defined by their probability of occurring in any given year. The challenge is that any size flood (and associated differences in damages) could occur in any future year.

One of the difficulties in interpreting event-level damages (i.e., what happens when a flood event actually occurs) is addressing those probabilities since any one event could occur in any given year. The process of annualizing future outcomes attempts uses the annual probability that an event will happen with the expected financial impacts of that event to place a value of those occurrences on a per-year basis. In the case of an actual flood-event (i.e., event-level damages), describing and estimating the effects are relatively straightforward. Annualized values, therefore represent another manner in which the magnitude of expected damages can be framed.

However, two reasons exist why annualized values were not produced in this report.

- 1) Annualized values are only useful when all damages are included. It would be premature to provide annualized estimates in the absence of damages from lost Federal crop insurance.
- 2) Annualizing damages for the overall staging area should be estimated by summing the annualized estimates for individual storage areas, or more accurately, from sub-storage areas. Complex hydrology results in many storage areas experiencing different flood effects in different sized flood events. Further, the economic losses vary among the storage areas due to the use of county-level data for the four counties in the study region. Providing annualized estimates for each storage area was beyond the scope of this study.

¹² See discussion of crop insurance as it pertains to the proposed Diversion at <http://www.fmDiversion.com/pdf/APS%20Minutes/2012/AUG1412M.pdf>.

Conclusions

Overall, the economic impact on crop production in the 175 storage areas may be less than expected. In evaluating the historical data and expected differences in flooding created by the Diversion, several reasons underpin this conclusion.

Discussion

There are no recorded flows on the Red River due to rain that would have triggered the use of the Diversion. Historically, the Diversion would have never been needed to protect against a summer flood. The Diversion is not expected to create losses after spring planting season..

Spring snow melt and runoff, in most cases, occur early relative to regional planting starts. Examples of these situations include the start of planting as late as May in 2014 and a large flood event in March in 2009. In the case of 2009, the flood event and planting time periods did not overlap. A large, relatively late flood event, such as 1997, is likely to impose the greatest impact on agricultural producers. Even though the 1997 flood event, for example, occurred in mid- to late April, there was no planting prior to that time due to the late snow melt and overall wet conditions. Again, there was limited overlap between the spring runoff and planting.

The engineering data indicate that the combined capacity of the Red River and the Diversion channel, once the community is protected with dikes, will move extensive amounts of water around the community. The exact amount and timing will not be known until the Diversion Operating Manual is finalized by the Corps, but the preliminary indications are that the Red River will handle 17,000 cfs through the community and the Diversion channel will handle an additional 22,000 cfs around the community. However, despite the stated capacities, the timing and flow of flood waters also will be based on the characteristics of the flood-event, and all floods are unique (e.g., compare the 1997 flood event to the 2009 flood event). The combined flow capacity of 39,000 cfs clearly exceeds the largest observed flow in Fargo of 29,800 cfs observed in 2009. Both the stated design capacity of the Diversion and the current hydrology data suggest that water will not be retained in the staging area for extensive periods, and it is highly likely that those lands will be planted in a flood year.

In the more modest flood events (e.g., 25-year and 50-year events), many storage areas are not adversely affected by the Diversion. A substantial portion of the 175 storage areas, most lying in relatively low elevations, would experience flooding Without the Diversion. Current hydrology modeling is suggesting that the majority of lands that would flood Without the Diversion will experience 1 to 7 days of additional time for the effects of flooding to be gone. For those lands, the Diversion may contribute to a delayed planting but is not responsible for all of the delayed planting. Most lands that will experience new flooding With the Diversion would require up to 25 days from the date when the staging area is activated until the effects of flooding are gone. However, not all of those days translate directly into planting delays. For much of that period, general weather conditions, such as temperature and normal dry-down from snow melt, prevent spring planting.

The impacts of planting delays from Diversion operations on corn, wheat, and sugarbeets are likely to be substantially different than soybeans. Soybeans had the lowest frequency and magnitude of revenue loss of the four crops. Soybeans also have the lowest relative yield decline of the four crops when planted beyond the optimal period. Over the planting periods

evaluated in this study, planting delays have less relative impact on soybeans than corn, wheat, or sugarbeets. Soybeans also are planted later in the spring, reducing the likelihood of planting delays due to the use of the staging area. This combination of factors is why soybeans have the lowest per-acre revenue losses. Soybeans also comprise the largest share of crops grown in the staging area, which further reduces the average revenue losses when all crop losses are combined within an entire storage area.

This study represents the first attempt to address potential effects of temporary water storage on agricultural production resulting from the use of the Diversion. As a result of this effort, insights were gained on how the flooding effects vary by location and elevation of land, and how the effects also are influenced by the size of flood event. Examining when the effects of flooding are over and when regional planting typically begins, suggests a high likelihood of relatively short planting delays. These conclusions are extremely helpful in advancing the discussion of how agricultural production might be affected, but a number of additional issues remain unquantified. While this project was not able to address all production-related issues, this study, along with its methodology, lays a strong foundation from which additional production questions can be addressed.

Economic Conclusions

Operation of the Diversion creates a high likelihood of modest planting delays and subsequent revenue loss. About 30,000 to 38,000 acres (depending upon flood size) have a 50 percent to 65 percent chance of a revenue loss in a flood year (excluding 10-year events or smaller).

While the probability of a revenue loss is high, the magnitude of losses is generally modest (less \$25/acre average for a storage area). The probability of revenue loss ranging from \$26 to \$75/acre average within a storage area is about 10 percent for flood events larger than a 10-year event.

The value of crop revenue loss per acre ranges from \$0 to more than \$200 depending the flood event and crop. The average loss within the range, although informative, does not reveal the risk or variability of loss. Observing the loss 5% above the least loss and 5% below the maximum loss reveals the range of possible losses (Appendix C).

Due to the complexity of the hydrology, which varies by storage area for the flood events evaluated, generalized statements about how producers will be individually affected are difficult. Revenue losses across all acres and crops within a storage area and by hydrology group measures the potential cumulative losses in the staging area and identifies general risk. However, care should be exercised that generalities and averages mask substantial differences for individual crops and storage areas. The economic impacts on some agricultural producers are likely to be considerably different than the average values within the hydrology groups.

Per-acre losses and cumulative losses would be larger if Federal crop insurance indemnities were included. Several uncertainties exist with how Federal crop insurance would be administered in the cases where the Diversion adds to existing flooding but the land would have flooded in the absence of the Diversion. Also, in cases where the Diversion is modeled to have no adverse effect, questions remain if the use of the Diversion affects the eligibility of Federal crop insurance to assist in mitigating planting delays on those lands. The degree to which Federal crop insurance coverage will be impacted as a result of Diversion operations is

unknown. This study only estimated the revenue losses associated with delayed planting that was due to operation of the Diversion. Including the potential value of lost insurance on all lands experiencing a planting delay (regardless if the planting delays was due to the Diversion) would increase the losses to producers and perhaps substantially increase estimated losses generated in this study.

Total losses in this study were based on the assumption that if any portion of a storage area was inundated, all land within that storage area was equally affected. Given the lack of available data to refine that assumption, developing estimates using all acreage was the best approach. However, overall losses due to the use of the Diversion would be sensitive to that assumption.

This study represents a geographic expansion of the previous study addressing potential effects of temporary water storage on agricultural production resulting from the use of the Diversion. As a result of this expanded geographic assessment, the acreage of agricultural lands affected by the Diversion's temporary water storage were expanded.

Examining when the effects of flooding may be gone and when regional planting typically begins, suggests a high likelihood of relatively short planting delays. These conclusions are extremely helpful in advancing the discussion of how agricultural production might be affected, but a number of additional issues remain unquantified. While this project was not able to address all production-related issues, this study, along with its methodology, lays a strong foundation from which additional production questions can be addressed.

Recommendations

-) Insurance Implications

Evaluate the potential loss of insurance indemnities during flood years and potential effects of reduced yields in flood years on adjustments to a producer's annual production history. Implications associated with effects on Federal crop insurance could be substantial.

-) Improve upon Key Assumptions

Study results are sensitive to dry-down assumptions. The days required for dry-down and clean-up was a static assumption, but should be re-examined to evaluate if dry-down periods can be statistically linked to planting rates or related to weather differences generally observed between the months of April and May.

Refinement in general data may require cooperation from producers operating within the staging area or cooperation from government agencies (e.g., Risk Management Service). County- or state-level information for crop yields, planting periods, planting rates and other agricultural factors was used in this assessment. More refined data, specific to the general staging area, would provide more precise estimates of the economic effects.

-) Variability of Effects at Producer Level Highlight Need for a Fair, Flexible, and Comprehensive Compensation Policy

This study demonstrates the complexity of framing and measuring the impacts of temporary water storage on agricultural producers. The FM Diversion Authority should continue to evaluate alternative compensation adjustments and mitigation strategies. Potential elements could include relieving risk to tenant producers, not just landowners. A compensation plan addressing full damages and including all affected parties would help alleviate the risk and financial concerns associated with temporary water storage.

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Appendix A
Hydrology Data for Storage Areas, With and Without Diversion Conditions,
10-year, 25-year, 50-year, 100-year, 500-year, and 1997-like Flood Events
FM Diversion Staging Area

Appendix Table A1. Storage Area Data, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling							
Storage Area	Section	Township	Range	County	State	Approximate Field Elevation ^a	Acres
CHRSA01	26	137	49	Cass	ND	915.0	307
CHRSA02	25	137	49	Cass	ND	914.5	305
CHRSA03	35	137	49	Cass	ND	918.0	304
CHRSA04	36	137	49	Cass	ND	918.0	284
CHRSA05	2 & 3	136	49	Richland	ND	921.0	320
CHRSA06	2	136	49	Richland	ND	921.5	117
CHRSA07	2	136	49	Richland	ND	917.5	151
CHRSA08	2	136	49	Richland	ND	918.5	161
CHRSA09	11	136	49	Richland	ND	922.5	301
CHRSA10	11	136	49	Richland	ND	920.5	326
CHRSA11	14	136	49	Richland	ND	924.5	305
CHRSA12	14	136	49	Richland	ND	924.5	327
CHRSA13	13	136	49	Richland	ND	918.0	629
CHRSA14	23	136	49	Richland	ND	924.0	317
CHRSA15	23	136	49	Richland	ND	919.0	324
CHRSA16	24	136	49	Richland	ND	917.0	629
CHRSA17	18 & 19	136	48	Richland	ND	919.5	839
WLUSA27	5	137	48	Clay	MN	910.0	430
WLUSA28	4	137	48	Clay	MN	912.5	290
WLUSA29	3 & 4	137	48	Clay	MN	913.0	935
WLUSA30	2	137	48	Clay	MN	915.5	629
WLUSA31	1 & 6	137	48 & 47	Clay	MN	917.0	1266
WLUSA32	12 & 7	137	48 & 47	Clay	MN	919.0	1270
WLUSA33	11	137	48	Clay	MN	915.0	631
WLUSA34	9	137	48	Clay	MN	913.0	326
WLUSA34a	10	137	48	Clay	MN	915.0	627
WLUSA35	8	137	48	Clay	MN	905.0	409
WLUSA36	17	137	48	Clay	MN	909.0	374
WLUSA37	17	137	48	Clay	MN	910.0	249
WLUSA38	16	137	48	Clay	MN	912.0	222
WLUSA39	15	137	48	Clay	MN	918.5	469
WLUSA40	14	137	48	Clay	MN	918.5	633
WLUSA41	13 & 18 & 17	137	48 & 47	Clay	MN	919.0	1466
WLUSA42	24	137	48	Clay	MN	921.0	631
WLUSA42a	19	137	47	Clay	MN	922.0	644
WLUSA43	23	137	48	Clay	MN	921.0	635
WLUSA44	22	137	48	Clay	MN	922.0	179
WLUSA45	21	137	48	Clay	MN	913.0	309
-continued-							

Table A1 Continued							
Storage Area	Section	Township	Range	County	State	Approximate Field Elevation ^a	Acres
WLUSA46	20	137	48	Clay	MN	912.5	630
WLUSA47	29	137	48	Clay	MN	913.0	625
WLUSA48	28	137	48	Clay	MN	920.0	308
WLUSA49	28	137	48	Clay	MN	920.0	328
WLUSA50	26	137	48	Clay	MN	922.0	630
WLUSA51	25	137	48	Clay	MN	923.5	634
WLUSA51a	30	137	47	Clay	MN	923.0	642
WLUSA53	35	137	48	Clay	MN	922.0	638
WLUSA54	33	137	48	Clay	MN	921.5	334
WLUSA55	33	137	48	Clay	MN	921.0	302
WLUSA56	32	137	48	Clay	MN	915.0	629
WLUSA57	5	136	48	Wilkin	MN	921.0	210
WLUSA58	5	136	48	Wilkin	MN	921.0	173
WLUSA59	5	136	48	Wilkin	MN	922.0	227
WLUSA63	8	136	48	Wilkin	MN	922.0	228
WLUSA64	8	136	48	Wilkin	MN	922.0	400
WLUSA65	17	136	48	Wilkin	MN	919.0	127
WLUSA66	17	136	48	Wilkin	MN	923.5	212
WLUSA67	16 & 17	136	48	Wilkin	MN	924.0	726
WLUSA72	21	136	48	Wilkin	MN	924.5	593
WRSA284	6	136	49	Richland	ND	923.0	597
WRSA289	32	137	49	Cass	ND	922.0	629
WRSA294	29	137	49	Cass	ND	919.5	625
WRSA299	20	137	49	Cass	ND	911.0	627
WRSA300	21	137	49	Cass	ND	909.5	626
WRSA302	23 & 24	137	49	Cass	ND	912.0	404
WRSA304	17	137	49	Cass	ND	911.5	635
WRSA305A	9	137	49	Cass	ND	910.5	225
WRSA305B	9	137	49	Cass	ND	909.0	408
WRSA305C	15 & 16	137	49	Cass	ND	908.5	808
WRSA305D	10	137	49	Cass	ND	910.0	432
WRSA306	13 & 14	137	49	Cass	ND	910.0	619
WRSA307	13	137	49	Cass	ND	910.0	254
WRSA309	8	137	49	Cass	ND	914.0	636
WRSA311	11	137	49	Cass	ND	907.0	305
WRSA312	12	137	49	Cass	ND	905.0	631
WRSA314	5	137	49	Cass	ND	912.5	619
WRSA315	4	137	49	Cass	ND	910.5	613
-continued-							

Table A1 Continued							
Storage Area	Section	Township	Range	County	State	Approximate Field Elevation ^a	Acres
WRS316	3	137	49	Cass	ND	910.0	611
WRS317A	1	137	49	Cass	ND	907.5	353
WRS317B	1	137	49	Cass	ND	906.5	230
WRS350	11	137	49	Cass	ND	910.0	274
WRS351	14	137	49	Cass	ND	908.0	309
WRS352	23	137	49	Cass	ND	911.0	297
WRS353	26	137	49	Cass	ND	917.0	292
WRS354	35	137	49	Cass	ND	918.0	295
WRS355	3	136	49	Richland	ND	917.5	415
WRS356	10	136	49	Richland	ND	923.5	622
WRS357	15	136	49	Richland	ND	922.5	614
WRS358	22	136	49	Richland	ND	923.0	492
WRS361	2	137	49	Cass	ND	907.0	192
WRS363	15	137	49	Cass	ND	911.0	268
WRS364	22	137	49	Cass	ND	912.0	252
WRS373	17	136	49	Richland	ND	927.5	632
WRS378	8	136	49	Richland	ND	926.0	156
WRS383	5	136	49	Richland	ND	923.5	153
WRS384	8	136	49	Richland	ND	925.0	155
WRS389	5	136	49	Richland	ND	921.5	151
WRS390	33	137	49	Cass	ND	916.0	269
WRS907	28	137	49	Cass	ND	913.0	394
Drain371	8	136	49	Richland	ND	922.0	160
Drain372	5	136	49	Richland	ND	921.5	319
Drain373	33	137	49	Cass	ND	919.0	332
Drain374	28	137	49	Cass	ND	915.0	241
RR1	32	136	48	Richland	ND	922.0	344
RR10	18	136	48	Richland	ND	920.0	164
RR11	18	136	48	Richland	ND	919.0	194
RR12	18	136	48	Wilkin	MN	918.5	123
RR13	7	136	48	Richland	ND	919.0	251
RR14	7	136	48	Wilkin	MN	919.0	361
RR15	12	136	49	Richland	ND	921.0	321
RR16	12	136	49	Richland	ND	918.5	319
RR17	66	136	48	Wilkin	MN	922.0	302
RR18	66	136	48	Wilkin	MN	921.5	341
RR19	1	136	49	Richland	ND	918.5	342
RR2	33	136	48	Richland	ND	928.5	557
-continued-							

Table A1 Continued							
Storage Area	Section	Township	Range	County	State	Approximate Field Elevation ^a	Acres
RR20	1	136	49	Richland	ND	918.0	250
RR21	36	137	49	Cass	ND	915.0	259
RR22	31	137	48	Clay	MN	917.5	215
RR23	36	137	49	Cass	ND	914.0	335
RR24	31	137	48	Clay	MN	912.5	171
RR25	25	137	49	Cass	ND	912.5	248
RR26	30	137	48	Clay	MN	914.0	176
RR27	25	137	49	Cass	ND	913.0	207
RR28	30	137	48	Clay	MN	913.0	310
RR29	19	137	48	Clay	MN	913.0	201
RR3	29	136	48	Richland	ND	921.0	362
RR30	19	137	48	Clay	MN	911.0	186
RR31	19	137	48	Clay	MN	910.0	230
RR32	18	137	48	Clay	MN	908.5	237
RR33	18	137	48	Cass	ND	907.5	63
RR34	18	137	48	Cass	ND	905.5	176
RR35	18	137	48	Clay	MN	908.0	134
RR36	7	137	48	Cass	ND	904.5	366
RR37	7	137	48	Clay	MN	906.0	235
RR38	6	137	48	Cass	ND	905.0	365
RR39	6	137	48	Clay	MN	908.0	195
RR4	29	136	48	Richland	ND	923.0	402
RR5	20	136	48	Richland	ND	920.0	125
RR6	20	136	48	Wilkin	MN	926.0	236
RR7	20	136	48	Richland	ND	920.0	141
RR8	20	136	48	Wilkin	MN	924.0	175
RR9	18	136	48	Richland	ND	919.0	89
WolvC1	34	137	48	Clay	MN	921.0	364
WolvC10	16	137	48	Clay	MN	917.0	156
WolvC11	16	137	48	Clay	MN	914.0	173
WolvC12	16	137	48	Clay	MN	911.0	88
WolvC13	9	137	48	Clay	MN	912.5	314
WolvC14	8	137	48	Clay	MN	908.0	208
WolvC15	5	137	48	Clay	MN	908.0	169
WolvC2	34	137	48	Clay	MN	922.0	269
WolvC3	27	137	48	Clay	MN	922.0	277
WolvC4	27	137	48	Clay	MN	921.5	356
WolvC5	21	137	48	Clay	MN	917.5	332
-continued-							

Table A1 Continued							
Storage Area	Section	Township	Range	County	State	Approximate Field Elevation ^a	Acres
WolvC6	22	137	48	Clay	MN	920.5	173
WolvC7	22	137	48	Clay	MN	921.0	157
WolvC8	22	137	48	Clay	MN	921.0	124
WolvC9	15	137	48	Clay	MN	919.5	160
WRRND1	4	136	49	Richland	ND	917.0	355
WRRND10	15	137	49	Cass	ND	911.0	76
WRRND11	10	137	49	Cass	ND	908.5	202
WRRND12	11	137	49	Cass	ND	908.0	16
WRRND13	2	137	49	Cass	ND	909.0	105
WRRND14	2	137	49	Cass	ND	909.0	213
WRRND15	2	137	49	Cass	ND	906.0	99
WRRND2	34	137	49	Cass	ND	917.5	146
WRRND3	34	137	49	Cass	ND	917.0	320
WRRND4	34	137	49	Cass	ND	916.5	197
WRRND5	21	137	49	Cass	ND	916.0	351
WRRND6	21	137	49	Cass	ND	914.5	288
WRRND7	22	137	49	Cass	ND	912.5	214
WRRND8	22	137	49	Cass	ND	912.5	173
WRRND9	15	137	49	Cass	ND	912.0	117
CHRSA18	26	136	49	Richland	ND	922.0	1,110
CHRSA19	25	136	49	Richland	ND	921.0	807
CHRSA20	30	136	48	Richland	ND	921.0	631
CHRSA23	31	136	48	Richland	ND	922.0	635

Appendix Table A2. Duration of Water Inundation, by Storage Area, by Flood Event Frequency for With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area

		Days of Water above Storage Area Elevation									
Storage Area	Approx. Field Elevation ^a	Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
CHRSA01	915.0	0	0	0	0	5	0	7.5	9	11.5	11.5
CHRSA02	914.5	0	0	0	2	10	0	9	11	13	13.5
CHRSA03	919.5	0	0	0	0	0	0	1.5	4.5	6.5	7.5
CHRSA04	918.0	0	0	0	0	7	0	6	8.5	10.5	11.5
CHRSA05	921.0	0	0	0	0	6.5	0	0	3	5	7.5
CHRSA06	921.5	0	0	0	0	6	0	0	2.5	4.5	7
CHRSA07	913.0	0	5	7.5	8.5	12.5	0	10.5	12	15	15
CHRSA08	918.5	0	0	0	2	7	0	5	7	8.5	10
CHRSA09	922.5	0	0	0	2	6	0	0	0	2.5	6
CHRSA10	920.5	0	0	0	0	5	0	0	4.5	6	8
CHRSA11	924.5	0	0	0	0	5	0	0	0	0	4.5
CHRSA12	924.5	0	0	0	0	5	0	0	0	0	6
CHRSA13	915.0	0	5.5	8	9	13.5	0	9.5	11.5	14	15.5
CHRSA14	924.0	0	0	0	0	5	0	0	0	0	5.5
CHRSA15	919.0	0	0	4	5	9.5	0	6	7.5	10	11.5
CHRSA16	917.0	0	3.5	6	7	11	0	7.5	9.5	12	14
CHRSA17	919.5	0	2	4.5	5.5	9.5	0	6	8	10	11.5
WLVA27	911.0	0	0	4.5	6	9	0	11.5	12.5	15	14.5
WLVA28	913.0	0	0	0	2.5	6.5	0	9.5	10.5	13	13
WLVA29	913.0	0	0	0	2.5	6.5	0	9.5	10.5	13	13
WLVA30	915.5	0	0	0	0	0	0	7.5	9.5	11	11.5
WLVA31	919.0	0	0	0	0	0	0	2	5	7	7.5
WLVA32	919.5	0	0	0	0	0	0	1.5	4.5	7.5	8.5
WLVA33	915.0	0	0	0	0	1.5	0	8.5	10	12	12.5
WLVA34	913.0	0	0	2.5	4	7.5	0	9.5	10.5	13	13
WLVA34a	915.0	0	0	0	0	1.5	0	8	9.5	11.5	12
WLVA35	905.0	5	9	11	13	19.5	5	14.5	15	18	20
WLVA36	909.0	0.5	6	8	9.5	14	0.5	13	13.5	16.5	17
WLVA37	910.0	2.5	5.5	8	7.5	12	2.5	12	13	15.5	15.5
WLVA38	912.0	2.5	3.5	6	6	9	2.5	11	12	14	14.5
WLVA39	918.5	0	0	0	0	0	0	4.5	6.5	8.5	9
WLVA40	918.5	0	0	0	0	0	0	4.5	7.5	9	9.5
WLVA41	921.0	0	0	0	0	0	0	0	0	5	6.5
WLVA42	921.0	0	0	0	0	0	0	0	0	5	5.5
WLVA42a	922.0	0	0	0	0	0	0	0	0	2	3.5
- continued -											

Appendix Table A2 Continued											
Storage Area	Approx. Field Elevation ^a	Days of Water above Storage Area Elevation									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WLUSA43	921.0	0	0	0	0	0	0	0	0.5	4.5	5.5
WLUSA44	922.0	0	0	0	0	0	0	0	0	2	3.5
WLUSA45	913.0	3	3.5	5	5.5	7.5	3	10	11.5	13.5	13.5
WLUSA46	913.0	0	0	4	5	9.5	0	9.5	11	13	14
WLUSA47	913.0	0	3.5	6.5	7.5	11	0	10	11.5	14	15
WLUSA48	920.0	0	0	0	0	1.5	0	0	4.5	6	7
WLUSA49	920.0	0	0	0	0	2	0	0	4	6.5	7
WLUSA50	922.0	0	0	0	0	1	0	0	0	4	5
WLUSA51	923.5	0	0	0	0	0	0	0	0	0	1
WLUSA51a	923.0	0	0	0	0	0	0	0	0	0	2.5
WLUSA53	922.0	0	0	0	2	2.5	0	0	1	4.5	5.5
WLUSA54	921.5	0	0	0	0	2.5	0	0	0.5	4.5	6.5
WLUSA55	921.0	0	0	0	0	2.5	0	0	2.5	5	7
WLUSA56	915.0	0	2	4.5	5.5	9.5	0	8.5	10	12.5	13
WLUSA57	921.0	0	0	0	0.5	8	0	0	3.5	5.5	9.5
WLUSA58	921.0	0	0	0	0.5	8.5	0	0	3.5	5.5	9.5
WLUSA59	922.0	0	0	0	1	8.5	0	0	3	4.5	10.5
WLUSA63	922.0	0	0	0	2	7	0	0	3.5	5	9
WLUSA64	922.0	0	0	0	1.5	7	0	0	3.5	5	9
WLUSA65	919.0	0	0	3.5	4.5	8.5	0	5.5	7.5	9.5	11
WLUSA66	923.5	0	0	0	2	7	0	0	2.5	4	8
WLUSA67	921.5	2.5	3	4.5	5.5	7.5	2.5	3.5	6.5	7.5	9
WLUSA72	924.5	0	0	0	0	6	0	0	0	2	7
WRSA284	923.0	0	0	0	0	0	0	0	0	0	0
WRSA289	922.0	0	0	0	0	0	0	0	0	2	4
WRSA294	919.5	0	0	0	0	4.5	0	1.5	4	5.5	7.5
WRSA299	911.0	5	9	11	13	17.5	5	11.5	13.5	15.5	17
WRSA300	908.0	8	12	14	17.5	26	7.5	13	15	17.5	23.5
WRSA302	912.0	0	3	5.5	7	10.5	0	10.5	12	14	14
WRSA304	911.5	5	8.5	10	12.5	17	4	11.5	12.5	15	16.5
WRSA305A	910.5	6	9.5	11.5	14	19	5	11.5	13.5	15	17.5
WRSA305B	908.5	7.5	11.5	13.5	16.5	24	7.5	12.5	14.5	17	21.5
WRSA305C	906.0	10	14.5	17	22	33	9.5	15.5	17	21.5	32
WRSA305D	913.0	2.5	7	8.5	10.5	14.5	2	10.5	12	14	14.5
WRSA306	910.0	2	8	10	11.5	15.5	2	13	14.5	17	17.5
WRSA307	910.0	0	6	8	9.5	14	0	12.5	13.5	16	16.5
- continued -											

Appendix Table A2 Continued											
		Days of Water above Storage Area Elevation									
Storage Area	Existing Conditions	Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WRSA309	914.0	0	5.5	7	9	12.5	0	9.5	11	13	13.5
WRSA311	907.0	6.5	10.5	12.5	15	21	6.5	15	16	18.5	19
WRSA312	905.0	8	12	14.5	17	26.5	8	15	16.5	18.5	23.5
WRSA314	912.5	0	2	4.5	7	9.5	0	10	11.5	13.5	14
WRSA315	910.5	0	0	5	7.5	10.5	3.5	11	12.5	14.5	14.5
WRSA316	910.5	3	8.5	10	12.5	16	3.5	11	12.5	14.5	15
WRSA317A	908.0	5.5	10	12	14	18.5	5	14.5	16	18	18.5
WRSA317B	906.0	3	8	10	12	17.5	3.5	14	14.5	17.5	18.5
WRSA350	910.0	2.5	8	10	12	15.5	2.5	13	15	17	17
WRSA351	908.0	5.5	10	12	13.5	18.5	5.5	14	16	18	18
WRSA352	910.5	0	8	10	11.5	15.5	0	12.5	14.5	16.5	16.5
WRSA353	917.0	0	0	2	4.5	7.5	0	6	7.5	9.5	10
WRSA354	918.0	0	4.5	6	8	11.5	0	7	8	10.5	12.5
WRSA355	914.5	5.5	9	11	13.5	18.5	5.5	11	13	15	18.5
WRSA356	917.5	4	8	9	12	16	4	9	11	13.5	16
WRSA357	919.0	2.5	6.5	8	10	14	2.5	7.5	9.5	12	14.5
WRSA358	921.0	0	4.5	6	8	11	0	5.5	7	9	11.5
WRSA361	907.0	6.5	10.5	12.5	15	21	6.5	14.5	16.5	18.5	19
WRSA363	911.0	0	8	9.5	11.5	15	0	12.5	14	16.5	16.5
WRSA364	912.0	0	7.5	9.5	11.5	14.5	0	12	13.5	15.5	15.5
WRSA373	927.5	0	0	0	0	0	0	0	0	0	0
WRSA378	926.0	0	0	0	0	3.5	0	0	0	0	4
WRSA383	923.5	0	0	0	0	0	0	0	0	0	0
WRSA384	925.0	0	0	0	0	4.5	0	0	0	0	4.5
WRSA389	921.5	0	0	3	5	8	0	0	4.5	6.5	8.5
WRSA390	913.0	5.5	9.5	11.5	14	19	5.5	11	13	15	18.5
WRSA907	913.0	3	7	9	11	15	3	10.5	12	14.5	15
Drain371	922.0	0	0	0	0	2	0	0	0	3.5	4.5
Drain372	921.5	0	0	0	0	1.5	0	0	0	3.5	5
Drain373	919.0	0	2.5	4.5	6.5	9	0	5	7	9	10
Drain374	915.0	4	7.5	9.5	11.5	16	3.5	10.5	11.5	14	15.5
RR1	922.0	0	3	5.5	6.5	10.5	0	5.5	8	9	11.5
RR10	920.0	0	1	4	5	9.5	0	5.5	7.5	9.5	11
RR11	919.0	0	0	4	5	9	0	5.5	7.5	10	11
RR12	918.5	0	1.5	4.5	5.5	9.5	0	6.5	8.5	10.5	11.5
RR13	919.0	0	0	3.5	4	9	0	5.5	7.5	9	11
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Appendix Table A2 Continued											
Storage Area	Existing Conditions	Days of Water above Storage Area Elevation									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
RR15	921.0	0	0	0	2	7.5	0	2	5.5	6.5	9
RR16	918.5	0	0	3.5	4	9	0	5.5	7.5	9.5	11
RR17	922.0	0	0	0	0	5.5	0	0	2.5	5	7.5
RR18	921.5	0	0	0	0	4.5	0	0	3	5	7.5
RR19	918.5	0	0	3	4	8.5	0	5.5	7.5	9.5	11
RR2	928.5	0	0	0	0	5.5	0	0	0	1	5.5
RR20	918.0	0	0	2	3	8	0	6	7.5	9.5	10.5
RR21	915.0	0	2	5	5.5	9.5	0	8.5	10	12.5	12.5
RR22	917.5	0	0	1	3	8	0	6	8	10	10.5
RR23	914.0	0	3	6	7	11	0	9.5	10.5	13	14
RR24	912.5	0	5	7.5	8.5	12.5	0	10.5	12.5	15	15
RR25	912.5	0	4	7.5	8	12.5	0	10.5	12	15	14.5
RR26	914.0	0	3	5.5	6.5	10.5	0	9.5	10.5	13	13.5
RR27	913.0	0	3.5	6.5	7.5	11.5	0	10	12	14.5	14
RR28	913.0	0	3.5	6.5	7.5	11.5	0	10	12	14.5	14
RR29	913.0	0	3.5	6	7	10.5	0	10	11.5	14.5	14
RR3	921.0	0	2.5	5	6	10	0	5.5	7.5	9	11.5
RR30	911.0	0	5.5	8	8.5	13.5	0	12	13	15.5	15.5
RR31	910.0	0	6	8.5	9.5	14	0.5	12.5	13	16	16
RR32	908.5	1.5	7	9	10.5	15.5	2.5	13	14	17	17
RR33	907.5	3	8	10	11.5	17.5	3	14	14.5	17.5	18.5
RR34	905.5	5	9.5	11.5	13.5	21	5	14.5	15	18.5	21
RR35	908.0	2.5	7	9	11	16	2.5	13.5	14	17	17
RR36	904.5	5.5	10	12	14.5	22.5	5.5	15	15.5	18.5	23
RR37	906.0	4	8.5	11	12.5	19	4	14.5	14.5	17.5	19.5
RR38	905.0	4.5	9	11	13	19.5	4.5	14.5	14.5	18	19.5
RR39	908.0	0.5	6.5	9	10	14	1	13	14	17	16.5
RR4	923.0	0	0	3.5	4	8.5	0	2.5	5.5	7	9.5
RR5	920.0	0	3	5.5	6	10.5	0	6	8	9.5	12
RR6	926.0	0	0	0	0	6	0	0	0	1.5	6.5
RR7	920.0	0	2	4.5	5.5	9.5	0	5.5	8	9.5	11
RR8	924.0	0	0	0	1.5	7	0	0	2.5	4.5	8
RR9	919.0	0	2	4.5	5.5	10	0	6.5	8.5	10	11.5
WolvC1	921.0	1.5	2	2.5	3.5	3.5	1.5	2	5.5	6.5	7
WolvC10	917.0	0	0	0	0	0	0	5.5	7.5	9.5	9.5
WolvC11	914.0	0	0	0	3	5	0	8.5	10	12	11.5
WolvC12	911.0	0	3.5	6	7	10	0	11.5	12.5	15	14
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Appendix Table A2 Continued											
Storage Area	Existing Conditions	Days of Water above Storage Area Elevation									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WolvC13	912.5	0	0	3.5	5	8	0	10	11	13.5	13.5
WolvC14	908.0	2	6.5	9	10	14	2	13.5	14	17	16.5
WolvC15	908.0	1	6.5	8.5	10	14	1	13	14	17	16.5
WolvC2	922.0	0	0	0	1.5	2.5	0	0	0.5	4.5	5.5
WolvC3	922.0	0	0	0	0	1.5	0	0	0	4	5
WolvC4	921.5	0	0	0	0	1.5	0	0	0	5	5.5
WolvC5	917.5	0	0	0	0	1.5	0	6	7.5	9	9
WolvC6	920.5	0	0	0	0	0	0	0	3	5.5	6
WolvC7	921.0	0	0	0	0	0	0	0	1.5	4.5	5.5
WolvC8	921.0	0	0	0	0	0	0	0	0.5	4.5	5.5
WolvC9	919.5	0	0	0	0	0	0	1.5	5	7	7.5
WRRND1	917.0	3.5	7	8.5	11	15	2.5	8.5	10.5	13	15
WRRND10	911.0	6	9.5	11.5	14	19	5.5	11.5	13	15.5	18
WRRND11	908.5	7.5	11	13.5	16.5	23	7.5	12.5	14.5	16.5	21
WRRND12	908.0	6.5	11	13	15.5	22.5	6.5	12.5	14.5	16.5	20
WRRND13	909.0	6	10	11.5	14	19	5.5	12	13	15.5	17.5
WRRND14	909.0	5.5	9.5	11.5	14	18.5	5	11.5	13	15.5	17
WRRND15	906.0	7.5	11	13.5	16	24	7	14	15	17	20.5
WRRND2	917.5	2.5	6.5	8	10	13.5	2	8	10	12	14
WRRND3	917.0	2.5	6.5	8	10	13.5	2.5	8.5	10	12.5	14
WRRND4	916.5	2.5	6.5	7.5	10	13.5	2.5	8.5	10.5	12.5	14
WRRND5	916.0	2.5	6.5	8	10	14	2.5	9	11	13	14
WRRND6	914.5	4	7.5	9.5	11.5	16	4	10.5	12	14.5	15.5
WRRND7	912.5	5.5	9	10.5	13.5	18	5	11	13	15	17
WRRND8	912.5	4.5	9	10.5	13	17.5	4.5	11	13	15	16.5
WRRND9	912.0	5	9	10.5	13	18	4.5	11	13	15	17
CHRSA18	922.0	0	0	0	2	7	0	0	4.5	6	8.5
CHRSA19	921.0	0	0	1.5	3	7.5	0	2.5	5.5	7	9.5
CHRSA20	921.0	0	3	5.5	6.5	10.5	0	6	8.5	9.5	12
CHRSA23	922.0	0	2.5	5	7.5	11	0	4.5	7	9	12
^a Feet above mean seal level. Lowest estimated elevation for storage area.											
Source: Houston-Moore Group (2016).											

Appendix Table A3. Time from Activation of Staging Area to Inundation, by Storage Area, by Flood Event Frequency for With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area

Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
CHRSA01	915.0	0	0	0	0	4	0	3	2.5	2.5	2.5
CHRSA02	914.5	0	0	0	4.5	3.5	0	3	2.5	2.5	2.5
CHRSA03	919.5	0	0	0	0	0	0	5.5	4.5	4.5	4
CHRSA04	918.0	0	0	0	0	3.5	0	4.5	3.5	3.5	3
CHRSA05	921.0	0	0	0	0	3.5	0	0	4.5	4.5	3.5
CHRSA06	921.5	0	0	0	0	3.5	0	0	4.5	4	3.5
CHRSA07	913.0	0	2.5	2	2	2	0	2	1.5	1.5	1.5
CHRSA08	918.5	0	0	0	3.5	3	0	3.5	3	3	2.5
CHRSA09	922.5	0	0	0	0	3.5	0	0	0	5	4
CHRSA10	920.5	0	0	0	0	3.5	0	0	3.5	3.5	3
CHRSA11	924.5	0	0	0	0	3.5	0	0	0	0	4
CHRSA12	924.5	0	0	0	0	3	0	0	0	0	3
CHRSA13	915.0	0	2	1.5	1.5	1.5	0	2	1.5	1.5	1.5
CHRSA14	924.0	0	0	0	0	3.5	0	0	0	0	3.5
CHRSA15	919.0	0	0	2.5	2.5	2	0	2.5	2.5	2	2
CHRSA16	917.0	0	2.5	2	2	2	0	2.5	2	2	1.5
CHRSA17	919.5	0	3	2.5	2.5	2	0	2.5	2	2	2
WLVSA27s	911.0	0	0	3.5	3.5	3.5	0	1.5	1.5	1.5	1.5
WLVSA28s	913.0	0	0	0	4.5	4	0	2	2	2	2
WLVSA29s	913.0	0	0	0	4.5	4	0	2	2	2	2
WLVSA30s	915.5	0	0	0	0	0	0	3	2.5	3	3
WLVSA31s	919.0	0	0	0	0	0	0	5.5	4.5	4.5	4.5
WLVSA32	919.5	0	0	0	0	0	0	5.5	4.5	4.5	4.5
WLVSA33	915.0	0	0	0	0	5	0	2.5	2.5	2.5	2.5
WLVSA34	913.0	0	0	4	4	3.5	0	2	2	2	2
WLVSA34a	915.0	0	0	0	0	5	0	2.5	2.5	2.5	2.5
WLVSA35	905.0	3	2	1.5	2	1.5	3	1	1	0.5	0.5
WLVSA36	909.0	5	3	2.5	2.5	2.5	5	1.5	1.5	1.5	1
WLVSA37	910.0	3	2	1.5	3	2.5	3	1.5	1.5	1.5	1
WLVSA38	912.0	3	1.5	1.5	3	3	3	1.5	1.5	2	1.5
WLVSA39	918.5	0	0	0	0	0	0	4	3.5	3.5	3.5
WLVSA40	918.5	0	0	0	0	0	0	4.5	3.5	4	4
WLVSA41	921.0	0	0	0	0	0	0	0	0	6	5.5
WLVSA42	921.0	0	0	0	0	0	0	0	0	5	5
WLVSA42a	922.0	0	0	0	0	0	0	0	0	6.5	6
WLVSA43	921.0	0	0	0	0	0	0	0	6	5	5
- continued -											

Appendix Table C3. Continued											
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WLUSA44	922.0	0	0	0	0	0	0	0	0	6	5.5
WLUSA45	913.0	2.5	1.5	1.5	3	3.5	2.5	1.5	1.5	2	2
WLUSA46	913.0	0	0	4	4	3	0	2.5	2	2.5	2
WLUSA47	913.0	0	3	2.5	2.5	2.5	0	2	2	2	1.5
WLUSA48	920.0	0	0	0	0	5	0	0	4	4	4
WLUSA49	920.0	0	0	0	0	5	0	0	4.5	4	4
WLUSA50	922.0	0	0	0	0	5.5	0	0	0	4.5	4.5
WLUSA51	923.5	0	0	0	0	0	0	0	0	0	6
WLUSA51a	923.0	0	0	0	0	0	0	0	0	0	5.5
WLUSA53	922.0	0	0	0	4	4.5	0	0	3	4	4
WLUSA54	921.5	0	0	0	0	4.5	0	0	5.5	4.5	4
WLUSA55	921.0	0	0	0	0	4.5	0	0	4.5	4	3.5
WLUSA56	915.0	0	3.5	3	3	2.5	0	2.5	2	2	2
WLUSA57	921.0	0	0	0	4.5	3	0	0	4	3.5	3
WLUSA58	921.0	0	0	0	4.5	3	0	0	4	3.5	3
WLUSA59	922.0	0	0	0	4.5	3.5	0	0	4	4	3
WLUSA63	922.0	0	0	0	3.5	3	0	0	3.5	3.5	2.5
WLUSA64	922.0	0	0	0	3.5	3	0	0	3.5	3.5	2.5
WLUSA65	919.0	0	0	3	3	2.5	0	3	2.5	2.5	2
WLUSA66	923.5	0	0	0	3.5	2.5	0	0	3.5	3.5	2.5
WLUSA67	921.5	2.5	1.5	1	2.5	2.5	2.5	1	1	2.5	2.5
WLUSA72	924.5	0	0	0	0	2.5	0	0	0	3.5	2.5
WUSA284	923.0	0	0	0	0	0	0	0	0	0	0
WUSA289	922.0	0	0	0	0	0	0	0	0	5	4.5
WUSA294	919.5	0	0	0	0	3	0	4.5	4	4	3
WUSA299	911.0	2.5	1.5	1	1.5	2	2.5	1	0.5	1	1.5
WUSA300	908.0	1.5	0.5	0.5	0.5	0.5	1.5	0.5	0	0.5	0.5
WUSA302	912.0	0	4	3.5	3.5	3.5	0	2	1.5	2	2
WUSA304	911.5	2.5	1.5	1.5	1.5	2	3	1	1	1	1.5
WUSA305A	910.5	2	1	1	1	1.5	2.5	1	0.5	1	1.5
WUSA305B	908.5	1.5	0.5	0.5	0.5	1	1.5	0.5	0.5	0.5	1
WUSA305C	906.0	0.5	0	0	0	0	1	0	0	0	0
WUSA305D	913.0	3.5	2	1.5	2	2	3.5	1.5	1	1.5	2
WUSA306	910.0	4	2.5	2	2.5	2.5	4.5	1.5	1	1.5	1.5
WUSA307	910.0	0	3	2.5	3	2.5	0	1.5	1.5	1.5	1
WUSA309	914.0	0	2.5	2	2.5	2.5	0	2	1.5	2	2.5
WUSA311	907.0	2	1	1	1	1.5	2	0.5	0.5	0.5	1
- continued -											

Appendix Table A3. Continued											
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WRS312	905.0	1.5	1	0.5	1	0.5	1.5	0.5	0	0.5	0.5
WRS314	912.5	0	3.5	3	3	3.5	0	1.5	1.5	1.5	2
WRS315	910.5	0	0	4	4	4	3	1	0.5	1	1.5
WRS316	910.5	3.5	2	2	2	2.5	3	1	0.5	1	1.5
WRS317A	908.0	2.5	1.5	1	1.5	1.5	3	1	0.5	1	1.5
WRS317B	906.0	4	2	2	2	2	4	1	1	1	0.5
WRS350	910.0	4	2.5	2	2	2.5	4	1.5	1	1.5	2
WRS351	908.0	2.5	1.5	1	1.5	1.5	2.5	1	0.5	1	1.5
WRS352	910.5	0	2.5	2	2.5	2.5	0	2	1.5	2	2.5
WRS353	917.0	0	0	3	3.5	3.5	0	3	2.5	3	3
WRS354	918.0	0	2.5	2	2	2.5	0	2	2	2	2.5
WRS355	914.5	2	1	0.5	1	1	2	1	0.5	1	1
WRS356	917.5	2.5	1	1	1	1.5	2.5	1	1	1	1.5
WRS357	919.0	3	1.5	1	1.5	1.5	3	1.5	1	1	1.5
WRS358	921.0	0	2	1.5	1.5	2	0	2	1.5	1.5	2
WRS361	907.0	2	1	1	1	1.5	2	0.5	0	0.5	1
WRS363	911.0	0	2.5	2	2	2.5	0	2	1.5	1.5	2
WRS364	912.0	0	2.5	2	2	2.5	0	2	1.5	2	2.5
WRS373	927.5	0	0	0	0	0	0	0	0	0	0
WRS378	926.0	0	0	0	0	4.5	0	0	0	0	4.5
WRS383	923.5	0	0	0	0	0	0	0	0	0	0
WRS384	925.0	0	0	0	0	4.5	0	0	0	0	4.5
WRS389	921.5	0	0	3	3	3	0	0	3	3	3
WRS390	913.0	2	1	0.5	1	1.5	2	1	0.5	1	1.5
WRS907	913.0	3	2	1.5	1.5	2	3	1.5	1.5	1.5	2
Drain371	922.0	0	0	0	0	4	0	0	0	4	4
Drain372	921.5	0	0	0	0	4.5	0	0	0	4.5	4
Drain373	919.0	0	2.5	2	2	2.5	0	2.5	2	2	2.5
Drain374	915.0	2.5	1.5	1	1.5	1.5	2.5	1	1	1	1.5
RR1	922.0	0	2.5	2	1.5	1.5	0	2	1.5	1.5	1.5
RR10	920.0	0	3.5	2.5	2.5	2	0	2.5	2	2	2
RR11	919.0	0	0	2.5	2.5	2	0	3	2.5	2	2
RR12	918.5	0	3.5	2.5	2.5	2	0	2.5	2	2	2
RR13	919.0	0	0	3	3	2	0	3	2.5	2.5	2
RR14	919.0	0	0	3	3	2	0	3	2.5	2.5	2
RR15	921.0	0	0	0	3.5	2.5	0	4	3	3	2.5
RR16	918.5	0	0	3	3	2	0	3	2.5	2.5	2
- continued -											

Appendix Table A3. Continued											
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
RR17	922.0	0	0	0	0	3	0	0	4	3.5	3
RR18	921.5	0	0	0	0	3.5	0	0	4	3.5	3
RR19	918.5	0	0	3	3	2.5	0	3	2.5	2.5	2
RR2	928.5	0	0	0	0	2.5	0	0	0	3.5	2.5
RR20	918.0	0	0	3.5	3.5	2.5	0	3	2.5	2.5	2
RR21	915.0	0	3.5	2.5	3	2.5	0	2.5	2	2	2
RR22	917.5	0	0	4	3.5	2.5	0	3	2.5	2.5	2.5
RR23	914.0	0	3	2.5	2.5	2	0	2	2	2	1.5
RR24	912.5	0	2.5	2	2	2	0	2	1.5	1.5	1.5
RR25	912.5	0	3	2	2.5	2	0	2	1.5	1.5	1.5
RR26	914.0	0	3	2.5	2.5	2.5	0	2	2	2	1.5
RR27	913.0	0	3	2.5	2.5	2	0	2	1.5	1.5	1.5
RR28	913.0	0	3	2.5	2.5	2	0	2	1.5	1.5	1.5
RR29	913.0	0	3	2.5	2.5	2.5	0	2	1.5	1.5	1.5
RR3	921.0	0	2.5	2	2	1.5	0	2.5	2	2	1.5
RR30	911.0	0	2.5	2	2.5	2	0	1.5	1.5	1.5	1
RR31	910.0	0	2.5	2	2	2	5	1.5	1.5	1.5	1
RR32	908.5	4.5	2.5	2	2	2	4	1.5	1	1	1
RR33	907.5	4	2	1.5	2	1.5	4	1	1	1	0.5
RR34	905.5	3.5	1.5	1.5	1.5	1.5	3.5	1	1	0.5	0.5
RR35	908.0	4	2.5	2	2	2	4	1	1	1	1
RR36	904.5	3	1.5	1.5	1.5	1.5	3	0.5	0.5	0.5	0
RR37	906.0	3.5	2	1.5	2	1.5	3.5	1	1	1	0.5
RR38	905.0	3.5	2	1.5	2	1.5	3.5	1	1	0.5	0.5
RR39	908.0	5	2.5	2	2.5	2.5	4.5	1.5	1	1	1
RR4	923.0	0	0	2.5	2.5	2	0	3	2.5	2	2
RR5	920.0	0	2.5	2	2	1.5	0	2.5	2	2	1.5
RR6	926.0	0	0	0	0	2.5	0	0	0	3.5	2.5
RR7	920.0	0	3	2.5	2.5	2	0	2.5	2	2	2
RR8	924.0	0	0	0	3.5	2.5	0	0	3.5	3	2.5
RR9	919.0	0	3	2.5	2.5	2	0	2.5	2	2	2
WolvC1	921.0	3	2	2	3.5	4	3	2	2	3.5	3.5
WolvC10	917.0	0	0	0	0	0	0	3.5	3	3	3
WolvC11	914.0	0	0	0	4	4	0	2.5	2	2.5	2.5
WolvC12	911.0	0	3	2.5	3	3	0	1.5	1.5	1.5	1.5
WolvC13	912.5	0	0	3.5	3.5	3.5	0	2	2	2	1.5
WolvC14	908.0	4	2.5	2	2.5	2.5	4	1	1	1	1
- continued -											

Appendix Table A3. Continued											
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated									
		Existing Conditions					Existing Conditions				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WolvC15	908.0	4.5	2.5	2	2.5	2.5	4.5	1.5	1	1	1
WolvC2	922.0	0	0	0	4.5	4.5	0	0	3	4	4
WolvC3	922.0	0	0	0	0	5	0	0	0	4.5	4.5
WolvC4	921.5	0	0	0	0	5	0	0	0	4	4.5
WolvC5	917.5	0	0	0	0	5	0	3	2.5	3	3.5
WolvC6	920.5	0	0	0	0	0	0	0	5	4.5	4.5
WolvC7	921.0	0	0	0	0	0	0	0	5.5	5	5
WolvC8	921.0	0	0	0	0	0	0	0	6	5	5
WolvC9	919.5	0	0	0	0	0	0	5	4	4	4
WRRND1	917.0	2.5	1.5	1	1	1.5	3	1.5	1	1	1.5
WRRND10	911.0	2	1	1	1	1.5	2	1	0.5	0.5	1.5
WRRND11	908.5	1.5	1	0.5	0.5	1	1.5	0.5	0	0.5	1
WRRND12	908.0	2	1	0.5	1	1	2	0.5	0	0.5	1
WRRND13	909.0	2	1	1	1	1.5	2.5	0.5	0.5	0.5	1
WRRND14	909.0	2.5	1	1	1	1.5	2.5	0.5	0.5	0.5	1.5
WRRND15	906.0	1.5	1	0.5	1	1	2	0.5	0	0.5	1
WRRND2	917.5	3	1.5	1	1.5	2	3	1.5	1	1.5	2
WRRND3	917.0	3	1.5	1	1.5	2	3	1.5	1	1.5	2
WRRND4	916.5	3	1.5	1.5	1.5	2	3	1.5	1	1.5	2
WRRND5	916.0	3	1.5	1.5	1.5	2	3	1.5	1	1.5	2
WRRND6	914.5	2.5	1.5	1	1.5	1.5	2.5	1	1	1	1.5
WRRND7	912.5	2	1	1	1	1.5	2	1	0.5	1	1.5
WRRND8	912.5	2.5	1	1	1	1.5	2.5	1	0.5	1	1.5
WRRND9	912.0	2.5	1	1	1	1.5	2.5	1	0.5	1	1.5
CHRSA18	922.0	0	0	0	3.5	2.5	0	0	3	3	2.5
CHRSA19	921.0	0	0	3.5	3	2.5	0	4	3	3	2
CHRSA20	921.0	0	2.5	2	1.5	1.5	0	2	1.5	1.5	1.5
CHRSA23	922.0	0	2.5	2	2	1.5	0	2.5	2	2	1.5

^aFeet above mean seal level. Lowest estimated elevation for storage area.
Source: Houston-Moore Group (2016).

Appendix Table A4. Time from Activation of Staging Area to When Flood Water Leaves, by Storage Area, by Flood Event Frequency for With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area

Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
CHRSA01	915.0	0	0	0	0	9	0	10.5	11.5	14	14
CHRSA02	914.5	0	0	0	6.5	13.5	0	12	13.5	15.5	16
CHRSA03	919.5	0	0	0	0	0	0	7	9	11	11.5
CHRSA04	918.0	0	0	0	0	10.5	0	10.5	12	14	14.5
CHRSA05	921.0	0	0	0	0	10	0	0	7.5	9.5	11
CHRSA06	921.5	0	0	0	0	9.5	0	0	7	8.5	10.5
CHRSA07	913.0	0	7.5	9.5	10.5	14.5	0	12.5	13.5	16.5	16.5
CHRSA08	918.5	0	0	0	5.5	10	0	8.5	10	11.5	12.5
CHRSA09	922.5	0	0	0	2	9.5	0	0	0	7.5	10
CHRSA10	920.5	0	0	0	0	8.5	0	0	8	9.5	11
CHRSA11	924.5	0	0	0	0	8.5	0	0	0	0	8.5
CHRSA12	924.5	0	0	0	0	8	0	0	0	0	9
CHRSA13	915.0	0	7.5	9.5	10.5	15	0	11.5	13	15.5	17
CHRSA14	924.0	0	0	0	0	8.5	0	0	0	0	9
CHRSA15	919.0	0	0	6.5	7.5	11.5	0	8.5	10	12	13.5
CHRSA16	917.0	0	6	8	9	13	0	10	11.5	14	15.5
CHRSA17	919.5	0	5	7	8	11.5	0	8.5	10	12	13.5
WLVA27	911.0	0	0	8	9.5	12.5	0	13	14	16.5	16
WLVA28	913.0	0	0	0	7	10.5	0	11.5	12.5	15	15
WLVA29	913.0	0	0	0	7	10.5	0	11.5	12.5	15	15
WLVA30	915.5	0	0	0	0	0	0	10.5	12	14	14.5
WLVA31	919.0	0	0	0	0	0	0	7.5	9.5	11.5	12
WLVA32	919.5	0	0	0	0	0	0	7	9	12	13
WLVA33	915.0	0	0	0	0	6.5	0	11	12.5	14.5	15
WLVA34	913.0	0	0	6.5	8	11	0	11.5	12.5	15	15
WLVA34a	915.0	0	0	0	0	6.5	0	10.5	12	14	14.5
WLVA35	905.0	8	11	12.5	15	21	8	15.5	16	18.5	20.5
WLVA36	909.0	5.5	9	10.5	12	16.5	5.5	14.5	15	18	18
WLVA37	910.0	5.5	7.5	9.5	10.5	14.5	5.5	13.5	14.5	17	16.5
WLVA38	912.0	5.5	5	7.5	9	12	5.5	12.5	13.5	16	16
WLVA39	918.5	0	0	0	0	0	0	8.5	10	12	12.5
WLVA40	918.5	0	0	0	0	0	0	9	11	13	13.5
WLVA41	921.0	0	0	0	0	0	0	0	0	11	12
WLVA42	921.0	0	0	0	0	0	0	0	0	10	10.5
WLVA42a	922.0	0	0	0	0	0	0	0	0	8.5	9.5
- continued -											

Appendix Table A4. Continued

Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WLUSA43	921.0	0	0	0	0	0	0	0	6.5	9.5	10.5
WLUSA44	922.0	0	0	0	0	0	0	0	0	8	9
WLUSA45	913.0	5.5	5	6.5	8.5	11	5.5	11.5	13	15.5	15.5
WLUSA46	913.0	0	0	8	9	12.5	0	12	13	15.5	16
WLUSA47	913.0	0	6.5	9	10	13.5	0	12	13.5	16	16.5
WLUSA48	920.0	0	0	0	0	6.5	0	0	8.5	10	11
WLUSA49	920.0	0	0	0	0	7	0	0	8.5	10.5	11
WLUSA50	922.0	0	0	0	0	6.5	0	0	0	8.5	9.5
WLUSA51	923.5	0	0	0	0	0	0	0	0	0	7
WLUSA51a	923.0	0	0	0	0	0	0	0	0	0	8
WLUSA53	922.0	0	0	0	6	7	0	0	4	8.5	9.5
WLUSA54	921.5	0	0	0	0	7	0	0	6	9	10.5
WLUSA55	921.0	0	0	0	0	7	0	0	7	9	10.5
WLUSA56	915.0	0	5.5	7.5	8.5	12	0	11	12	14.5	15
WLUSA57	921.0	0	0	0	5	11	0	0	7.5	9	12.5
WLUSA58	921.0	0	0	0	5	11.5	0	0	7.5	9	12.5
WLUSA59	922.0	0	0	0	5.5	12	0	0	7	8.5	13.5
WLUSA63	922.0	0	0	0	5.5	10	0	0	7	8.5	11.5
WLUSA64	922.0	0	0	0	5	10	0	0	7	8.5	11.5
WLUSA65	919.0	0	0	6.5	7.5	11	0	8.5	10	12	13
WLUSA66	923.5	0	0	0	5.5	9.5	0	0	6	7.5	10.5
WLUSA67	921.5	5	4.5	5.5	8	10	5	4.5	7.5	10	11.5
WLUSA72	924.5	0	0	0	0	8.5	0	0	0	5.5	9.5
WRSA284	923.0	0	0	0	0	0	0	0	0	0	0
WRSA289	922.0	0	0	0	0	0	0	0	0	7	8.5
WRSA294	919.5	0	0	0	0	7.5	0	6	8	9.5	10.5
WRSA299	911.0	7.5	10.5	12	14.5	19.5	7.5	12.5	14	16.5	18.5
WRSA300	908.0	9.5	12.5	14.5	18	26.5	9	13.5	15	18	24
WRSA302	912.0	0	7	9	10.5	14	0	12.5	13.5	16	16
WRSA304	911.5	7.5	10	11.5	14	19	7	12.5	13.5	16	18
WRSA305A	910.5	8	10.5	12.5	15	20.5	7.5	12.5	14	16	19
WRSA305B	908.5	9	12	14	17	25	9	13	15	17.5	22.5
WRSA305C	906.0	10.5	14.5	17	22	33	10.5	15.5	17	21.5	32
WRSA305D	913.0	6	9	10	12.5	16.5	5.5	12	13	15.5	16.5
WRSA306	910.0	6	10.5	12	14	18	6.5	14.5	15.5	18.5	19
WRSA307	910.0	0	9	10.5	12.5	16.5	0	14	15	17.5	17.5
WRSA309	914.0	0	8	9	11.5	15	0	11.5	12.5	15	16
- continued -											

Appendix Table A4. Continued

Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WRSA311	907.0	8.5	11.5	13.5	16	22.5	8.5	15.5	16.5	19	20
WRSA312	905.0	9.5	13	15	18	27	9.5	15.5	16.5	19	24
WRSA314	912.5	0	5.5	7.5	10	13	0	11.5	13	15	16
WRSA315	910.5	0	0	9	11.5	14.5	6.5	12	13	15.5	16
WRSA316	910.5	6.5	10.5	12	14.5	18.5	6.5	12	13	15.5	16.5
WRSA317A	908.0	8	11.5	13	15.5	20	8	15.5	16.5	19	20
WRSA317B	906.0	7	10	12	14	19.5	7.5	15	15.5	18.5	19
WRSA350	910.0	6.5	10.5	12	14	18	6.5	14.5	16	18.5	19
WRSA351	908.0	8	11.5	13	15	20	8	15	16.5	19	19.5
WRSA352	910.5	0	10.5	12	14	18	0	14.5	16	18.5	19
WRSA353	917.0	0	0	5	8	11	0	9	10	12.5	13
WRSA354	918.0	0	7	8	10	14	0	9	10	12.5	15
WRSA355	914.5	7.5	10	11.5	14.5	19.5	7.5	12	13.5	16	19.5
WRSA356	917.5	6.5	9	10	13	17.5	6.5	10	12	14.5	17.5
WRSA357	919.0	5.5	8	9	11.5	15.5	5.5	9	10.5	13	16
WRSA358	921.0	0	6.5	7.5	9.5	13	0	7.5	8.5	10.5	13.5
WRSA361	907.0	8.5	11.5	13.5	16	22.5	8.5	15	16.5	19	20
WRSA363	911.0	0	10.5	11.5	13.5	17.5	0	14.5	15.5	18	18.5
WRSA364	912.0	0	10	11.5	13.5	17	0	14	15	17.5	18
WRSA373	927.5	0	0	0	0	0	0	0	0	0	0
WRSA378	926.0	0	0	0	0	8	0	0	0	0	8.5
WRSA383	923.5	0	0	0	0	0	0	0	0	0	0
WRSA384	925.0	0	0	0	0	9	0	0	0	0	9
WRSA389	921.5	0	0	6	8	11	0	0	7.5	9.5	11.5
WRSA390	913.0	7.5	10.5	12	15	20.5	7.5	12	13.5	16	20
WRSA907	913.0	6	9	10.5	12.5	17	6	12	13.5	16	17
Drain371	922.0	0	0	0	0	6	0	0	0	7.5	8.5
Drain372	921.5	0	0	0	0	6	0	0	0	8	9
Drain373	919.0	0	5	6.5	8.5	11.5	0	7.5	9	11	12.5
Drain374	915.0	6.5	9	10.5	13	17.5	6	11.5	12.5	15	17
RR1	922.0	0	5.5	7.5	8	12	0	7.5	9.5	10.5	13
RR10	920.0	0	4.5	6.5	7.5	11.5	0	8	9.5	11.5	13
RR11	919.0	0	0	6.5	7.5	11	0	8.5	10	12	13
RR12	918.5	0	5	7	8	11.5	0	9	10.5	12.5	13.5
RR13	919.0	0	0	6.5	7	11	0	8.5	10	11.5	13
RR14	919.0	0	0	6.5	7	11	0	8.5	10	11.5	13
RR15	921.0	0	0	0	5.5	10	0	6	8.5	9.5	11.5
- continued -											

Appendix Table A4. Continued

Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
RR16	918.5	0	0	6.5	7	11	0	8.5	10	12	13
RR17	922.0	0	0	0	0	8.5	0	0	6.5	8.5	10.5
RR18	921.5	0	0	0	0	8	0	0	7	8.5	10.5
RR19	918.5	0	0	6	7	11	0	8.5	10	12	13
RR2	928.5	0	0	0	0	8	0	0	0	4.5	8
RR20	918.0	0	0	5.5	6.5	10.5	0	9	10	12	12.5
RR21	915.0	0	5.5	7.5	8.5	12	0	11	12	14.5	14.5
RR22	917.5	0	0	5	6.5	10.5	0	9	10.5	12.5	13
RR23	914.0	0	6	8.5	9.5	13	0	11.5	12.5	15	15.5
RR24	912.5	0	7.5	9.5	10.5	14.5	0	12.5	14	16.5	16.5
RR25	912.5	0	7	9.5	10.5	14.5	0	12.5	13.5	16.5	16
RR26	914.0	0	6	8	9	13	0	11.5	12.5	15	15
RR27	913.0	0	6.5	9	10	13.5	0	12	13.5	16	15.5
RR28	913.0	0	6.5	9	10	13.5	0	12	13.5	16	15.5
RR29	913.0	0	6.5	8.5	9.5	13	0	12	13	16	15.5
RR3	921.0	0	5	7	8	11.5	0	8	9.5	11	13
RR30	911.0	0	8	10	11	15.5	0	13.5	14.5	17	16.5
RR31	910.0	0	8.5	10.5	11.5	16	5.5	14	14.5	17.5	17
RR32	908.5	6	9.5	11	12.5	17.5	6.5	14.5	15	18	18
RR33	907.5	7	10	11.5	13.5	19	7	15	15.5	18.5	19
RR34	905.5	8.5	11	13	15	22.5	8.5	15.5	16	19	21.5
RR35	908.0	6.5	9.5	11	13	18	6.5	14.5	15	18	18
RR36	904.5	8.5	11.5	13.5	16	24	8.5	15.5	16	19	23
RR37	906.0	7.5	10.5	12.5	14.5	20.5	7.5	15.5	15.5	18.5	20
RR38	905.0	8	11	12.5	15	21	8	15.5	15.5	18.5	20
RR39	908.0	5.5	9	11	12.5	16.5	5.5	14.5	15	18	17.5
RR4	923.0	0	0	6	6.5	10.5	0	5.5	8	9	11.5
RR5	920.0	0	5.5	7.5	8	12	0	8.5	10	11.5	13.5
RR6	926.0	0	0	0	0	8.5	0	0	0	5	9
RR7	920.0	0	5	7	8	11.5	0	8	10	11.5	13
RR8	924.0	0	0	0	5	9.5	0	0	6	7.5	10.5
RR9	919.0	0	5	7	8	12	0	9	10.5	12	13.5
WolvC1	921.0	4.5	4	4.5	7	7.5	4.5	4	7.5	10	10.5
WolvC10	917.0	0	0	0	0	0	0	9	10.5	12.5	12.5
WolvC11	914.0	0	0	0	7	9	0	11	12	14.5	14
WolvC12	911.0	0	6.5	8.5	10	13	0	13	14	16.5	15.5
WolvC13	912.5	0	0	7	8.5	11.5	0	12	13	15.5	15
- continued -											

Appendix Table A4. Continued											
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area									
		Existing Conditions					With Diversion Staging Area				
		10-yr	25-yr	50-yr	100-yr	500-yr	10-yr	25-yr	50-yr	100-yr	500-yr
WolvC14	908.0	6	9	11	12.5	16.5	6	14.5	15	18	17.5
WolvC15	908.0	5.5	9	10.5	12.5	16.5	5.5	14.5	15	18	17.5
WolvC2	922.0	0	0	0	6	7	0	0	3.5	8.5	9.5
WolvC3	922.0	0	0	0	0	6.5	0	0	0	8.5	9.5
WolvC4	921.5	0	0	0	0	6.5	0	0	0	9	10
WolvC5	917.5	0	0	0	0	6.5	0	9	10	12	12.5
WolvC6	920.5	0	0	0	0	0	0	0	8	10	10.5
WolvC7	921.0	0	0	0	0	0	0	0	7	9.5	10.5
WolvC8	921.0	0	0	0	0	0	0	0	6.5	9.5	11.5
WolvC9	919.5	0	0	0	0	0	0	6.5	9	11	16.5
WRRND1	917.0	6	8.5	9.5	12	16.5	5.5	10	11.5	14	19.5
WRRND10	911.0	8	10.5	12.5	15	20.5	7.5	12.5	13.5	16	22
WRRND11	908.5	9	12	14	17	24	9	13	14.5	17	21
WRRND12	908.0	8.5	12	13.5	16.5	23.5	8.5	13	14.5	17	18.5
WRRND13	909.0	8	11	12.5	15	20.5	8	12.5	13.5	16	18.5
WRRND14	909.0	8	10.5	12.5	15	20	7.5	12	13.5	16	21.5
WRRND15	906.0	9	12	14	17	25	9	14.5	15	17.5	16
WRRND2	917.5	5.5	8	9	11.5	15.5	5	9.5	11	13.5	16
WRRND3	917.0	5.5	8	9	11.5	15.5	5.5	10	11	14	16
WRRND4	916.5	5.5	8	9	11.5	15.5	5.5	10	11.5	14	16
WRRND5	916.0	5.5	8	9.5	11.5	16	5.5	10.5	12	14.5	17
WRRND6	914.5	6.5	9	10.5	13	17.5	6.5	11.5	13	15.5	18.5
WRRND7	912.5	7.5	10	11.5	14.5	19.5	7	12	13.5	16	18
WRRND8	912.5	7	10	11.5	14	19	7	12	13.5	16	18.5
WRRND9	912.0	7.5	10	11.5	14	19.5	7	12	13.5	16	11
CHRSA18	922.0	0	0	0	5.5	9.5	0	0	7.5	9	11.5
CHRSA19	921.0	0	0	5	6	10	0	6.5	8.5	10	11.5
CHRSA20	921.0	0	5.5	7.5	8	12	0	8	10	11	13.5
CHRSA23	922.0	0	5	7	9.5	12.5	0	7	9	11	13.5
^a Feet above mean seal level. Lowest estimated elevation for storage area.											
Source: Houston-Moore Group (2016).											

Appendix Table A5. Acreage of Storage Areas That Do Not Flood in Either the With or Without Diversion Conditions, by Storage Area, by Flood Event Frequency (Hydrology Group One)

Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
CHRSA01	915.0	307				
CHRSA02	914.5	305				
CHRSA03	919.5	304				
CHRSA04	918.0	284				
CHRSA05	921.0	320	320			
CHRSA06	921.5	117	117			
CHRSA07	913.0	151				
CHRSA08	918.5	161				
CHRSA09	922.5	301	301	301		
CHRSA10	920.5	326	326			
CHRSA11	924.5	305	305	305	305	
CHRSA12	924.5	327	327	327	327	
CHRSA13	915.0	629				
CHRSA14	924.0	317	317	317	317	
CHRSA15	919.0	324				
CHRSA16	917.0	629				
CHRSA17	919.5	839				
WLUSA27	911.0	430				
WLUSA28	913.0	290				
WLUSA29	913.0	935				
WLUSA30	915.5	629				
WLUSA31	919.0	1,266				
WLUSA32	919.5	1,270				
WLUSA33	915.0	631				
WLUSA34	913.0	326				
WLUSA34a	915.0	627				
WLUSA35	905.0					
WLUSA36	909.0					
WLUSA37	910.0					
WLUSA38	912.0					
WLUSA39	918.5	469				
WLUSA40	918.5	633				
WLUSA41	921.0	1,466	1,466	1,466		
WLUSA42	921.0	631	631	631		
WLUSA42a	922.0	644	644	644		
WLUSA43	921.0	635	635			
- continued -						

Appendix Table A5. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WLVSA44	922.0	179	179	179		
WLVSA45	913.0					
WLVSA46	913.0	630				
WLVSA47	913.0	625				
WLVSA48	920.0	308	308			
WLVSA49	920.0	328	328			
WLVSA50	922.0	630	630	630		
WLVSA51	923.5	634	634	634	634	
WLVSA51a	923.0	642	642	642	642	
WLVSA53	922.0	638	638			
WLVSA54	921.5	334	334			
WLVSA55	921.0	302	302			
WLVSA56	915.0	629				
WLVSA57	921.0	210	210			
WLVSA58	921.0	173	173			
WLVSA59	922.0	227	227			
WLVSA63	922.0	228	228			
WLVSA64	922.0	400	400			
WLVSA65	919.0	127				
WLVSA66	923.5	212	212			
WLVSA67	921.5					
WLVSA72	924.5	593	593	593		
WRSA284	923.0	597	597	597	597	597
WRSA289	922.0	629	629	629		
WRSA294	919.5	625				
WRSA299	911.0					
WRSA300	908.0					
WRSA302	912.0	404				
WRSA304	911.5					
WRSA305A	910.5					
WRSA305B	908.5					
WRSA305C	906.0					
WRSA305D	913.0					
WRSA306	910.0					
WRSA307	910.0	254				
WRSA309	914.0	636				
WRSA311	907.0					
- continued -						

Appendix Table A5. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WRSA312	905.0					
WRSA314	912.5	619				
WRSA315	910.5					
WRSA316	910.5					
WRSA317A	908.0					
WRSA317B	906.0					
WRSA350	910.0					
WRSA351	908.0					
WRSA352	910.5	297				
WRSA353	917.0	292				
WRSA354	918.0	295				
WRSA355	914.5					
WRSA356	917.5					
WRSA357	919.0					
WRSA358	921.0	492				
WRSA361	907.0					
WRSA363	911.0	268				
WRSA364	912.0	252				
WRSA373	927.5	632	632	632	632	632
WRSA378	926.0	156	156	156	156	
WRSA383	923.5	153	153	153	153	153
WRSA384	925.0	155	155	155	155	
WRSA389	921.5	151	151			
WRSA390	913.0					
WRSA907	913.0					
Drain371	922.0	160	160	160		
Drain372	921.5	319	319	319		
Drain373	919.0	332				
Drain374	915.0					
RR1	922.0	344				
RR10	920.0	164				
RR11	919.0	194				
RR12	918.5	123				
RR13	919.0	251				
RR14	919.0	361				
RR15	921.0	321				
RR16	918.5	319				
RR17	922.0	302	302			
- continued -						

Appendix Table A5. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
RR18	921.5	341	341			
RR19	918.5	342				
RR2	928.5	557	557	557		
RR20	918.0	250				
RR21	915.0	259				
RR22	917.5	215				
RR23	914.0	335				
RR24	912.5	171				
RR25	912.5	248				
RR26	914.0	176				
RR27	913.0	207				
RR28	913.0	310				
RR29	913.0	201				
RR3	921.0	362				
RR30	911.0	186				
RR31	910.0					
RR32	908.5					
RR33	907.5					
RR34	905.5					
RR35	908.0					
RR36	904.5					
RR37	906.0					
RR38	905.0					
RR39	908.0					
RR4	923.0	402				
RR5	920.0	125				
RR6	926.0	236	236	236		
RR7	920.0	141				
RR8	924.0	175	175			
RR9	919.0	89				
WolvC1	921.0					
WolvC10	917.0	156				
WolvC11	914.0	173				
WolvC12	911.0	88				
WolvC13	912.5	314				
WolvC14	908.0					
WolvC15	908.0					
WolvC2	922.0	269	269			
- continued -						

Appendix Table A5. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WolvC3	922.0	277	277	277		
WolvC4	921.5	356	356	356		
WolvC5	917.5	332				
WolvC6	920.5	173	173			
WolvC7	921.0	157	157			
WolvC8	921.0	124	124			
WolvC9	919.5	160				
WRRND1	917.0					
WRRND10	911.0					
WRRND11	908.5					
WRRND12	908.0					
WRRND13	909.0					
WRRND14	909.0					
WRRND15	906.0					
WRRND2	917.5					
WRRND3	917.0					
WRRND4	916.5					
WRRND5	916.0					
WRRND6	914.5					
WRRND7	912.5					
WRRND8	912.5					
WRRND9	912.0					
CHRSA18	922.0	1,110	1,110			
CHRSA19	921.0	807				
CHRSA20	921.0	631				
CHRSA23	922.0	635				
Totals		48,027	18,338	10,155	3,918	1,382
^a Feet above mean seal level. Lowest estimated elevation for storage area.						
Source: Houston-Moore Group (2016).						

Appendix Table A6. Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is the Same Duration With and Without Diversion Conditions, by Storage Area, by Flood Event Frequency (Hydrology Group Two)

Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
CHRSA01	915.0					
CHRSA02	914.5					
CHRSA03	919.5					
CHRSA04	918.0					
CHRSA05	921.0					
CHRSA06	921.5					
CHRSA07	913.0					
CHRSA08	918.5					
CHRSA09	922.5					301
CHRSA10	920.5					
CHRSA11	924.5					
CHRSA12	924.5					
CHRSA13	915.0					
CHRSA14	924.0					
CHRSA15	919.0					
CHRSA16	917.0					
CHRSA17	919.5					
WLUSA27	911.0					
WLUSA28	913.0					
WLUSA29	913.0					
WLUSA30	915.5					
WLUSA31	919.0					
WLUSA32	919.5					
WLUSA33	915.0					
WLUSA34	913.0					
WLUSA34a	915.0					
WLUSA35	905.0	409				
WLUSA36	909.0	374				
WLUSA37	910.0	249				
WLUSA38	912.0	222				
WLUSA39	918.5					
WLUSA40	918.5					
WLUSA41	921.0					
WLUSA42	921.0					
WLUSA42a	922.0					
WLUSA43	921.0					
- continued -						

Appendix Table A6. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WLVSA44	922.0					
WLVSA45	913.0	309				
WLVSA46	913.0					
WLVSA47	913.0					
WLVSA48	920.0					
WLVSA49	920.0					
WLVSA50	922.0					
WLVSA51	923.5					
WLVSA51a	923.0					
WLVSA53	922.0					
WLVSA54	921.5					
WLVSA55	921.0					
WLVSA56	915.0					
WLVSA57	921.0					
WLVSA58	921.0					
WLVSA59	922.0					
WLVSA63	922.0					
WLVSA64	922.0					
WLVSA65	919.0					
WLVSA66	923.5					
WLVSA67	921.5					
WLVSA72	924.5					
WRSA284	923.0					
WRSA289	922.0					
WRSA294	919.5					
WRSA299	911.0	627				
WRSA300	908.0	626				
WRSA302	912.0					
WRSA304	911.5					
WRSA305A	910.5					
WRSA305B	908.5	408				
WRSA305C	906.0	808				
WRSA305D	913.0	432				
WRSA306	910.0					
WRSA307	910.0					
WRSA309	914.0					
WRSA311	907.0	305				
- continued -						

Appendix Table A6. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WRS312	905.0	631				
WRS314	912.5					
WRS315	910.5					
WRS316	910.5					611
WRS317A	908.0	353				
WRS317B	906.0	230				
WRS350	910.0	274				
WRS351	908.0	309				
WRS352	910.5					
WRS353	917.0					
WRS354	918.0					
WRS355	914.5	415				415
WRS356	917.5					622
WRS357	919.0					
WRS358	921.0					
WRS361	907.0	192				
WRS363	911.0					
WRS364	912.0					
WRS373	927.5					
WRS378	926.0					
WRS383	923.5					
WRS384	925.0					155
WRS389	921.5					
WRS390	913.0	269				269
WRS907	913.0	394				394
Drain371	922.0					
Drain372	921.5					
Drain373	919.0					
Drain374	915.0					
RR1	922.0					
RR10	920.0					
RR11	919.0					
RR12	918.5					
RR13	919.0					
RR14	919.0					
RR15	921.0					
RR16	918.5					
RR17	922.0					
- continued -						

Appendix Table A6. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
RR18	921.5					
RR19	918.5					
RR2	928.5					557
RR20	918.0					
RR21	915.0					
RR22	917.5					
RR23	914.0					
RR24	912.5					
RR25	912.5					
RR26	914.0					
RR27	913.0					
RR28	913.0					
RR29	913.0					
RR3	921.0					
RR30	911.0					
RR31	910.0					
RR32	908.5					
RR33	907.5	63				63
RR34	905.5	176				
RR35	908.0	134				134
RR36	904.5	366				
RR37	906.0	235				
RR38	905.0	365				
RR39	908.0	195				
RR4	923.0					
RR5	920.0					
RR6	926.0					
RR7	920.0					
RR8	924.0					
RR9	919.0					
WolvC1	921.0	364	364			
WolvC10	917.0					
WolvC11	914.0					
WolvC12	911.0					
WolvC13	912.5					
WolvC14	908.0	208				
WolvC15	908.0	169				
WolvC2	922.0					
- continued -						

Appendix Table A6. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WolvC3	922.0					
WolvC4	921.5					
WolvC5	917.5					
WolvC6	920.5					
WolvC7	921.0					
WolvC8	921.0					
WolvC9	919.5					
WRRND1	917.0					355
WRRND10	911.0					
WRRND11	908.5	202			202	
WRRND12	908.0	16				
WRRND13	909.0	105				
WRRND14	909.0					
WRRND15	906.0	99				
WRRND2	917.5					
WRRND3	917.0	320				
WRRND4	916.5	197				
WRRND5	916.0	351				351
WRRND6	914.5	288				
WRRND7	912.5					
WRRND8	912.5	173				
WRRND9	912.0					
CHRSA18	922.0					
CHRSA19	921.0					
CHRSA20	921.0					
CHRSA23	922.0					
Totals		11,863	364	0	202	4,231
^a Feet above mean seal level. Lowest estimated elevation for storage area.						
Source: Houston-Moore Group (2016).						

Appendix Table A7. Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is Longer With the Diversion, by Storage Area, by Flood Event Frequency (Hydrology Group Three)

Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
CHRSA01	915.0					307
CHRSA02	914.5				305	305
CHRSA03	919.5					
CHRSA04	918.0					284
CHRSA05	921.0					320
CHRSA06	921.5					117
CHRSA07	913.0			151	151	151
CHRSA08	918.5				161	161
CHRSA09	922.5					301
CHRSA10	920.5					326
CHRSA11	924.5					
CHRSA12	924.5					327
CHRSA13	915.0		629	629	629	629
CHRSA14	924.0					317
CHRSA15	919.0			324	324	324
CHRSA16	917.0		629	629	629	629
CHRSA17	919.5		839	839	839	839
WLUSA27	911.0		430	430	430	430
WLUSA28	913.0			290	290	290
WLUSA29	913.0				935	935
WLUSA30	915.5					
WLUSA31	919.0					
WLUSA32	919.5					
WLUSA33	915.0					631
WLUSA34	913.0			326	326	326
WLUSA34a	915.0					627
WLUSA35	905.0		409	409	409	
WLUSA36	909.0		374	374	374	374
WLUSA37	910.0		249	249	249	249
WLUSA38	912.0		222	222	222	222
WLUSA39	918.5					
WLUSA40	918.5					
WLUSA41	921.0					
WLUSA42	921.0					
WLUSA42a	922.0					
WLUSA43	921.0					
- continued -						

Appendix Table A7. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WLVSA44	922.0					
WLVSA45	913.0		309	309	309	309
WLVSA46	913.0			630	630	630
WLVSA47	913.0		625	625	625	625
WLVSA48	920.0					308
WLVSA49	920.0					328
WLVSA50	922.0					630
WLVSA51	923.5					
WLVSA51a	923.0					
WLVSA53	922.0				638	638
WLVSA54	921.5					334
WLVSA55	921.0					302
WLVSA56	915.0		629	629	629	629
WLVSA57	921.0				210	210
WLVSA58	921.0				173	173
WLVSA59	922.0				227	227
WLVSA63	922.0				228	228
WLVSA64	922.0				400	400
WLVSA65	919.0			127	127	127
WLVSA66	923.5				212	212
WLVSA67	921.5				726	726
WLVSA72	924.5					593
WRSA284	923.0					
WRSA289	922.0					
WRSA294	919.5					625
WRSA299	911.0		627	627	627	
WRSA300	908.0		626	626	626	
WRSA302	912.0		404	404	404	404
WRSA304	911.5		635	635	635	
WRSA305A	910.5		225	225	225	
WRSA305B	908.5		408	408	408	
WRSA305C	906.0		808	808	808	
WRSA305D	913.0		432	432	432	
WRSA306	910.0	619	619	619	619	619
WRSA307	910.0		254	254	254	254
WRSA309	914.0		636	636	636	636
WRSA311	907.0		305	305	305	
- continued -						

Appendix Table A7. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WRSA312	905.0		631	631	631	
WRSA314	912.5		619	619	619	619
WRSA315	910.5			613	613	613
WRSA316	910.5	611	611	611	611	
WRSA317A	908.0		353	353	353	
WRSA317B	906.0		230	230	230	230
WRSA350	910.0		274	274	274	274
WRSA351	908.0		309	309	309	
WRSA352	910.5		297	297	297	297
WRSA353	917.0			292	292	292
WRSA354	918.0		295	295	295	295
WRSA355	914.5		415	415	415	
WRSA356	917.5			622	622	
WRSA357	919.0		614	614	614	614
WRSA358	921.0		492	492	492	492
WRSA361	907.0		192	192	192	
WRSA363	911.0		268	268	268	268
WRSA364	912.0		252	252	252	252
WRSA373	927.5					
WRSA378	926.0					156
WRSA383	923.5					
WRSA384	925.0					
WRSA389	921.5			151	151	151
WRSA390	913.0		269	269	269	
WRSA907	913.0		394	394	394	
Drain371	922.0					160
Drain372	921.5					319
Drain373	919.0		332	332	332	332
Drain374	915.0		241	241	241	
RR1	922.0		344	344	344	344
RR10	920.0		164	164	164	164
RR11	919.0			194	194	194
RR12	918.5		123	123	123	123
RR13	919.0			251	251	251
RR14	919.0			361	361	361
RR15	921.0				321	321
RR16	918.5			319	319	319
RR17	922.0					302
- continued -						

Appendix Table A7. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
RR18	921.5					341
RR19	918.5			342	342	342
RR2	928.5					
RR20	918.0			250	250	250
RR21	915.0		259	259	259	259
RR22	917.5			215	215	215
RR23	914.0		335	335	335	335
RR24	912.5		171	171	171	171
RR25	912.5		248	248	248	248
RR26	914.0		176	176	176	176
RR27	913.0		207	207	207	207
RR28	913.0		310	310	310	310
RR29	913.0		201	201	201	201
RR3	921.0		362	362	362	362
RR30	911.0		186	186	186	186
RR31	910.0		230	230	230	230
RR32	908.5	237	237	237	237	237
RR33	907.5		63	63	63	
RR34	905.5		176	176	176	
RR35	908.0		134	134	134	
RR36	904.5		366	366	366	
RR37	906.0		235	235	235	
RR38	905.0		365	365	365	
RR39	908.0		195	195	195	195
RR4	923.0			402	402	402
RR5	920.0		125	125	125	125
RR6	926.0					236
RR7	920.0		141	141	141	141
RR8	924.0				175	175
RR9	919.0		89	89	89	89
WolvC1	921.0			364	364	364
WolvC10	917.0					
WolvC11	914.0				173	173
WolvC12	911.0		88	88	88	88
WolvC13	912.5			314	314	314
WolvC14	908.0		208	208	208	208
WolvC15	908.0		169	169	169	169
WolvC2	922.0				269	269
- continued -						

Appendix Table A7. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WolvC3	922.0					277
WolvC4	921.5					356
WolvC5	917.5					332
WolvC6	920.5					0
WolvC7	921.0					
WolvC8	921.0					
WolvC9	919.5					
WRRND1	917.0		355	355	355	
WRRND10	911.0		76	76	76	
WRRND11	908.5		202	202		
WRRND12	908.0		16	16	16	
WRRND13	909.0		105	105	105	
WRRND14	909.0		213	213	213	
WRRND15	906.0		99	99	99	
WRRND2	917.5		146	146	146	146
WRRND3	917.0		320	320	320	320
WRRND4	916.5		197	197	197	197
WRRND5	916.0		351	351	351	
WRRND6	914.5		288	288	288	
WRRND7	912.5		214	214	214	
WRRND8	912.5		173	173	173	
WRRND9	912.0		117	117	117	
CHRSA18	922.0				1,110	1,110
CHRSA19	921.0			807	807	807
CHRSA20	921.0		631	631	631	631
CHRSA23	922.0		635	635	635	635
Totals		1,467	28,456	35,803	41,865	39,163
^a Feet above mean seal level. Lowest estimated elevation for storage area.						
Source: Houston-Moore Group (2016).						

Appendix Table A8. Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is Shorter With the Diversion, by Storage Area, by Flood Event Frequency (Hydrology Group Four)

Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
CHRSA01	915.0					
CHRSA02	914.5					
CHRSA03	919.5					
CHRSA04	918.0					
CHRSA05	921.0					
CHRSA06	921.5					
CHRSA07	913.0					
CHRSA08	918.5					
CHRSA09	922.5					
CHRSA10	920.5					
CHRSA11	924.5					
CHRSA12	924.5					
CHRSA13	915.0					
CHRSA14	924.0					
CHRSA15	919.0					
CHRSA16	917.0					
CHRSA17	919.5					
WLVSA27	911.0					
WLVSA28	913.0					
WLVSA29	913.0					
WLVSA30	915.5					
WLVSA31	919.0					
WLVSA32	919.5					
WLVSA33	915.0					
WLVSA34	913.0					
WLVSA34a	915.0					
WLVSA35	905.0					409
WLVSA36	909.0					
WLVSA37	910.0					
WLVSA38	912.0					
WLVSA39	918.5					
WLVSA40	918.5					
WLVSA41	921.0					
WLVSA42	921.0					
WLVSA42a	922.0					
WLVSA43	921.0					
- continued -						

Appendix Table A8. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WLVSA44	922.0					
WLVSA45	913.0					
WLVSA46	913.0					
WLVSA47	913.0					
WLVSA48	920.0					
WLVSA49	920.0					
WLVSA50	922.0					
WLVSA51	923.5					
WLVSA51a	923.0					
WLVSA53	922.0					
WLVSA54	921.5					
WLVSA55	921.0					
WLVSA56	915.0					
WLVSA57	921.0					
WLVSA58	921.0					
WLVSA59	922.0					
WLVSA63	922.0					
WLVSA64	922.0					
WLVSA65	919.0					
WLVSA66	923.5					
WLVSA67	921.5					
WLVSA72	924.5					
WRSA284	923.0					
WRSA289	922.0					
WRSA294	919.5					
WRSA299	911.0					627
WRSA300	908.0					626
WRSA302	912.0					
WRSA304	911.5	635				635
WRSA305A	910.5	225				225
WRSA305B	908.5					408
WRSA305C	906.0					808
WRSA305D	913.0					432
WRSA306	910.0					
WRSA307	910.0					
WRSA309	914.0					
WRSA311	907.0					305
- continued -						

Appendix Table A8. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WRSA312	905.0					631
WRSA314	912.5					
WRSA315	910.5					
WRSA316	910.5					
WRSA317A	908.0					353
WRSA317B	906.0					
WRSA350	910.0					
WRSA351	908.0					309
WRSA352	910.5					
WRSA353	917.0					
WRSA354	918.0					
WRSA355	914.5					
WRSA356	917.5					
WRSA357	919.0					
WRSA358	921.0					
WRSA361	907.0					192
WRSA363	911.0					
WRSA364	912.0					
WRSA373	927.5					
WRSA378	926.0					
WRSA383	923.5					
WRSA384	925.0					
WRSA389	921.5					
WRSA390	913.0					
WRSA907	913.0					
Drain371	922.0					
Drain372	921.5					
Drain373	919.0					
Drain374	915.0	241				241
RR1	922.0					
RR10	920.0					
RR11	919.0					
RR12	918.5					
RR13	919.0					
RR14	919.0					
RR15	921.0					
RR16	918.5					
RR17	922.0					
- continued -						

Appendix Table A8. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
RR18	921.5					
RR19	918.5					
RR2	928.5					
RR20	918.0					
RR21	915.0					
RR22	917.5					
RR23	914.0					
RR24	912.5					
RR25	912.5					
RR26	914.0					
RR27	913.0					
RR28	913.0					
RR29	913.0					
RR3	921.0					
RR30	911.0					
RR31	910.0					
RR32	908.5					
RR33	907.5					
RR34	905.5					176
RR35	908.0					
RR36	904.5					366
RR37	906.0					235
RR38	905.0					365
RR39	908.0					
RR4	923.0					
RR5	920.0					
RR6	926.0					
RR7	920.0					
RR8	924.0					
RR9	919.0					
WolvC1	921.0					
WolvC10	917.0					
WolvC11	914.0					
WolvC12	911.0					
WolvC13	912.5					
WolvC14	908.0					
WolvC15	908.0					
WolvC2	922.0					
- continued -						

Appendix Table A8. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WolvC3	922.0					
WolvC4	921.5					
WolvC5	917.5					
WolvC6	920.5					
WolvC7	921.0					
WolvC8	921.0					
WolvC9	919.5					
WRRND1	917.0	355				
WRRND10	911.0	76				76
WRRND11	908.5					202
WRRND12	908.0					16
WRRND13	909.0					105
WRRND14	909.0	213				213
WRRND15	906.0					99
WRRND2	917.5	146				
WRRND3	917.0					
WRRND4	916.5					
WRRND5	916.0					
WRRND6	914.5					288
WRRND7	912.5	214				214
WRRND8	912.5					173
WRRND9	912.0	117				117
CHRSA18	922.0					
CHRSA19	921.0					
CHRSA20	921.0					
CHRSA23	922.0					
Totals		2,221	0	0	0	8,845
^a Feet above mean seal level. Lowest estimated elevation for storage area. Source: Houston-Moore Group (2016).						

Appendix Table A9. Acreage of Storage Areas That Flood With the Diversion but Would Not Flood With Existing Conditions, by Storage Area, by Flood Event Frequency (Hydrology Group Five)

Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
CHRSA01	915.0		307	307	307	
CHRSA02	914.5		305	305		
CHRSA03	919.5		304	304	304	304
CHRSA04	918.0		284	284	284	
CHRSA05	921.0			320	320	
CHRSA06	921.5			117	117	
CHRSA07	913.0		151			
CHRSA08	918.5		161	161		
CHRSA09	922.5				301	
CHRSA10	920.5			326	326	
CHRSA11	924.5					
CHRSA12	924.5					
CHRSA13	915.0					
CHRSA14	924.0					
CHRSA15	919.0		324			
CHRSA16	917.0					
CHRSA17	919.5					
WLUSA27	911.0					
WLUSA28	913.0		290			
WLUSA29	913.0		935	935		
WLUSA30	915.5		629	629	629	629
WLUSA31	919.0		1,266	1,266	1,266	1,266
WLUSA32	919.5		1,270	1,270	1,270	1,270
WLUSA33	915.0		631	631	631	
WLUSA34	913.0		326			
WLUSA34a	915.0		627	627	627	
WLUSA35	905.0					
WLUSA36	909.0					
WLUSA37	910.0					
WLUSA38	912.0					
WLUSA39	918.5		469	469	469	469
WLUSA40	918.5		633	633	633	633
WLUSA41	921.0		1,466	1,466	1,466	1,466
WLUSA42	921.0				631	631
WLUSA42a	922.0				644	644
WLUSA43	921.0			635	635	635
- continued -						

Appendix Table A9. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WLVSA44	922.0				179	179
WLVSA45	913.0					
WLVSA46	913.0		630			
WLVSA47	913.0					
WLVSA48	920.0			308	308	
WLVSA49	920.0			328	328	
WLVSA50	922.0				630	
WLVSA51	923.5					634
WLVSA51a	923.0					642
WLVSA53	922.0			638		
WLVSA54	921.5			334	334	
WLVSA55	921.0			302	302	
WLVSA56	915.0					
WLVSA57	921.0			210		
WLVSA58	921.0			173		
WLVSA59	922.0			227		
WLVSA63	922.0			228		
WLVSA64	922.0			400		
WLVSA65	919.0		127			
WLVSA66	923.5			212		
WLVSA67	921.5					
WLVSA72	924.5				593	
WRS284	923.0					
WRS289	922.0				629	629
WRS294	919.5		625	625	625	
WRS299	911.0					
WRS300	908.0					
WRS302	912.0					
WRS304	911.5					
WRS305A	910.5					
WRS305B	908.5					
WRS305C	906.0					
WRS305D	913.0					
WRS306	910.0					
WRS307	910.0					
WRS309	914.0					
WRS311	907.0					
- continued -						

Appendix Table A9. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WRS312	905.0					
WRS314	912.5					
WRS315	910.5	613	613			
WRS316	910.5					
WRS317A	908.0					
WRS317B	906.0					
WRS350	910.0					
WRS351	908.0					
WRS352	910.5					
WRS353	917.0		292			
WRS354	918.0					
WRS355	914.5					
WRS356	917.5					
WRS357	919.0					
WRS358	921.0					
WRS361	907.0					
WRS363	911.0					
WRS364	912.0					
WRS373	927.5					
WRS378	926.0					
WRS383	923.5					
WRS384	925.0					
WRS389	921.5					
WRS390	913.0					
WRS907	913.0					
Drain371	922.0				160	
Drain372	921.5				319	
Drain373	919.0					
Drain374	915.0					
RR1	922.0					
RR10	920.0					
RR11	919.0		194			
RR12	918.5					
RR13	919.0		251			
RR14	919.0		361			
RR15	921.0		321	321		
RR16	918.5		319			
RR17	922.0			302	302	
- continued -						

Appendix Table A9. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
RR18	921.5			341	341	
RR19	918.5		342			
RR2	928.5				557	
RR20	918.0		250			
RR21	915.0					
RR22	917.5		215			
RR23	914.0					
RR24	912.5					
RR25	912.5					
RR26	914.0					
RR27	913.0					
RR28	913.0					
RR29	913.0					
RR3	921.0					
RR30	911.0					
RR31	910.0	230				
RR32	908.5					
RR33	907.5					
RR34	905.5					
RR35	908.0					
RR36	904.5					
RR37	906.0					
RR38	905.0					
RR39	908.0					
RR4	923.0		402			
RR5	920.0					
RR6	926.0				236	
RR7	920.0					
RR8	924.0			175		
RR9	919.0					
WolvC1	921.0					
WolvC10	917.0		156	156	156	156
WolvC11	914.0		173	173		
WolvC12	911.0					
WolvC13	912.5		314			
WolvC14	908.0					
WolvC15	908.0					
WolvC2	922.0			269		
- continued -						

Appendix Table A9. Continued						
Storage Area	Approx. Field Elevation ^a	Flood Event Size				
		10-yr	25-yr	50-yr	100-yr	500-yr
		----- acres -----				
WolvC3	922.0				277	
WolvC4	921.5				356	
WolvC5	917.5		332	332	332	
WolvC6	920.5			173	173	173
WolvC7	921.0			157	157	157
WolvC8	921.0			124	124	124
WolvC9	919.5		160	160	160	160
WRRND1	917.0					
WRRND10	911.0					
WRRND11	908.5					
WRRND12	908.0					
WRRND13	909.0					
WRRND14	909.0					
WRRND15	906.0					
WRRND2	917.5					
WRRND3	917.0					
WRRND4	916.5					
WRRND5	916.0					
WRRND6	914.5					
WRRND7	912.5					
WRRND8	912.5					
WRRND9	912.0					
CHRSA18	922.0			1,110		
CHRSA19	921.0		807			
CHRSA20	921.0					
CHRSA23	922.0					
Totals		843	17,264	18,464	18,437	10,801
^a Feet above mean seal level. Lowest estimated elevation for storage area. Source: Houston-Moore Group (2016).						

Appendix Table A10. Designation of Storage Areas in Common Hydrology Groups, by Size of Flood Event, FM Diversion Staging Area					
Storage Area	Flood Event Size				
	10-yr	25-yr	50-yr	100-yr	500-yr
	----- Group Number and Description of Common Hydrology -----				
CHRSA01	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
CHRSA02	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
CHRSA03	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
CHRSA04	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
CHRSA05	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
CHRSA06	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
CHRSA07	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
CHRSA08	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
CHRSA09	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer
CHRSA10	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
CHRSA11	1 No flooding	1 No flooding	1 No flooding	1 No flooding	2 Floods, same
CHRSA12	1 No flooding	1 No flooding	1 No flooding	1 No flooding	3 Floods, longer
CHRSA13	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
CHRSA14	1 No flooding	1 No flooding	1 No flooding	1 No flooding	3 Floods, longer
CHRSA15	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
CHRSA16	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
CHRSA17	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLVA27	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLVA28	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLVA29	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
WLVA30	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WLVA31	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WLVA32	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WLVA33	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
WLVA34	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
- continued -					

Appendix Table A10. Continued					
Storage Area	Flood Event Size				
	10-yr	25-yr	50-yr	100-yr	500-yr
	----- Group Number and Description of Common Hydrology -----				
WLUSA34a	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
WLUSA35	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
WLUSA36	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WLUSA37	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLUSA38	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLUSA39	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLUSA40	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WLUSA41	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WLUSA42	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WLUSA42a	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods
WLUSA43	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods
WLUSA44	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WLUSA45	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods
WLUSA46	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLUSA47	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLUSA48	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLUSA49	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
WLUSA50	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
WLUSA51	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer
WLUSA51a	1 No flooding	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods
WLUSA53	1 No flooding	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods
WLUSA54	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
WLUSA55	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
WLUSA56	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
WLUSA57	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
- continued -					

Appendix Table A10. Continued

Storage Area	Flood Event Size				
	10-yr	25-yr	50-yr	100-yr	500-yr
	----- Group Number and Description of Common Hydrology -----				
WLVS458	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
WLVS459	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
WLVS463	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
WLVS464	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
WLVS465	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
WLVS466	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
WLVS467	1 No flooding	1 No flooding	1 No flooding	3 Floods, longer	3 Floods, longer
WLVS472	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer
WRS4284	1 No flooding	1 No flooding	1 No flooding	1 No flooding	1 No flooding
WRS4289	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods
WRS4294	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
WRS4299	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4300	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4302	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS4304	4 Floods, shorter	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4305A	4 Floods, shorter	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4305B	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4305C	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4305D	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4306	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS4307	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS4309	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS4311	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4312	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4314	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS4315	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS4316	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer	2 Floods, same
WRS4317A	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS4317B	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS4350	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
- continued -					

Appendix Table A10. Continued

Storage Area	Flood Event Size				
	10-yr	25-yr	50-yr	100-yr	500-yr
	----- Group Number and Description of Common Hydrology -----				
WRS351	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS352	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS353	1 No flooding	5 No flood, Now floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS354	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS355	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	2 Floods, same
WRS356	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	2 Floods, same
WRS357	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS358	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS361	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS363	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS364	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS373	1 No flooding	1 No flooding	1 No flooding	1 No flooding	1 No flooding
WRS378	1 No flooding	1 No flooding	1 No flooding	1 No flooding	3 Floods, longer
WRS383	1 No flooding	1 No flooding	1 No flooding	1 No flooding	1 No flooding
WRS384	1 No flooding	1 No flooding	1 No flooding	1 No flooding	2 Floods, same
WRS389	1 No flooding	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRS390	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRS907	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	2 Floods, same
Drain371	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer
Drain372	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer
Drain373	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
Drain374	4 Floods, shorter	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
RR1	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR10	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR11	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR12	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR13	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR14	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR15	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
RR16	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR17	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
RR18	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
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Appendix Table A10. Continued

Storage Area	Flood Event Size				
	10-yr	25-yr	50-yr	100-yr	500-yr
	----- Group Number and Description of Common Hydrology -----				
RR19	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR2	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	2 Floods, same
RR20	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR21	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR22	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR23	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR24	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR25	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR26	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR27	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR28	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR29	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR3	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR30	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR31	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR32	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR33	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	2 Floods, same
RR34	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
RR35	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	2 Floods, same
RR36	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
RR37	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
RR38	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
RR39	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR4	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR5	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR6	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer
RR7	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
RR8	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
WolvC1	2 Floods, same	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer
WolvC10	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
RR9	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WolvC11	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
- continued -					

Appendix Table A10. Continued					
Storage Area	Flood Event Size				
	10-yr	25-yr	50-yr	100-yr	500-yr
	----- Group Number and Description of Common Hydrology -----				
WolvC12	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WolvC13	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
WolvC14	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WolvC15	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WolvC2	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
WolvC3	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer
WolvC4	1 No flooding	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer
WolvC5	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	3 Floods, longer
WolvC6	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WolvC7	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WolvC8	1 No flooding	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WolvC9	1 No flooding	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods	5 No Flood, Now Floods
WRRND1	4 Floods, shorter	3 Floods, longer	3 Floods, longer	3 Floods, longer	2 Floods, same
WRRND10	4 Floods, shorter	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRRND11	2 Floods, same	3 Floods, longer	3 Floods, longer	2 Floods, same	4 Floods, shorter
WRRND12	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRRND13	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRRND14	4 Floods, shorter	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRRND15	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRRND2	4 Floods, shorter	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRRND3	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRRND4	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
WRRND5	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	2 Floods, same
WRRND6	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRRND7	4 Floods, shorter	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRRND8	2 Floods, same	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
WRRND9	4 Floods, shorter	3 Floods, longer	3 Floods, longer	3 Floods, longer	4 Floods, shorter
CHRSA18	1 No flooding	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer
CHRSA19	1 No flooding	5 No Flood, Now Floods	3 Floods, longer	3 Floods, longer	3 Floods, longer
CHRSA20	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer
CHRSA23	1 No flooding	3 Floods, longer	3 Floods, longer	3 Floods, longer	3 Floods, longer

Appendix Table A11. Duration of Water Inundation, by Storage Area, 1997-Like Flood Event, With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area

		Days of Water above Storage Area Elevation	
Storage Area	Approx. Field Elevation ^a	Existing Conditions	With Diversion Staging Area
		1997-Like Event	1997-Like Event
CHRSA01	915.0	0	15.5
CHRSA02	914.5	0	16.5
CHRSA03	918.0	0	11
CHRSA04	918.0	0	12.5
CHRSA05	921.0	0	5.5
CHRSA06	921.5	0	4.5
CHRSA07	917.5	6	15
CHRSA08	918.5	0	13
CHRSA09	922.5	0	0
CHRSA10	920.5	0	8.5
CHRSA11	924.5	0	0
CHRSA12	924.5	0	0
CHRSA13	918.0	13.5	17.5
CHRSA14	924.0	0	0
CHRSA15	919.0	11	15.5
CHRSA16	917.0	15.5	19
CHRSA17	919.5	13.5	16.5
WLUSA27	910.0	14.5	22.5
WLUSA28	912.5	0	19.5
WLUSA29	913.0	0	18.5
WLUSA30	915.5	0	15
WLUSA31	917.0	0	13
WLUSA32	919.0	0	9
WLUSA33	915.0	0	15.5
WLUSA34	913.0	3.5	18.5
WLUSA34a	915.0	0	15.5
WLUSA35	905.0	23.5	25.5
WLUSA36	909.0	19	23.5
WLUSA37	910.0	16.5	22.5
WLUSA38	912.0	12.5	20.5
WLUSA39	918.5	0	10.5
WLUSA40	918.5	0	11
WLUSA41	919.0	0	9.5
WLUSA42	921.0	0	0
WLUSA42a	922.0	0	0
- continued -			

Appendix Table A11. Continued			
Storage Area	Approx. Field Elevation ^a	Days of Water above Storage Area Elevation	
		Existing Conditions	With Diversion Staging Area
		1997-Like Event	1997-Like Event
WLUSA43	921.0	0	0
WLUSA44	922.0	0	0
WLUSA45	913.0	7	18.5
WLUSA46	912.5	12	20
WLUSA47	913.0	16	21
WLUSA48	920.0	0	6
WLUSA49	920.0	0	5
WLUSA50	922.0	0	0
WLUSA51	923.5	0	0
WLUSA51a	923.0	0	0
WLUSA53	922.0	0	0.5
WLUSA54	921.5	0	0
WLUSA55	921.0	0	4.5
WLUSA56	915.0	13	18.5
WLUSA57	921.0	0	7.5
WLUSA58	921.0	0	7.5
WLUSA59	922.0	0	6.5
WLUSA63	922.0	0	8
WLUSA64	922.0	0	8
WLUSA65	919.0	11	15
WLUSA66	923.5	0	6
WLUSA67	924.0	0	0
WLUSA72	924.5	0	0
WRS284	923.0	0	0
WRS289	922.0	0	0
WRS294	919.5	0	6.5
WRS299	911.0	23.5	23.5
WRS300	909.5	27.5	26
WRS302	912.0	12.5	20
WRS304	911.5	22.5	22
WRS305A	910.5	24.5	24
WRS305B	909.0	29	27.5
WRS305C	908.5	30.5	28.5
WRS305D	910.0	26.5	25
WRS306	910.0	20	23.5
WRS307	910.0	18	23
- continued -			

Appendix Table A11. Continued			
Storage Area	Approx. Field Elevation ^a	Days of Water above Storage Area Elevation	
		Existing Conditions	With Diversion Staging Area
		1997-Like Event	1997-Like Event
WRS309	914.0	16.5	18.5
WRS311	907.0	27	26
WRS312	905.0	32.5	30
WRS314	912.5	8	19
WRS315	910.5	1.5	21
WRS316	910.0	20.5	23
WRS317A	907.5	25.5	25.5
WRS317B	906.5	21.5	24
WRS350	910.0	20	23.5
WRS351	908.0	24	25
WRS352	911.0	18.5	22
WRS353	917.0	0	12.5
WRS354	918.0	14.5	16
WRS355	917.5	19	20
WRS356	923.5	0	2
WRS357	922.5	6	9
WRS358	923.0	7.5	10
WRS361	907.0	27	26
WRS363	911.0	18	22.5
WRS364	912.0	18.5	21
WRS373	927.5	0	0
WRS378	926.0	0	0
WRS383	923.5	0	0
WRS384	925.0	0	0
WRS389	921.5	0	7
WRS390	916.0	20	20
WRS907	913.0	19.5	20
Drain371	922.0	0	0
Drain372	921.5	0	0
Drain373	919.0	8	12.5
Drain374	915.0	21	21.5
RR1	922.0	15.5	17
RR10	920.0	12	15.5
RR11	919.0	11	15.5
RR12	918.5	12.5	16
RR13	919.0	10	15
- continued -			

Appendix Table A11. Continued			
Storage Area	Approx. Field Elevation ^a	Days of Water above Storage Area Elevation	
		Existing Conditions	With Diversion Staging Area
		1997-Like Event	1997-Like Event
RR14	919.0	10	15
RR15	921.0	0.5	11.5
RR16	918.5	9.5	15
RR17	922.0	0	6
RR18	921.5	0	6
RR19	918.5	8.5	14.5
RR2	928.5	0	0
RR20	918.0	4	14
RR21	915.0	13	18.5
RR22	917.5	3	14.5
RR23	914.0	15	20
RR24	912.5	18	22.5
RR25	912.5	17.5	22
RR26	914.0	14.5	20
RR27	913.0	15.5	21
RR28	913.0	15.5	21
RR29	913.0	15	21
RR3	921.0	14.5	16.5
RR30	911.0	18.5	23
RR31	910.0	19.5	23
RR32	908.5	21	24
RR33	907.5	22.5	24.5
RR34	905.5	24.5	26
RR35	908.0	21	24
RR36	904.5	25.5	26.5
RR37	906.0	23.5	25.5
RR38	905.0	23.5	25.5
RR39	908.0	19.5	24
RR4	923.0	9.5	13.5
RR5	920.0	14.5	17
RR6	926.0	0	0
RR7	920.0	13	16
RR8	924.0	0	7
RR9	919.0	13.5	17
WolvC1	921.0	2	2.5
WolvC10	917.0	0	13
WolvC11	914.0	0	17
- continued -			

Appendix Table A11. Continued			
		Days of Water above Storage Area Elevation	
Storage Area	Approx. Field Elevation ^a	Existing Conditions	With Diversion Staging Area
		1997-Like Event	1997-Like Event
WolvC12	911.0	14.5	21.5
WolvC13	912.5	8	19.5
WolvC14	908.0	20	24
WolvC15	908.0	19.5	24
WolvC2	922.0	0	0
WolvC3	922.0	0	0
WolvC4	921.5	0	0
WolvC5	917.5	0	12.5
WolvC6	920.5	0	2.5
WolvC7	921.0	0	0
WolvC8	921.0	0	0
WolvC9	919.5	0	7.5
WRRND1	917.0	20	20.5
WRRND10	911.0	25	24.5
WRRND11	908.5	29.5	27.5
WRRND12	908.0	28.5	26.5
WRRND13	909.0	25	24
WRRND14	909.0	24.5	23.5
WRRND15	906.0	30	27.5
WRRND2	917.5	18.5	19.5
WRRND3	917.0	18.5	19.5
WRRND4	916.5	18.5	19.5
WRRND5	916.0	18.5	20
WRRND6	914.5	21	21.5
WRRND7	912.5	24	23.5
WRRND8	912.5	23	23
WRRND9	912.0	24	23
CHRSA18	922.0	0	10
CHRSA19	921.0	4	12
CHRSA20	921.0	15.5	17.5
CHRSA23	922.0	14	16

Appendix Table A12. Time from Activation of Staging Area to Inundation, by Storage Area, 1997-like Flood Event, With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area

Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated	
		Existing Conditions	With Diversion Staging Area
		1997	1997
CHRSA01	915.0	0	3.5
CHRSA02	914.5	0	3.5
CHRSA03	918.0	0	5.5
CHRSA04	918.0	0	5.5
CHRSA05	921.0	0	7
CHRSA06	921.5	0	6.5
CHRSA07	917.5	5.5	3.5
CHRSA08	918.5	0	4
CHRSA09	922.5	0	0
CHRSA10	920.5	0	5.5
CHRSA11	924.5	0	0
CHRSA12	924.5	0	0
CHRSA13	918.0	3.5	2.5
CHRSA14	924.0	0	0
CHRSA15	919.0	4.5	3
CHRSA16	917.0	3	2
CHRSA17	919.5	3.5	3
WLVSA27s	910.0	4	1.5
WLVSA28s	912.5	0	2.5
WLVSA29s	913.0	0	2.5
WLVSA30s	915.5	0	3.5
WLVSA31s	917.0	0	4.5
WLVSA32	919.0	0	6
WLVSA33	915.0	0	3.5
WLVSA34	913.0	6.5	2.5
WLVSA34a	915.0	0	3.5
WLVSA35	905.0	1.5	0.5
WLVSA36	909.0	3	1.5
WLVSA37	910.0	3	1.5
WLVSA38	912.0	3	2
WLVSA39	918.5	0	5
WLVSA40	918.5	0	5
WLVSA41	919.0	0	5.5
WLVSA42	921.0	0	0
WLVSA42a	922.0	0	0
WLVSA43	921.0	0	0
- continued -			

Appendix Table A12. Continued			
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated	
		Existing Conditions	With Diversion Staging Area
		1997	1997
WLVSA44	922.0	0	0
WLVSA45	913.0	3	2.5
WLVSA46	912.5	5.5	3
WLVSA47	913.0	3.5	2
WLVSA48	920.0	0	6.5
WLVSA49	920.0	0	7
WLVSA50	922.0	0	0
WLVSA51	923.5	0	0
WLVSA51a	923.0	0	0
WLVSA53	922.0	0	4.5
WLVSA54	921.5	0	0
WLVSA55	921.0	0	6.5
WLVSA56	915.0	4	2.5
WLVSA57	921.0	0	6
WLVSA58	921.0	0	6
WLVSA59	922.0	0	6
WLVSA63	922.0	0	5.5
WLVSA64	922.0	0	5.5
WLVSA65	919.0	4.5	3.5
WLVSA66	923.5	0	6
WLVSA67	924.0	0	0
WLVSA72	924.5	0	0
WRSA284	923.0	0	0
WRSA289	922.0	0	0
WRSA294	919.5	0	5.5
WRSA299	911.0	1	0.5
WRSA300	909.5	0	0
WRSA302	912.0	5	2.5
WRSA304	911.5	1.5	1
WRSA305A	910.5	0.5	0.5
WRSA305B	909.0	0	0
WRSA305C	908.5	0	0
WRSA305D	910.0	0	0
WRSA306	910.0	3	1.5
WRSA307	910.0	3.5	1.5
WRSA309	914.0	3	2.5
WRSA311	907.0	0	0
- continued -			

Appendix Table A12. Continued			
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated	
		Existing Conditions	With Diversion Staging Area
		1997	1997
WRSA312	905.0	0	0
WRSA314	912.5	4.5	2
WRSA315	910.5	8.5	0.5
WRSA316	910.0	2.5	0.5
WRSA317A	907.5	0.5	0.5
WRSA317B	906.5	2	1
WRSA350	910.0	3	1.5
WRSA351	908.0	1	0.5
WRSA352	911.0	3.5	2.5
WRSA353	917.0	0	4
WRSA354	918.0	3	3
WRSA355	917.5	1.5	1.5
WRSA356	923.5	0	6.5
WRSA357	922.5	4	4
WRSA358	923.0	4.5	4
WRSA361	907.0	0	0
WRSA363	911.0	3.5	2
WRSA364	912.0	3	3
WRSA373	927.5	0	0
WRSA378	926.0	0	0
WRSA383	923.5	0	0
WRSA384	925.0	0	0
WRSA389	921.5	0	6
WRSA390	916.0	1.5	1.5
WRSA907	913.0	2	2
Drain371	922.0	0	0
Drain372	921.5	0	0
Drain373	919.0	3.5	3.5
Drain374	915.0	1.5	1
RR1	922.0	2.5	2
RR10	920.0	4	3
RR11	919.0	4.5	3
RR12	918.5	4	3
RR13	919.0	4.5	3.5
RR14	919.0	4.5	3.5
RR15	921.0	6.5	4.5
RR16	918.5	5	3.5
RR17	922.0	0	6
- continued -			

Appendix Table A12. Continued			
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated	
		Existing Conditions	With Diversion Staging Area
		1997	1997
RR18	921.5	0	6
RR19	918.5	5	3.5
RR2	928.5	0	0
RR20	918.0	6	4
RR21	915.0	4	2.5
RR22	917.5	6	3.5
RR23	914.0	3.5	2
RR24	912.5	2.5	1.5
RR25	912.5	3	1.5
RR26	914.0	3.5	2
RR27	913.0	3.5	2
RR28	913.0	3.5	2
RR29	913.0	3.5	2
RR3	921.0	3	2.5
RR30	911.0	2.5	1.5
RR31	910.0	2.5	1.5
RR32	908.5	2	1
RR33	907.5	1.5	1
RR34	905.5	1	0.5
RR35	908.0	2	1
RR36	904.5	1	0.5
RR37	906.0	1.5	0.5
RR38	905.0	1.5	0.5
RR39	908.0	2.5	1
RR4	923.0	4.5	3.5
RR5	920.0	3	2.5
RR6	926.0	0	0
RR7	920.0	3.5	3
RR8	924.0	0	5.5
RR9	919.0	3.5	2.5
WolvC1	921.0	3.5	3.5
WolvC10	917.0	0	4
WolvC11	914.0	0	3
WolvC12	911.0	3.5	2
WolvC13	912.5	5.5	2.5
WolvC14	908.0	2.5	1
WolvC15	908.0	2.5	1
WolvC2	922.0	0	0
- continued -			

Appendix Table A12. Continued			
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area for Field to be Inundated	
		Existing Conditions	With Diversion Staging Area
		1997	1997
WolvC3	922.0	0	0
WolvC4	921.5	0	0
WolvC5	917.5	0	4
WolvC6	920.5	0	7.5
WolvC7	921.0	0	0
WolvC8	921.0	0	0
WolvC9	919.5	0	6
WRRND1	917.0	1.5	1
WRRND10	911.0	0.5	0
WRRND11	908.5	0	0
WRRND12	908.0	0	0
WRRND13	909.0	0.5	0
WRRND14	909.0	0.5	0
WRRND15	906.0	0	0
WRRND2	917.5	2	1.5
WRRND3	917.0	2	1.5
WRRND4	916.5	2	1.5
WRRND5	916.0	2	1.5
WRRND6	914.5	1.5	1
WRRND7	912.5	0.5	0.5
WRRND8	912.5	1	0.5
WRRND9	912.0	0.5	0.5
CHRSA18	922.0	0	5
CHRSA19	921.0	6	4.5
CHRSA20	921.0	2.5	2
CHRSA23	922.0	3	2.5
^a Feet above mean seal level. Lowest estimated elevation for storage area.			
Source: Houston-Moore Group (2016).			

Appendix Table A13. Time from Activation of Staging Area to When Flood Water Leaves, by Storage Area, 1997-Like Flood Event, With and Without Diversion Conditions, FM Diversion Staging Area, Phase 7.2 HEC-RAS Modeling With Inclusion of Surveyed Culverts in Staging Area

Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area	
		Existing Conditions	With Diversion Staging Area
		1997	1997
CHRSA01	915.0	0	19
CHRSA02	914.5	0	20
CHRSA03	918.0	0	16.5
CHRSA04	918.0	0	18
CHRSA05	921.0	0	12.5
CHRSA06	921.5	0	11
CHRSA07	917.5	11.5	18.5
CHRSA08	918.5	0	17
CHRSA09	922.5	0	0
CHRSA10	920.5	0	14
CHRSA11	924.5	0	0
CHRSA12	924.5	0	0
CHRSA13	918.0	17	20
CHRSA14	924.0	0	0
CHRSA15	919.0	15.5	18.5
CHRSA16	917.0	18.5	21
CHRSA17	919.5	17	19.5
WLUSA27	910.0	18.5	24
WLUSA28	912.5	0	22
WLUSA29	913.0	0	21
WLUSA30	915.5	0	18.5
WLUSA31	917.0	0	17.5
WLUSA32	919.0	0	15
WLUSA33	915.0	0	19
WLUSA34	913.0	10	21
WLUSA34a	915.0	0	19
WLUSA35	905.0	25	26
WLUSA36	909.0	22	25
WLUSA37	910.0	19.5	24
WLUSA38	912.0	15.5	22.5
WLUSA39	918.5	0	15.5
WLUSA40	918.5	0	16
WLUSA41	919.0	0	15
WLUSA42	921.0	0	0
WLUSA42a	922.0	0	0
- continued -			

Appendix Table A13. Continued			
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area	
		Existing Conditions	With Diversion Staging Area
		1997	1997
WLUSA43	921.0	0	0
WLUSA44	922.0	0	0
WLUSA45	913.0	10	21
WLUSA46	912.5	17.5	23
WLUSA47	913.0	19.5	23
WLUSA48	920.0	0	12.5
WLUSA49	920.0	0	12
WLUSA50	922.0	0	0
WLUSA51	923.5	0	0
WLUSA51a	923.0	0	0
WLUSA53	922.0	0	5
WLUSA54	921.5	0	0
WLUSA55	921.0	0	11
WLUSA56	915.0	17	21
WLUSA57	921.0	0	13.5
WLUSA58	921.0	0	13.5
WLUSA59	922.0	0	12.5
WLUSA63	922.0	0	13.5
WLUSA64	922.0	0	13.5
WLUSA65	919.0	15.5	18.5
WLUSA66	923.5	0	12
WLUSA67	924.0	0	0
WLUSA72	924.5	0	0
WUSA284	923.0	0	0
WUSA289	922.0	0	0
WUSA294	919.5	0	12
WUSA299	911.0	24.5	24
WUSA300	909.5	27.5	26
WUSA302	912.0	17.5	22.5
WUSA304	911.5	24	23
WUSA305A	910.5	25	24.5
WUSA305B	909.0	29	27.5
WUSA305C	908.5	30.5	28.5
WUSA305D	910.0	26.5	25
WUSA306	910.0	23	25
WUSA307	910.0	21.5	24.5
- continued -			

Appendix Table A13. Continued			
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area	
		Existing Conditions	With Diversion Staging Area
		1997	1997
WRS309	914.0	19.5	21
WRS311	907.0	27	26
WRS312	905.0	32.5	30
WRS314	912.5	12.5	21
WRS315	910.5	10	21.5
WRS316	910.0	23	23.5
WRS317A	907.5	26	26
WRS317B	906.5	23.5	25
WRS350	910.0	23	25
WRS351	908.0	25	25.5
WRS352	911.0	22	24.5
WRS353	917.0	0	16.5
WRS354	918.0	17.5	19
WRS355	917.5	20.5	21.5
WRS356	923.5	0	8.5
WRS357	922.5	10	13
WRS358	923.0	12	14
WRS361	907.0	27	26
WRS363	911.0	21.5	24.5
WRS364	912.0	21.5	24
WRS373	927.5	0	0
WRS378	926.0	0	0
WRS383	923.5	0	0
WRS384	925.0	0	0
WRS389	921.5	0	13
WRS390	916.0	21.5	21.5
WRS907	913.0	21.5	22
Drain371	922.0	0	0
Drain372	921.5	0	0
Drain373	919.0	11.5	16
Drain374	915.0	22.5	22.5
RR1	922.0	18	19
RR10	920.0	16	18.5
RR11	919.0	15.5	18.5
RR12	918.5	16.5	19
RR13	919.0	14.5	18.5
RR14	919.0	14.5	18.5
- continued -			

Appendix Table A13. Continued			
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area	
		Existing Conditions	With Diversion Staging Area
		1997	1997
RR15	921.0	7	16
RR16	918.5	14.5	18.5
RR17	922.0	0	12
RR18	921.5	0	12
RR19	918.5	13.5	18
RR2	928.5	0	0
RR20	918.0	10	18
RR21	915.0	17	21
RR22	917.5	9	18
RR23	914.0	18.5	22
RR24	912.5	20.5	24
RR25	912.5	20.5	23.5
RR26	914.0	18	22
RR27	913.0	19	23
RR28	913.0	19	23
RR29	913.0	18.5	23
RR3	921.0	17.5	19
RR30	911.0	21	24.5
RR31	910.0	22	24.5
RR32	908.5	23	25
RR33	907.5	24	25.5
RR34	905.5	25.5	26.5
RR35	908.0	23	25
RR36	904.5	26.5	27
RR37	906.0	25	26
RR38	905.0	25	26
RR39	908.0	22	25
RR4	923.0	14	17
RR5	920.0	17.5	19.5
RR6	926.0	0	0
RR7	920.0	16.5	19
RR8	924.0	0	12.5
RR9	919.0	17	19.5
WolvC1	921.0	5.5	6
WolvC10	917.0	0	17
WolvC11	914.0	0	20
WolvC12	911.0	18	23.5
- continued -			

Appendix Table A13. Continued			
Storage Area	Approx. Field Elevation ^a	Days from Activation of Staging Area Until Flood Water Leaves the Storage Area	
		Existing Conditions	With Diversion Staging Area
		1997	1997
WolvC13	912.5	13.5	22
WolvC14	908.0	22.5	25
WolvC15	908.0	22	25
WolvC2	922.0	0	0
WolvC3	922.0	0	0
WolvC4	921.5	0	0
WolvC5	917.5	0	16.5
WolvC6	920.5	0	10
WolvC7	921.0	0	0
WolvC8	921.0	0	0
WolvC9	919.5	0	13.5
WRRND1	917.0	21.5	21.5
WRRND10	911.0	25.5	24.5
WRRND11	908.5	29.5	27.5
WRRND12	908.0	28.5	26.5
WRRND13	909.0	25.5	24
WRRND14	909.0	25	23.5
WRRND15	906.0	30	27.5
WRRND2	917.5	20.5	21
WRRND3	917.0	20.5	21
WRRND4	916.5	20.5	21
WRRND5	916.0	20.5	21.5
WRRND6	914.5	22.5	22.5
WRRND7	912.5	24.5	24
WRRND8	912.5	24	23.5
WRRND9	912.0	24.5	23.5
CHRSA18	922.0	0	15
CHRSA19	921.0	10	16.5
CHRSA20	921.0	18	19.5
CHRSA23	922.0	17	18.5
^a Feet above mean seal level. Lowest estimated elevation for storage area.			
Source: Houston-Moore Group (2016).			

Appendix Table A14. Acreage of Storage Areas That Do Not Flood in Either the With or Without Diversion Conditions, by Storage Area, 1997-Like Flood Event (Hydrology Group One)

Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
CHRSA01	915.0	
CHRSA02	914.5	
CHRSA03	918.0	
CHRSA04	918.0	
CHRSA05	921.0	
CHRSA06	921.5	
CHRSA07	917.5	
CHRSA08	918.5	
CHRSA09	922.5	301
CHRSA10	920.5	
CHRSA11	924.5	305
CHRSA12	924.5	327
CHRSA13	918.0	
CHRSA14	924.0	317
CHRSA15	919.0	
CHRSA16	917.0	
CHRSA17	919.5	
WLVA27	910.0	
WLVA28	912.5	
WLVA29	913.0	
WLVA30	915.5	
WLVA31	917.0	
WLVA32	919.0	
WLVA33	915.0	
WLVA34	913.0	
WLVA34a	915.0	
WLVA35	905.0	
WLVA36	909.0	
WLVA37	910.0	
WLVA38	912.0	
WLVA39	918.5	
WLVA40	918.5	
WLVA41	919.0	
WLVA42	921.0	631
WLVA42a	922.0	644
WLVA43	921.0	635
- continued -		

Appendix Table A14. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WLVSA44	922.0	179
WLVSA45	913.0	
WLVSA46	912.5	
WLVSA47	913.0	
WLVSA48	920.0	
WLVSA49	920.0	
WLVSA50	922.0	630
WLVSA51	923.5	634
WLVSA51a	923.0	642
WLVSA53	922.0	
WLVSA54	921.5	334
WLVSA55	921.0	
WLVSA56	915.0	
WLVSA57	921.0	
WLVSA58	921.0	
WLVSA59	922.0	
WLVSA63	922.0	
WLVSA64	922.0	
WLVSA65	919.0	
WLVSA66	923.5	
WLVSA67	924.0	726
WLVSA72	924.5	593
WRSA284	923.0	597
WRSA289	922.0	629
WRSA294	919.5	
WRSA299	911.0	
WRSA300	909.5	
WRSA302	912.0	
WRSA304	911.5	
WRSA305A	910.5	
WRSA305B	909.0	
WRSA305C	908.5	
WRSA305D	910.0	
WRSA306	910.0	
WRSA307	910.0	
WRSA309	914.0	
WRSA311	907.0	
- continued -		

Appendix Table A14. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WRSA312	905.0	
WRSA314	912.5	
WRSA315	910.5	
WRSA316	910.0	
WRSA317A	907.5	
WRSA317B	906.5	
WRSA350	910.0	
WRSA351	908.0	
WRSA352	911.0	
WRSA353	917.0	
WRSA354	918.0	
WRSA355	917.5	
WRSA356	923.5	
WRSA357	922.5	
WRSA358	923.0	
WRSA361	907.0	
WRSA363	911.0	
WRSA364	912.0	
WRSA373	927.5	
WRSA378	926.0	
WRSA383	923.5	
WRSA384	925.0	
WRSA389	921.5	
WRSA390	916.0	
WRSA907	913.0	
Drain371	922.0	
Drain372	921.5	
Drain373	919.0	
Drain374	915.0	
RR1	922.0	
RR10	920.0	
RR11	919.0	
RR12	918.5	
RR13	919.0	
RR14	919.0	
RR15	921.0	
RR16	918.5	
RR17	922.0	
- continued -		

Appendix Table A14. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
RR18	921.5	
RR19	918.5	
RR2	928.5	557
RR20	918.0	
RR21	915.0	
RR22	917.5	
RR23	914.0	
RR24	912.5	
RR25	912.5	
RR26	914.0	
RR27	913.0	
RR28	913.0	
RR29	913.0	
RR3	921.0	
RR30	911.0	
RR31	910.0	
RR32	908.5	
RR33	907.5	
RR34	905.5	
RR35	908.0	
RR36	904.5	
RR37	906.0	
RR38	905.0	
RR39	908.0	
RR4	923.0	
RR5	920.0	
RR6	926.0	236
RR7	920.0	
RR8	924.0	
RR9	919.0	
WolvC1	921.0	
WolvC10	917.0	
WolvC11	914.0	
WolvC12	911.0	
WolvC13	912.5	
WolvC14	908.0	
WolvC15	908.0	
WolvC2	922.0	269
- continued -		

Appendix Table A14. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WolvC3	922.0	277
WolvC4	921.5	356
WolvC5	917.5	
WolvC6	920.5	
WolvC7	921.0	157
WolvC8	921.0	124
WolvC9	919.5	
WRRND1	917.0	
WRRND10	911.0	
WRRND11	908.5	
WRRND12	908.0	
WRRND13	909.0	
WRRND14	909.0	
WRRND15	906.0	
WRRND2	917.5	
WRRND3	917.0	
WRRND4	916.5	
WRRND5	916.0	
WRRND6	914.5	
WRRND7	912.5	
WRRND8	912.5	
WRRND9	912.0	
CHRSA18	922.0	
CHRSA19	921.0	
CHRSA20	921.0	
CHRSA23	922.0	
Total		11,675

Appendix Table A15. Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is the Same Duration With and Without Diversion Conditions, by Storage Area, 1997-Like Flood Event (Hydrology Group Two)		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
CHRSA01	915.0	
CHRSA02	914.5	
CHRSA03	918.0	
CHRSA04	918.0	
CHRSA05	921.0	
CHRSA06	921.5	
CHRSA07	917.5	
CHRSA08	918.5	
CHRSA09	922.5	
CHRSA10	920.5	
CHRSA11	924.5	
CHRSA12	924.5	
CHRSA13	918.0	
CHRSA14	924.0	
CHRSA15	919.0	
CHRSA16	917.0	
CHRSA17	919.5	
WLUSA27	910.0	
WLUSA28	912.5	
WLUSA29	913.0	
WLUSA30	915.5	
WLUSA31	917.0	
WLUSA32	919.0	
WLUSA33	915.0	
WLUSA34	913.0	
WLUSA34a	915.0	
WLUSA35	905.0	
WLUSA36	909.0	
WLUSA37	910.0	
WLUSA38	912.0	
WLUSA39	918.5	
WLUSA40	918.5	
WLUSA41	919.0	
WLUSA42	921.0	
WLUSA42a	922.0	
- continued -		

Appendix Table A15. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WLVSA43	921.0	
WLVSA44	922.0	
WLVSA45	913.0	
WLVSA46	912.5	
WLVSA47	913.0	
WLVSA48	920.0	
WLVSA49	920.0	
WLVSA50	922.0	
WLVSA51	923.5	
WLVSA51a	923.0	
WLVSA53	922.0	
WLVSA54	921.5	
WLVSA55	921.0	
WLVSA56	915.0	
WLVSA57	921.0	
WLVSA58	921.0	
WLVSA59	922.0	
WLVSA63	922.0	
WLVSA64	922.0	
WLVSA65	919.0	
WLVSA66	923.5	
WLVSA67	924.0	
WLVSA72	924.5	
WRSA284	923.0	
WRSA289	922.0	
WRSA294	919.5	
WRSA299	911.0	
WRSA300	909.5	
WRSA302	912.0	
WRSA304	911.5	
WRSA305A	910.5	
WRSA305B	909.0	
WRSA305C	908.5	
WRSA305D	910.0	
WRSA306	910.0	
WRSA307	910.0	
WRSA309	914.0	
- continued -		

Appendix Table A15. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WRS311	907.0	
WRS312	905.0	
WRS314	912.5	
WRS315	910.5	
WRS316	910.0	
WRS317A	907.5	353
WRS317B	906.5	
WRS350	910.0	
WRS351	908.0	
WRS352	911.0	
WRS353	917.0	
WRS354	918.0	
WRS355	917.5	
WRS356	923.5	
WRS357	922.5	
WRS358	923.0	
WRS361	907.0	
WRS363	911.0	
WRS364	912.0	
WRS373	927.5	
WRS378	926.0	
WRS383	923.5	
WRS384	925.0	
WRS389	921.5	
WRS390	916.0	269
WRS907	913.0	
Drain371	922.0	
Drain372	921.5	
Drain373	919.0	
Drain374	915.0	241
RR1	922.0	
RR10	920.0	
RR11	919.0	
RR12	918.5	
RR13	919.0	
RR14	919.0	
RR15	921.0	
- continued -		

Appendix Table A15. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
RR17	922.0	
RR18	921.5	
RR19	918.5	
RR2	928.5	
RR20	918.0	
RR21	915.0	
RR22	917.5	
RR23	914.0	
RR24	912.5	
RR25	912.5	
RR26	914.0	
RR27	913.0	
RR28	913.0	
RR29	913.0	
RR3	921.0	
RR30	911.0	
RR31	910.0	
RR32	908.5	
RR33	907.5	
RR34	905.5	
RR35	908.0	
RR36	904.5	
RR37	906.0	
RR38	905.0	
RR39	908.0	
RR4	923.0	
RR5	920.0	
RR6	926.0	
RR7	920.0	
RR8	924.0	
RR9	919.0	
WolvC1	921.0	
WolvC10	917.0	
WolvC11	914.0	
WolvC12	911.0	
WolvC13	912.5	
WolvC14	908.0	
WolvC15	908.0	
- continued -		

Appendix Table A15. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WolvC3	922.0	
WolvC4	921.5	
WolvC5	917.5	
WolvC6	920.5	
WolvC7	921.0	
WolvC8	921.0	
WolvC9	919.5	
WRRND1	917.0	355
WRRND10	911.0	
WRRND11	908.5	
WRRND12	908.0	
WRRND13	909.0	
WRRND14	909.0	
WRRND15	906.0	
WRRND2	917.5	
WRRND3	917.0	
WRRND4	916.5	
WRRND5	916.0	
WRRND6	914.5	288
WRRND7	912.5	
WRRND8	912.5	
WRRND9	912.0	
CHRSA18	922.0	
CHRSA19	921.0	
CHRSA20	921.0	
CHRSA23	922.0	
Total		1,506
^a Feet above mean seal level. Lowest estimated elevation for storage area.		
Source: Houston-Moore Group (2016).		

Appendix Table A16. Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is Longer With the Diversion, by Storage Area, 1997-Like Flood Event (Hydrology Group Three)

Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
CHRSA01	915.0	
CHRSA02	914.5	
CHRSA03	918.0	
CHRSA04	918.0	
CHRSA05	921.0	
CHRSA06	921.5	
CHRSA07	917.5	151
CHRSA08	918.5	
CHRSA09	922.5	
CHRSA10	920.5	
CHRSA11	924.5	
CHRSA12	924.5	
CHRSA13	918.0	629
CHRSA14	924.0	
CHRSA15	919.0	324
CHRSA16	917.0	629
CHRSA17	919.5	839
WLVSA27	910.0	430
WLVSA28	912.5	
WLVSA29	913.0	
WLVSA30	915.5	
WLVSA31	917.0	
WLVSA32	919.0	
WLVSA33	915.0	
WLVSA34	913.0	326
WLVSA34a	915.0	
WLVSA35	905.0	409
WLVSA36	909.0	374
WLVSA37	910.0	249
WLVSA38	912.0	222
WLVSA39	918.5	
WLVSA40	918.5	
WLVSA41	919.0	
WLVSA42	921.0	
WLVSA42a	922.0	
WLVSA43	921.0	
- continued -		

Appendix Table A16. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WLVSA44	922.0	
WLVSA45	913.0	309
WLVSA46	912.5	630
WLVSA47	913.0	625
WLVSA48	920.0	
WLVSA49	920.0	
WLVSA50	922.0	
WLVSA51	923.5	
WLVSA51a	923.0	
WLVSA53	922.0	
WLVSA54	921.5	
WLVSA55	921.0	
WLVSA56	915.0	629
WLVSA57	921.0	
WLVSA58	921.0	
WLVSA59	922.0	
WLVSA63	922.0	
WLVSA64	922.0	
WLVSA65	919.0	127
WLVSA66	923.5	
WLVSA67	924.0	
WLVSA72	924.5	
WRS284	923.0	
WRS289	922.0	
WRS294	919.5	
WRS299	911.0	
WRS300	909.5	
WRS302	912.0	404
WRS304	911.5	
WRS305A	910.5	
WRS305B	909.0	
WRS305C	908.5	
WRS305D	910.0	
WRS306	910.0	619
WRS307	910.0	254
WRS309	914.0	636
WRS311	907.0	
- continued -		

Appendix Table A16. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WRSA312	905.0	
WRSA314	912.5	619
WRSA315	910.5	613
WRSA316	910.0	611
WRSA317A	907.5	
WRSA317B	906.5	230
WRSA350	910.0	274
WRSA351	908.0	309
WRSA352	911.0	297
WRSA353	917.0	
WRSA354	918.0	295
WRSA355	917.5	415
WRSA356	923.5	
WRSA357	922.5	614
WRSA358	923.0	492
WRSA361	907.0	
WRSA363	911.0	268
WRSA364	912.0	252
WRSA373	927.5	
WRSA378	926.0	
WRSA383	923.5	
WRSA384	925.0	
WRSA389	921.5	
WRSA390	916.0	
WRSA907	913.0	394
Drain371	922.0	
Drain372	921.5	
Drain373	919.0	332
Drain374	915.0	
RR1	922.0	344
RR10	920.0	164
RR11	919.0	194
RR12	918.5	123
RR13	919.0	251
RR14	919.0	361
RR15	921.0	321
RR16	918.5	319
RR17	922.0	
- continued -		

Appendix Table A16. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
RR19	918.5	342
RR2	928.5	
RR20	918.0	250
RR21	915.0	259
RR22	917.5	215
RR23	914.0	335
RR24	912.5	171
RR25	912.5	248
RR26	914.0	176
RR27	913.0	207
RR28	913.0	310
RR29	913.0	201
RR3	921.0	362
RR30	911.0	186
RR31	910.0	230
RR32	908.5	237
RR33	907.5	63
RR34	905.5	176
RR35	908.0	134
RR36	904.5	366
RR37	906.0	235
RR38	905.0	365
RR39	908.0	195
RR4	923.0	402
RR5	920.0	125
RR6	926.0	
RR7	920.0	141
RR8	924.0	
RR9	919.0	89
WolvC1	921.0	364
WolvC10	917.0	
WolvC11	914.0	
WolvC12	911.0	88
WolvC13	912.5	314
WolvC14	908.0	208
WolvC15	908.0	169
WolvC2	922.0	
WolvC3	922.0	
- continued -		

Appendix Table A16. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WolvC5	917.5	
WolvC6	920.5	
WolvC7	921.0	
WolvC8	921.0	
WolvC9	919.5	
WRRND1	917.0	
WRRND10	911.0	
WRRND11	908.5	
WRRND12	908.0	
WRRND13	909.0	
WRRND14	909.0	
WRRND15	906.0	
WRRND2	917.5	146
WRRND3	917.0	320
WRRND4	916.5	197
WRRND5	916.0	351
WRRND6	914.5	
WRRND7	912.5	
WRRND8	912.5	
WRRND9	912.0	
CHRSA18	922.0	
CHRSA19	921.0	807
CHRSA20	921.0	631
CHRSA23	922.0	635
Total		28,243
^a Feet above mean seal level. Lowest estimated elevation for storage area. Source: Houston-Moore Group (2016).		

Appendix Table A17. Acreage of Storage Areas That Flood With and Without Diversion, but Inundation is Shorter With the Diversion, by Storage Area, 1997-Like Flood Event (Hydrology Group Four)

Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
CHRSA01	915.0	
CHRSA02	914.5	
CHRSA03	918.0	
CHRSA04	918.0	
CHRSA05	921.0	
CHRSA06	921.5	
CHRSA07	917.5	
CHRSA08	918.5	
CHRSA09	922.5	
CHRSA10	920.5	
CHRSA11	924.5	
CHRSA12	924.5	
CHRSA13	918.0	
CHRSA14	924.0	
CHRSA15	919.0	
CHRSA16	917.0	
CHRSA17	919.5	
WLVA27	910.0	
WLVA28	912.5	
WLVA29	913.0	
WLVA30	915.5	
WLVA31	917.0	
WLVA32	919.0	
WLVA33	915.0	
WLVA34	913.0	
WLVA34a	915.0	
WLVA35	905.0	
WLVA36	909.0	
WLVA37	910.0	
WLVA38	912.0	
WLVA39	918.5	
WLVA40	918.5	
WLVA41	919.0	
WLVA42	921.0	
WLVA42a	922.0	
WLVA43	921.0	
- continued -		

Appendix Table A17. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WLUSA44	913.0	
WLUSA45	912.5	
WLUSA46	913.0	
WLUSA47	920.0	
WLUSA48	920.0	
WLUSA49	922.0	
WLUSA50	923.5	
WLUSA51	923.0	
WLUSA51a	922.0	
WLUSA53	921.5	
WLUSA54	921.0	
WLUSA55	915.0	
WLUSA56	921.0	
WLUSA57	921.0	
WLUSA58	922.0	
WLUSA59	922.0	
WLUSA63	922.0	
WLUSA64	919.0	
WLUSA65	923.5	
WLUSA66	924.0	
WLUSA67	924.5	
WLUSA72	923.0	
WRSA284	922.0	
WRSA289	919.5	
WRSA294	911.0	
WRSA299	909.5	627
WRSA300	912.0	626
WRSA302	911.5	
WRSA304	910.5	635
WRSA305A	909.0	225
WRSA305B	908.5	408
WRSA305C	910.0	808
WRSA305D	910.0	432
WRSA306	910.0	
WRSA307	914.0	
WRSA309	907.0	
WRSA311	907.0	305
- continued -		

Appendix Table A17. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WRS312	905.0	631
WRS314	912.5	
WRS315	910.5	
WRS316	910.0	
WRS317A	907.5	
WRS317B	906.5	
WRS350	910.0	
WRS351	908.0	
WRS352	911.0	
WRS353	917.0	
WRS354	918.0	
WRS355	917.5	
WRS356	923.5	
WRS357	922.5	
WRS358	923.0	
WRS361	907.0	192
WRS363	911.0	
WRS364	912.0	
WRS373	927.5	
WRS378	926.0	
WRS383	923.5	
WRS384	925.0	
WRS389	921.5	
WRS390	916.0	
WRS907	913.0	
Drain371	922.0	
Drain372	921.5	
Drain373	919.0	
Drain374	915.0	
RR1	922.0	
RR10	920.0	
RR11	919.0	
RR12	918.5	
RR13	919.0	
RR14	919.0	
RR15	921.0	
RR16	918.5	
RR17	922.0	
- continued -		

Appendix Table A17. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
RR19	918.5	
RR2	928.5	
RR20	918.0	
RR21	915.0	
RR22	917.5	
RR23	914.0	
RR24	912.5	
RR25	912.5	
RR26	914.0	
RR27	913.0	
RR28	913.0	
RR29	913.0	
RR3	921.0	
RR30	911.0	
RR31	910.0	
RR32	908.5	
RR33	907.5	
RR34	905.5	
RR35	908.0	
RR36	904.5	
RR37	906.0	
RR38	905.0	
RR39	908.0	
RR4	923.0	
RR5	920.0	
RR6	926.0	
RR7	920.0	
RR8	924.0	
RR9	919.0	
WolvC1	921.0	
WolvC10	917.0	
WolvC11	914.0	
WolvC12	911.0	
WolvC13	912.5	
WolvC14	908.0	
WolvC15	908.0	
WolvC2	922.0	
WolvC3	922.0	
- continued -		

Appendix Table A17. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WolvC5	917.5	
WolvC6	920.5	
WolvC7	921.0	
WolvC8	921.0	
WolvC9	919.5	
WRRND1	917.0	
WRRND10	911.0	76
WRRND11	908.5	202
WRRND12	908.0	16
WRRND13	909.0	105
WRRND14	909.0	213
WRRND15	906.0	99
WRRND2	917.5	
WRRND3	917.0	
WRRND4	916.5	
WRRND5	916.0	
WRRND6	914.5	
WRRND7	912.5	214
WRRND8	912.5	173
WRRND9	912.0	117
CHRSA18	922.0	
CHRSA19	921.0	
CHRSA20	921.0	
CHRSA23	922.0	
Total		6,104
^a Feet above mean seal level. Lowest estimated elevation for storage area. Source: Houston-Moore Group (2016).		

Appendix Table A18. Acreage of Storage Areas That Flood With the Diversion but Would Not Flood With Existing Conditions, by Storage Area, 1997-Like Flood Event (Hydrology Group Five)

Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
CHRSA01	915.0	307
CHRSA02	914.5	305
CHRSA03	918.0	304
CHRSA04	918.0	284
CHRSA05	921.0	320
CHRSA06	921.5	117
CHRSA07	917.5	
CHRSA08	918.5	161
CHRSA09	922.5	
CHRSA10	920.5	326
CHRSA11	924.5	
CHRSA12	924.5	
CHRSA13	918.0	
CHRSA14	924.0	
CHRSA15	919.0	
CHRSA16	917.0	
CHRSA17	919.5	
WLVSA27	910.0	
WLVSA28	912.5	290
WLVSA29	913.0	935
WLVSA30	915.5	629
WLVSA31	917.0	1,266
WLVSA32	919.0	1,270
WLVSA33	915.0	631
WLVSA34	913.0	
WLVSA34a	915.0	627
WLVSA35	905.0	
WLVSA36	909.0	
WLVSA37	910.0	
WLVSA38	912.0	
WLVSA39	918.5	469
WLVSA40	918.5	633
WLVSA41	919.0	1,466
WLVSA42	921.0	
WLVSA42a	922.0	
WLVSA43	921.0	
- continued -		

Appendix Table A18. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WLVSA44	922.0	
WLVSA45	913.0	
WLVSA46	912.5	
WLVSA47	913.0	
WLVSA48	920.0	308
WLVSA49	920.0	328
WLVSA50	922.0	
WLVSA51	923.5	
WLVSA51a	923.0	
WLVSA53	922.0	638
WLVSA54	921.5	
WLVSA55	921.0	302
WLVSA56	915.0	
WLVSA57	921.0	210
WLVSA58	921.0	173
WLVSA59	922.0	227
WLVSA63	922.0	228
WLVSA64	922.0	400
WLVSA65	919.0	
WLVSA66	923.5	212
WLVSA67	924.0	
WLVSA72	924.5	
WRSA284	923.0	
WRSA289	922.0	
WRSA294	919.5	625
WRSA299	911.0	
WRSA300	909.5	
WRSA302	912.0	
WRSA304	911.5	
WRSA305A	910.5	
WRSA305B	909.0	
WRSA305C	908.5	
WRSA305D	910.0	
WRSA306	910.0	
WRSA307	910.0	
WRSA309	914.0	
WRSA311	907.0	
- continued -		

Appendix Table A18. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WRS312	905.0	
WRS314	912.5	
WRS315	910.5	
WRS316	910.0	
WRS317A	907.5	
WRS317B	906.5	
WRS350	910.0	
WRS351	908.0	
WRS352	911.0	
WRS353	917.0	292
WRS354	918.0	
WRS355	917.5	
WRS356	923.5	622
WRS357	922.5	
WRS358	923.0	
WRS361	907.0	
WRS363	911.0	
WRS364	912.0	
WRS373	927.5	
WRS378	926.0	
WRS383	923.5	
WRS384	925.0	
WRS389	921.5	151
WRS390	916.0	
WRS907	913.0	
Drain371	922.0	
Drain372	921.5	
Drain373	919.0	
Drain374	915.0	
RR1	922.0	
RR10	920.0	
RR11	919.0	
RR12	918.5	
RR13	919.0	
RR14	919.0	
RR15	921.0	
RR16	918.5	
RR17	922.0	302
- continued -		

Appendix Table A18. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
RR19	918.5	
RR2	928.5	
RR20	918.0	
RR21	915.0	
RR22	917.5	
RR23	914.0	
RR24	912.5	
RR25	912.5	
RR26	914.0	
RR27	913.0	
RR28	913.0	
RR29	913.0	
RR3	921.0	
RR30	911.0	
RR31	910.0	
RR32	908.5	
RR33	907.5	
RR34	905.5	
RR35	908.0	
RR36	904.5	
RR37	906.0	
RR38	905.0	
RR39	908.0	
RR4	923.0	
RR5	920.0	
RR6	926.0	
RR7	920.0	
RR8	924.0	175
RR9	919.0	
WolvC1	921.0	
WolvC10	917.0	156
WolvC11	914.0	173
WolvC12	911.0	
WolvC13	912.5	
WolvC14	908.0	
WolvC15	908.0	
WolvC2	922.0	
WolvC3	922.0	
- continued -		

Appendix Table A18. Continued		
Storage Area	Approx. Field Elevation ^a	Flood Event Size
		1997
		----- acres -----
WolvC5	917.5	332
WolvC6	920.5	173
WolvC7	921.0	
WolvC8	921.0	
WolvC9	919.5	160
WRRND1	917.0	
WRRND10	911.0	
WRRND11	908.5	
WRRND12	908.0	
WRRND13	909.0	
WRRND14	909.0	
WRRND15	906.0	
WRRND2	917.5	
WRRND3	917.0	
WRRND4	916.5	
WRRND5	916.0	
WRRND6	914.5	
WRRND7	912.5	
WRRND8	912.5	
WRRND9	912.0	
CHRSA18	922.0	1110
CHRSA19	921.0	
CHRSA20	921.0	
CHRSA23	922.0	
Total		17,978
^a Feet above mean seal level. Lowest estimated elevation for storage area. Source: Houston-Moore Group (2016).		

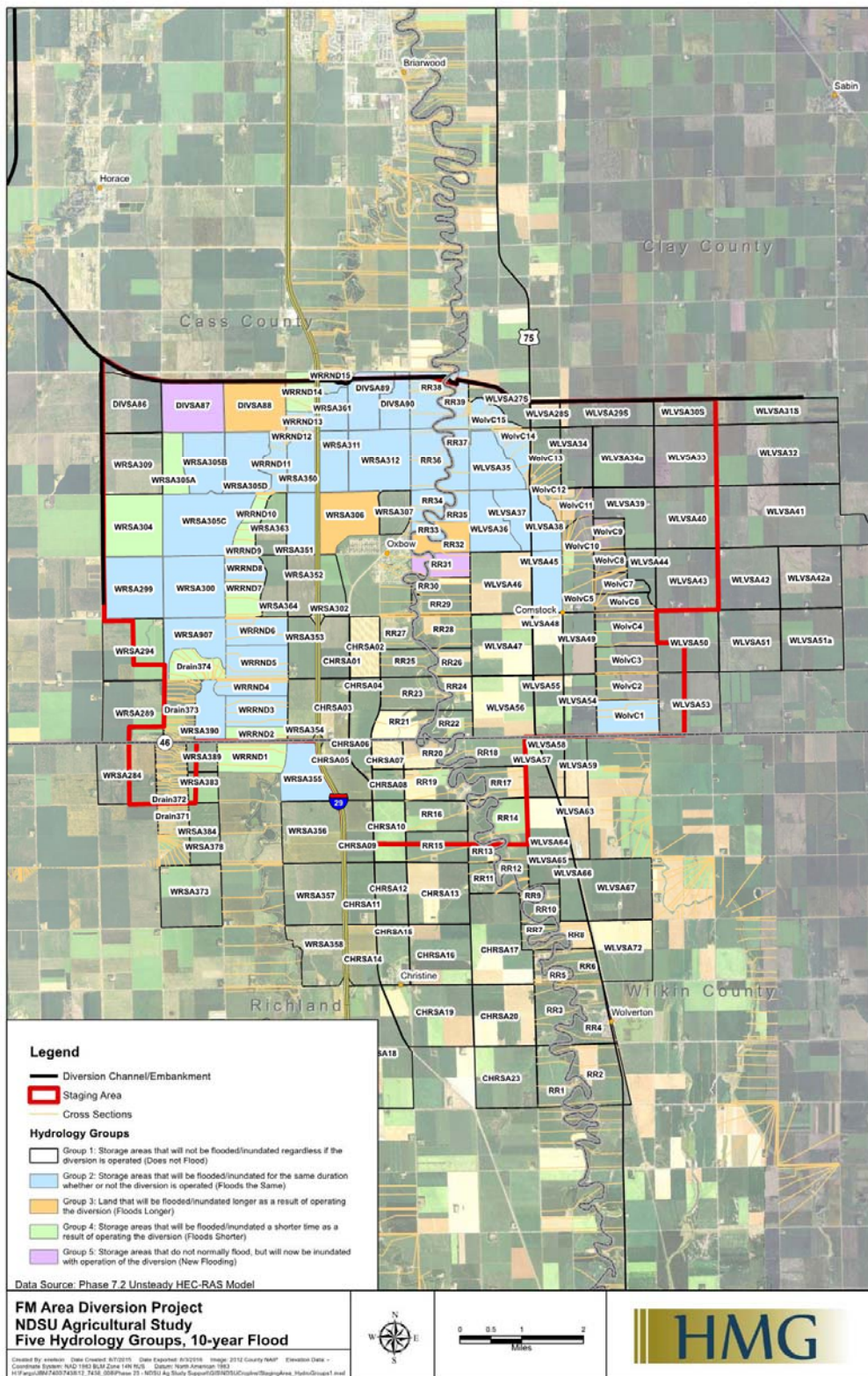
Appendix Table A19. Designation of Storage Areas in Common Hydrology Groups, 1997-Like Flood Event, FM Diversion Staging Area	
Storage Area	Flood Event
	1997
	----- Group Number and Description of Common Hydrology -----
CHRSA01	5 Now Floods
CHRSA02	5 Now Floods
CHRSA03	5 Now Floods
CHRSA04	5 Now Floods
CHRSA05	5 Now Floods
CHRSA06	5 Now Floods
CHRSA07	3 Floods Longer
CHRSA08	5 Now Floods
CHRSA09	1 No Flooding
CHRSA10	5 Now Floods
CHRSA11	1 No Flooding
CHRSA12	1 No Flooding
CHRSA13	3 Floods Longer
CHRSA14	1 No Flooding
CHRSA15	3 Floods Longer
CHRSA16	3 Floods Longer
CHRSA17	3 Floods Longer
WLVA27	3 Floods Longer
WLVA28	5 Now Floods
WLVA29	5 Now Floods
WLVA30	5 Now Floods
WLVA31	5 Now Floods
WLVA32	5 Now Floods
WLVA33	5 Now Floods
WLVA34	3 Floods Longer
WLVA34a	5 Now Floods
WLVA35	3 Floods Longer
WLVA36	3 Floods Longer
WLVA37	3 Floods Longer
WLVA38	3 Floods Longer
WLVA39	5 Now Floods
WLVA40	5 Now Floods
WLVA41	5 Now Floods
WLVA42	1 No Flooding
WLVA42a	1 No Flooding
WLVA43	1 No Flooding
- continued -	

Appendix Table A19. Continued	
Storage Area	Flood Event
	1997
	----- Group Number and Description of Common Hydrology -----
WLUSA44	1 No Flooding
WLUSA45	3 Floods Longer
WLUSA46	3 Floods Longer
WLUSA47	3 Floods Longer
WLUSA48	5 Now Floods
WLUSA49	5 Now Floods
WLUSA50	1 No Flooding
WLUSA51	1 No Flooding
WLUSA51a	1 No Flooding
WLUSA53	5 Now Floods
WLUSA54	1 No Flooding
WLUSA55	5 Now Floods
WLUSA56	3 Floods Longer
WLUSA57	5 Now Floods
WLUSA58	5 Now Floods
WLUSA59	5 Now Floods
WLUSA63	5 Now Floods
WLUSA64	5 Now Floods
WLUSA65	3 Floods Longer
WLUSA66	5 Now Floods
WLUSA67	1 No Flooding
WLUSA72	1 No Flooding
WRSA284	1 No Flooding
WRSA289	1 No Flooding
WRSA294	5 Now Floods
WRSA299	4 Floods Shorter
WRSA300	4 Floods Shorter
WRSA302	3 Floods Longer
WRSA304	4 Floods Shorter
WRSA305A	4 Floods Shorter
WRSA305B	4 Floods Shorter
WRSA305C	4 Floods Shorter
WRSA305D	4 Floods Shorter
WRSA306	3 Floods Longer
WRSA307	3 Floods Longer
WRSA309	3 Floods Longer
WRSA311	4 Floods Shorter
- continued -	

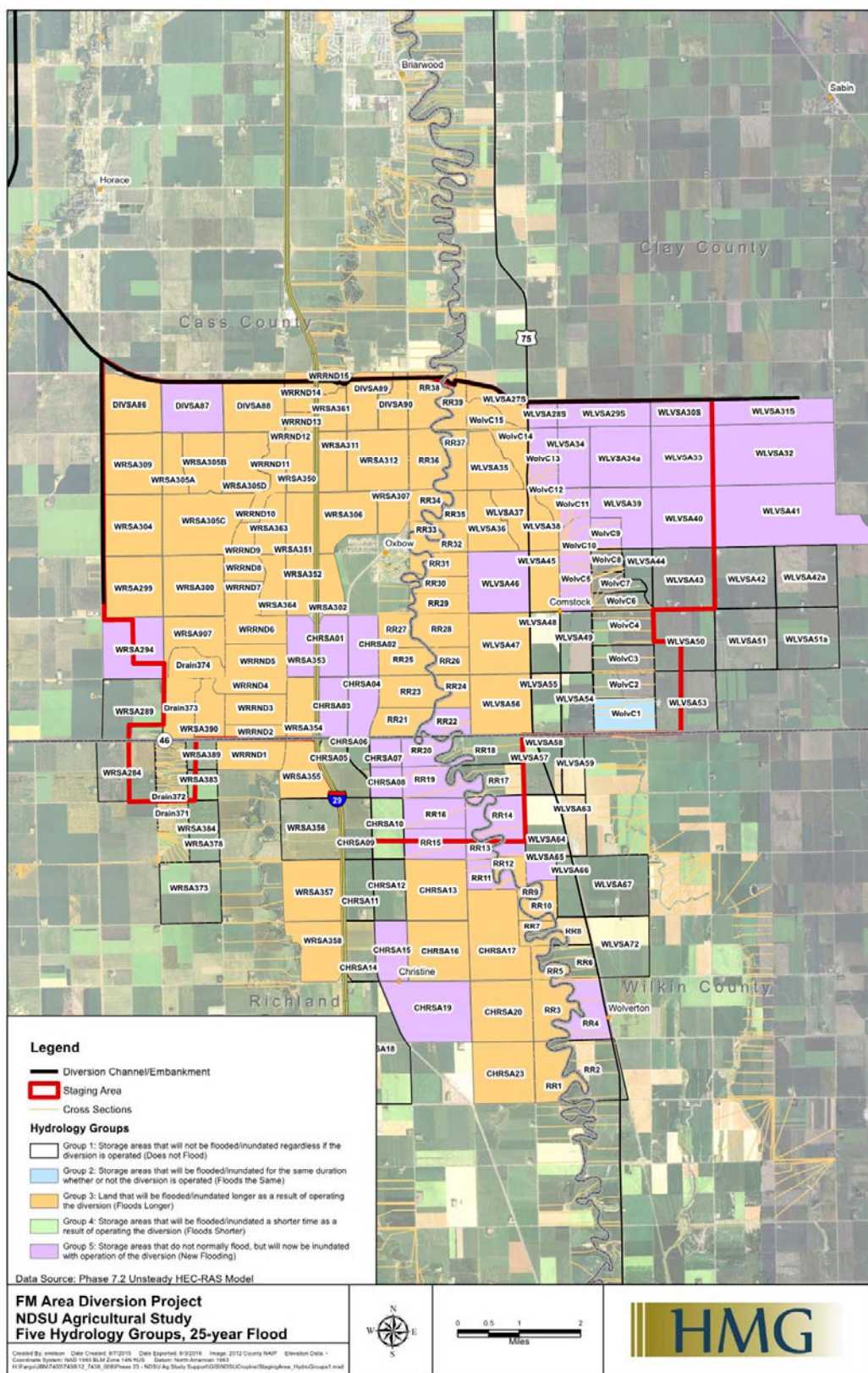
Appendix Table A19. Continued	
Storage Area	Flood Event
	1997
	----- Group Number and Description of Common Hydrology -----
WRS312	4 Floods Shorter
WRS314	3 Floods Longer
WRS315	3 Floods Longer
WRS316	3 Floods Longer
WRS317A	2 Floods Same
WRS317B	3 Floods Longer
WRS350	3 Floods Longer
WRS351	3 Floods Longer
WRS352	3 Floods Longer
WRS353	5 Now Floods
WRS354	3 Floods Longer
WRS355	3 Floods Longer
WRS356	5 Now Floods
WRS357	3 Floods Longer
WRS358	3 Floods Longer
WRS361	4 Floods Shorter
WRS363	3 Floods Longer
WRS364	3 Floods Longer
WRS373	1 No Flooding
WRS378	1 No Flooding
WRS383	1 No Flooding
WRS384	1 No Flooding
WRS389	5 Now Floods
WRS390	2 Floods Same
WRS907	3 Floods Longer
Drain371	1 No Flooding
Drain372	1 No Flooding
Drain373	3 Floods Longer
Drain374	2 Floods Same
RR1	3 Floods Longer
RR10	3 Floods Longer
RR11	3 Floods Longer
RR12	3 Floods Longer
RR13	3 Floods Longer
RR14	3 Floods Longer
RR15	3 Floods Longer
RR16	3 Floods Longer
RR17	5 Now Floods
- continued -	

Appendix Table A19. Continued	
Storage Area	Flood Event
	1997
	----- Group Number and Description of Common Hydrology -----
RR19	3 Floods Longer
RR2	1 No Flooding
RR20	3 Floods Longer
RR21	3 Floods Longer
RR22	3 Floods Longer
RR23	3 Floods Longer
RR24	3 Floods Longer
RR25	3 Floods Longer
RR26	3 Floods Longer
RR27	3 Floods Longer
RR28	3 Floods Longer
RR29	3 Floods Longer
RR3	3 Floods Longer
RR30	3 Floods Longer
RR31	3 Floods Longer
RR32	3 Floods Longer
RR33	3 Floods Longer
RR34	3 Floods Longer
RR35	3 Floods Longer
RR36	3 Floods Longer
RR37	3 Floods Longer
RR38	3 Floods Longer
RR39	3 Floods Longer
RR4	3 Floods Longer
RR5	3 Floods Longer
RR6	1 No Flooding
RR7	3 Floods Longer
RR8	5 Now Floods
RR9	3 Floods Longer
WolvC1	3 Floods Longer
WolvC10	5 Now Floods
WolvC11	5 Now Floods
WolvC12	3 Floods Longer
WolvC13	3 Floods Longer
WolvC14	3 Floods Longer
WolvC15	3 Floods Longer
WolvC2	1 No Flooding
WolvC3	1 No Flooding
WolvC4	1 No Flooding
- continued -	

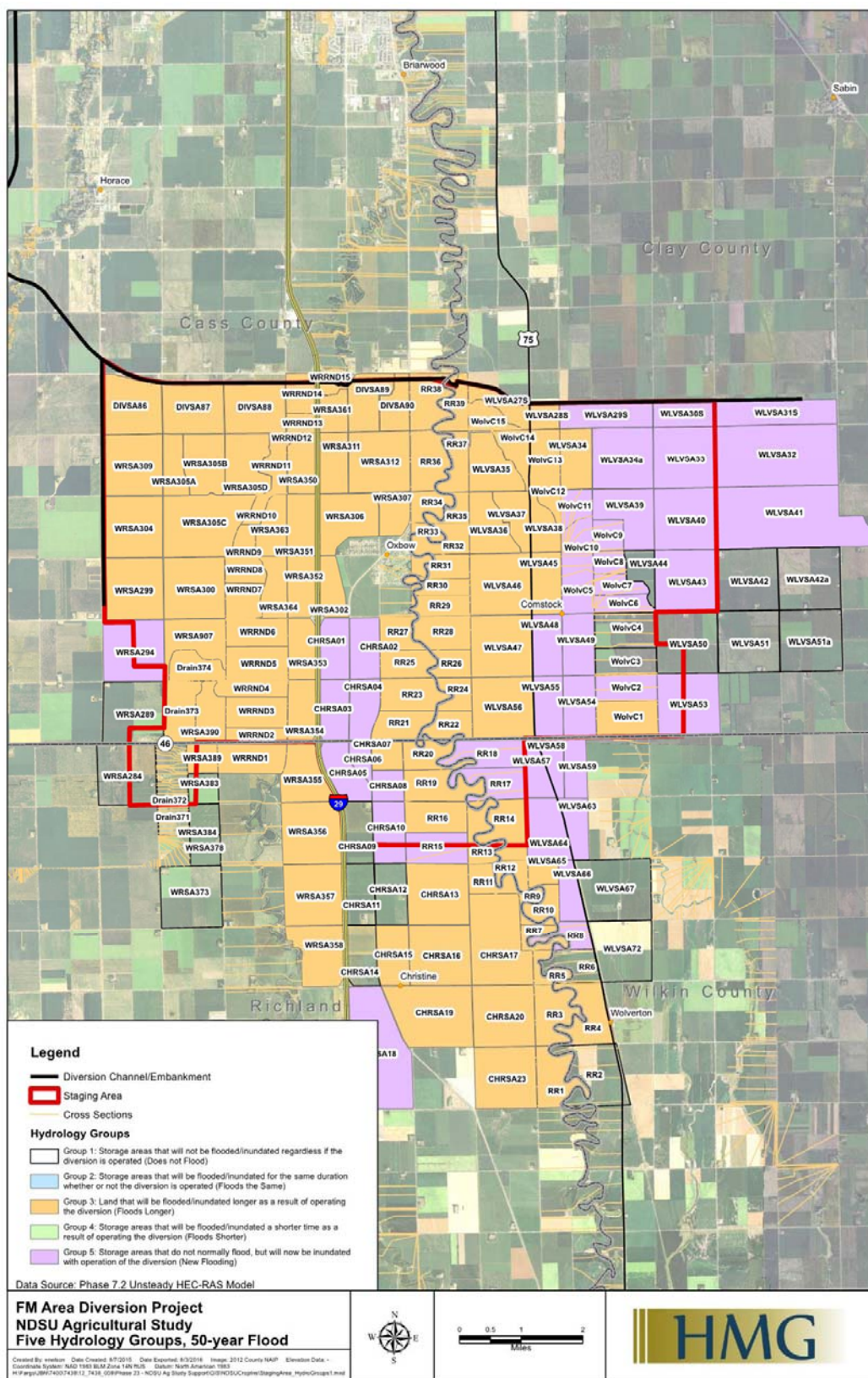
Appendix Table A19. Continued	
Storage Area	Flood Event
	1997
	----- Group Number and Description of Common Hydrology -----
WolvC6	5 Now Floods
WolvC7	1 No Flooding
WolvC8	1 No Flooding
WolvC9	5 Now Floods
WRRND1	2 Floods Same
WRRND10	4 Floods Shorter
WRRND11	4 Floods Shorter
WRRND12	4 Floods Shorter
WRRND13	4 Floods Shorter
WRRND14	4 Floods Shorter
WRRND15	4 Floods Shorter
WRRND2	3 Floods Longer
WRRND3	3 Floods Longer
WRRND4	3 Floods Longer
WRRND5	3 Floods Longer
WRRND6	2 Floods Same
WRRND7	4 Floods Shorter
WRRND8	4 Floods Shorter
WRRND9	4 Floods Shorter
CHRSA18	5 Now Floods
CHRSA19	3 Floods Longer
CHRSA20	3 Floods Longer
CHRSA23	3 Floods Longer



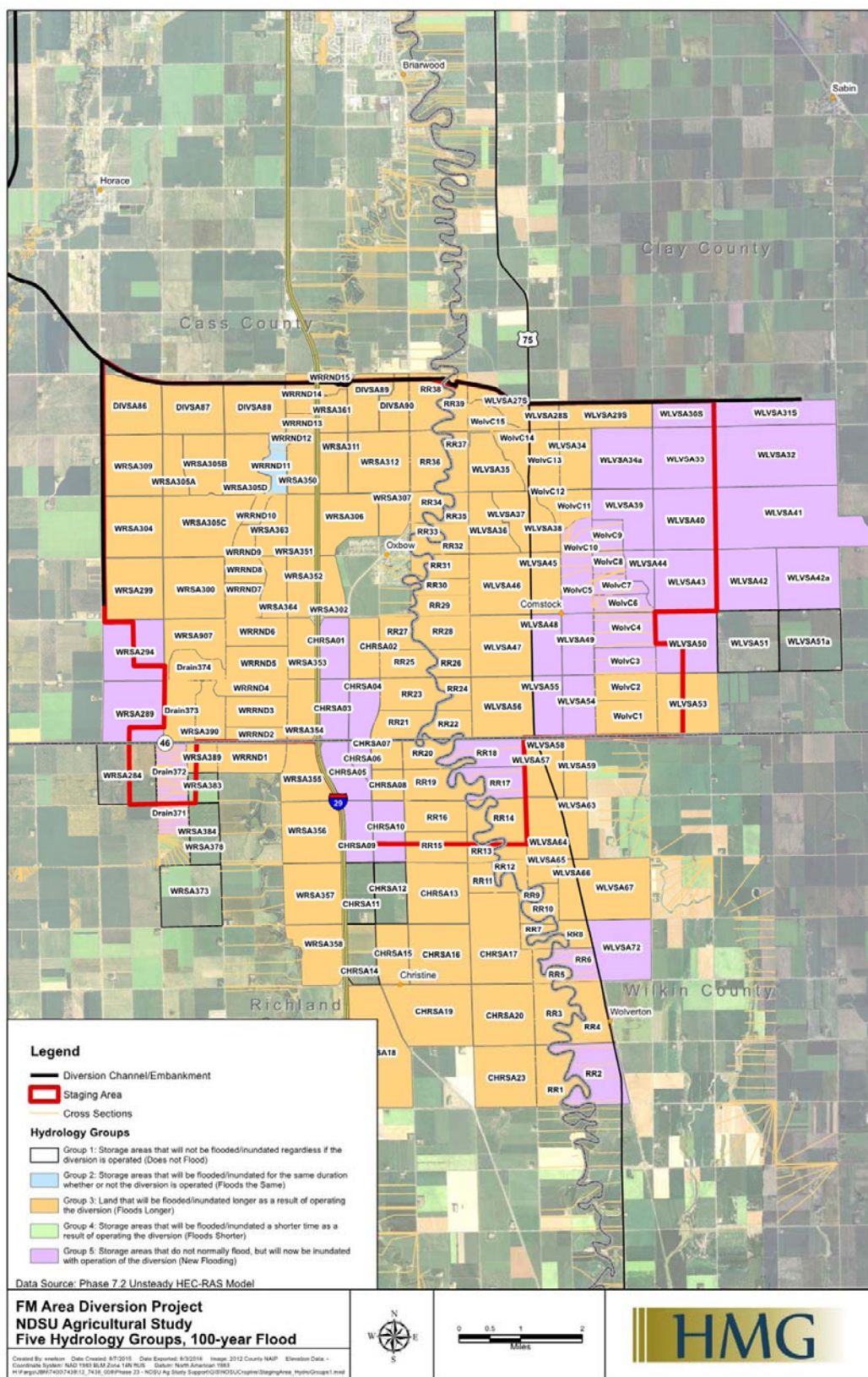
Appendix Figure A1. Hydrology Groups for Storage Areas, 10-year Flood Event



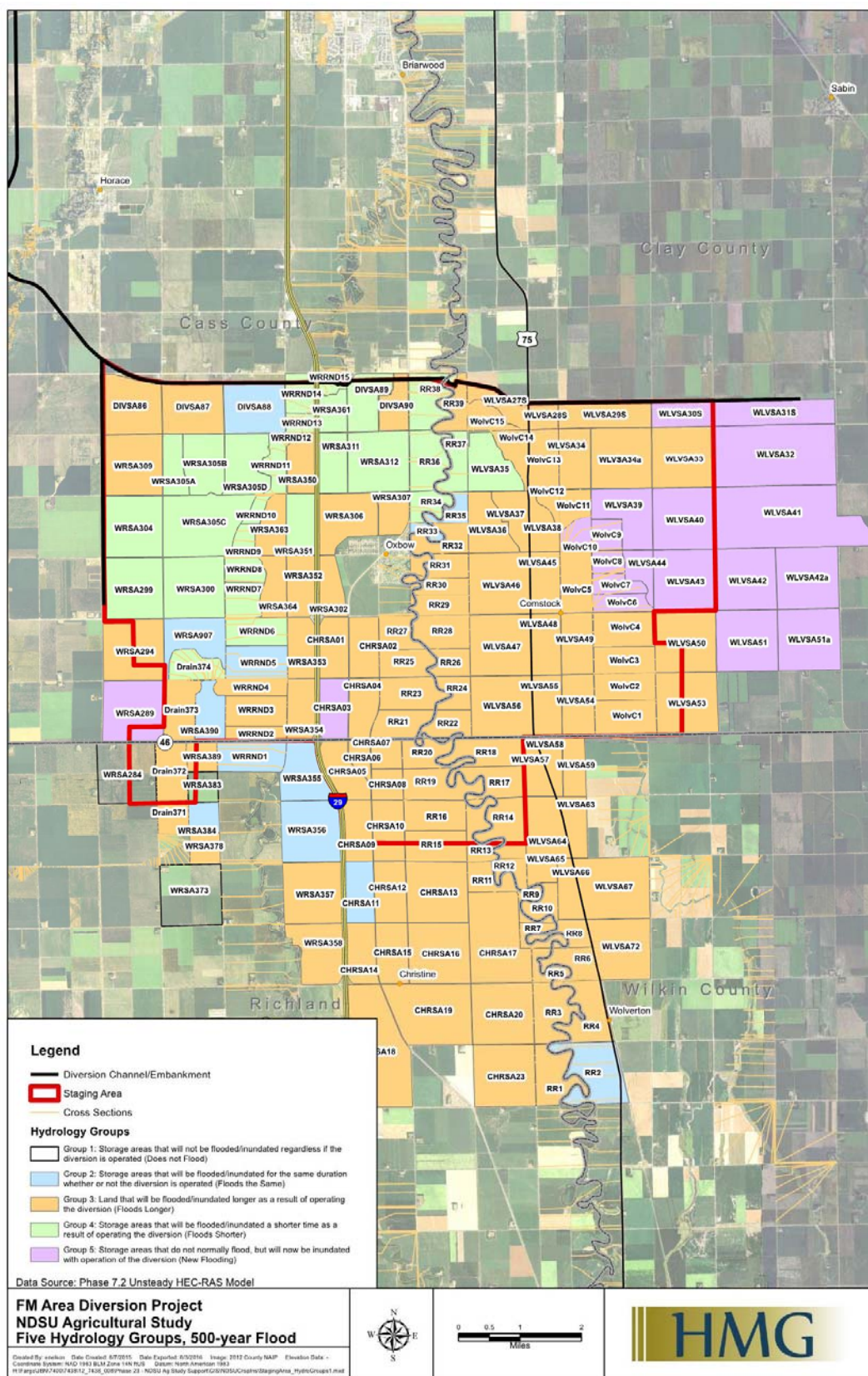
Appendix Figure A2. Hydrology Groups for Storage Areas, 25-year Flood Event



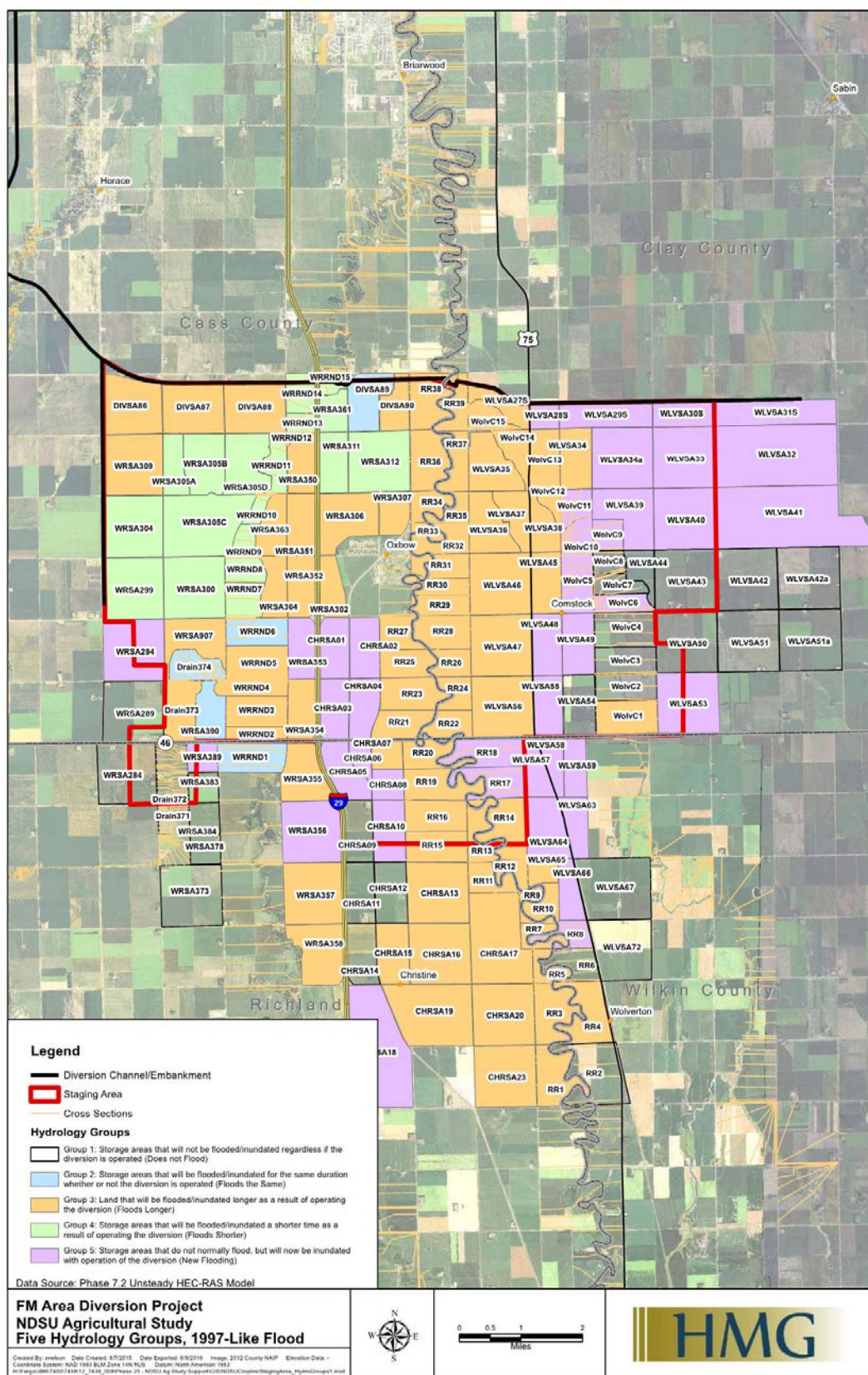
Appendix Figure A3. Hydrology Groups for Storage Areas, 50-year Flood Event



Appendix Figure A4. Hydrology Groups for Storage Areas, 100-year Flood Event



Appendix Figure A5. Hydrology Groups for Storage Areas, 500-year Flood Event



Appendix B
Likelihood of Per-Acre Revenue Losses by Crop

Appendix Table B1. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Corn and Soybeans, 10-year Flood Event

	Time from Activation of Staging Area until the Effects of Flooding are over ^a			Per Acre Losses for Individual Crop							
Hydrology Group	WO	W	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	\$101 to \$125/acre ^b Loss	\$126 to \$150/acre ^b Loss	Over \$150/acre ^b Loss
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----							
				Corn							
3	16.2	16.8	1 to 5	67.4%	32.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	na	na	6 to 10	na	na	na	na	na	na	na	na
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	16	16 to 20	71.3%	26.3%	2.1%	0.3%	0.1%	0.0%	0.0%	0.0%
5	na	Na	Over 20	na	na	na	na	na	na	na	na
				Soybeans ^c							
3	16.2	16.8	1 to 5	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	na	na	6 to 10	na	na	na	na	na	na	na	na
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	16	16 to 20	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	na	na	Over 20	na	na	na	na	na	na	na	na

Na=not applicable. There were no storage areas in those categories.

WO=Without Diversion, W=With Diversion

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas Within the groups.

^c Actual odds are not 100 percent that soybeans have no losses. The number of replications With a revenue loss for soybeans was too few to register in the rounding of the percentages.

Appendix Table B2. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Wheat and Sugarbeets, 10-year Flood Event

	Time from Activation of Staging Area until the Effects of Flooding are over ^a			Per Acre Losses for Individual Crop							
Hydrology Group	WO	W	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	\$101 to \$125/acre ^b Loss	\$126 to \$150/acre ^b Loss	Over \$150/acre ^b Loss
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----							
				Wheat							
3	16.2	16.8	1 to 5	67.2%	32.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	na	na	6 to 10	na	na	na	na	na	na	na	na
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	16	16 to 20	70.9%	20.9%	6.2%	1.6%	0.4%	0.0%	0.0%	0.0%
5	na	na	Over 20	na	na	na	na	na	na	na	na
				Sugarbeets							
3	16.2	16.8	1 to 5	67.2%	32.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	na	na	6 to 10	na	na	na	na	na	na	na	na
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	16	16 to 20	70.9%	1.8%	7.1%	4.0%	2.0%	1.1%	0.7%	0.4%
5	na	na	Over 20	na	na	na	na	na	na	na	na

Na=not applicable. There were no storage areas in those categories.
WO=Without Diversion, W=With Diversion

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas Within the groups.

Appendix Table B3. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Corn and Soybeans, 25-year Flood Event

	Time from Activation of Staging Area until the Effects of Flooding are over ^a			Per Acre Losses for Individual Crop							
Hydrology Group	WO	W	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	\$101 to \$125/acre ^b Loss	\$126 to \$150/acre ^b Loss	Over \$150/acre ^b Loss
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----							
				Corn							
3	19	21.9	1 to 5	36.5%	62.7%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%
3	16.9	22.7	6 to 10	40.4%	47.6%	11.4%	0.4%	0.2%	0.0%	0.0%	0.0%
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	18.1	16 to 20	59.6%	35.4%	4.0%	0.8%	0.1%	0.1%	0.0%	0.0%
5	0	21.4	Over 20	47.7%	38.5%	10.7%	2.2%	0.6%	0.1%	0.1%	0.1%
				Soybeans							
3	19	21.9	1 to 5	97.3%	2.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	16.9	22.7	6 to 10	98.2%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	18.1	16 to 20	99.9%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	0	21.4	Over 20	99.2%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Na=not applicable. There were no storage areas in those categories.

WO=Without Diversion, W=With Diversion

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas Within the groups.

Appendix Table B5. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Corn and Soybeans, 50-year Flood Event

	Time from Activation of Staging Area until the Effects of Flooding are over ^a			Per Acre Losses for Individual Crop							
Hydrology Group	WO	W	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	\$101 to \$125/acre ^b Loss	\$126 to \$150/acre ^b Loss	Over \$150/acre ^b Loss
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----							
				Corn							
3	19.7	22.6	1 to 5	32.7%	66.4%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%
3	17.2	23.1	6 to 10	40.4%	45.6%	13.3%	0.4%	0.2%	0.0%	0.0%	0.0%
5	0	13.8	11 to 15	81.7%	17.3%	0.9%	0.1%	0.0%	0.0%	0.0%	0.0%
5	0	17.7	16 to 20	59.6%	35.0%	4.3%	0.9%	0.1%	0.1%	0.0%	0.0%
5	0	21.8	Over 20	44.0%	40.7%	11.7%	2.5%	0.8%	0.2%	0.1%	0.1%
				Soybeans							
3	19.7	22.6	1 to 5	95.9%	4.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	17.2	23.1	6 to 10	98.2%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	0	13.8	11 to 15	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	0	17.7	16 to 20	99.9%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	0	21.8	Over 20	98.8%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Na=not applicable. There were no storage areas in those categories.

WO=Without Diversion, W=With Diversion

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas Within the groups.

Appendix Table B6. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Wheat and Sugarbeets, 50-year Flood Event

	Time from Activation of Staging Area until the Effects of Flooding are over ^a			Per Acre Losses for Individual Crop							
Hydrology Group	WO	W	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	\$101 to \$125/acre ^b Loss	\$126 to \$150/acre ^b Loss	Over \$150/acre ^b Loss
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----							
				Wheat							
3	19.7	22.6	1 to 5	32.7%	67.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	17.2	23.1	6 to 10	44.4%	26.2%	33.4%	0.0%	0.0%	0.0%	0.0%	0.0%
5	0	13.8	11 to 15	81.3%	14.7%	3.3%	0.7%	0.1%	0.0%	0.0%	0.0%
5	0	17.7	16 to 20	59.4%	26.7%	9.6%	3.3%	0.9%	0.1%	0.0%	0.0%
5	0	21.8	Over 20	43.9%	27.2%	15.8%	8.3%	3.5%	1.0%	0.2%	0.0%
				Sugarbeets							
3	19.7	22.6	1 to 5	32.7%	29.0%	38.3%	0.0%	0.0%	0.0%	0.0%	0.0%
3	17.2	23.1	6 to 10	44.4%	13.3%	10.3%	15.3%	20.8%	0.0%	0.0%	0.1%
5	0	13.8	11 to 15	81.3%	9.8%	4.7%	2.0%	1.1%	0.7%	0.3%	0.1%
5	0	17.7	16 to 20	59.4%	16.5%	9.0%	5.8%	4.1%	2.3%	1.4%	1.6%
5	0	21.8	Over 20	44.0%	16.4%	9.9%	8.4%	7.1%	4.9%	3.8%	5.6%
Na=not applicable. There were no storage areas in those categories. WO=Without Diversion, W=With Diversion ^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting. ^b The range of losses per acre represent an average of all storage areas Within the groups.											

Appendix Table B9. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Corn and Soybeans, 500-year Flood Event

	Time from Activation of Staging Area until the Effects of Flooding are over ^a			Per Acre Losses for Individual Crop							
Hydrology Group	WO	W	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	\$101 to \$125/acre ^b Loss	\$126 to \$150/acre ^b Loss	Over \$150/acre ^b Loss
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----							
				Corn							
3	21.6	23.6	1 to 5	25.6%	73.9%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%
3	16.5	24.0	6 to 10	40.4%	34.4%	21.7%	2.9%	0.4%	0.3%	0.0%	0.0%
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	18.4	16 to 20	59.6%	35.1%	4.3%	0.8%	0.1%	0.1%	0.0%	0.0%
5	0	22.1	Over 20	40.4%	39.9%	14.2%	3.8%	1.1%	0.4%	0.1%	0.1%
				Soybeans							
3	21.6	23.6	1 to 5	91.9%	8.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	16.5	24.0	6 to 10	98.2%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	18.4	16 to 20	99.9%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	0	22.1	Over 20	98.2%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Na=not applicable. There were no storage areas in those categories.

WO=Without Diversion, W=With Diversion

^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood With existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting.

^b The range of losses per acre represent an average of all storage areas Within the groups.

Appendix Table B10. Probability of Losses Resulting from Use of the Staging Area, Hydrology Groups Three and Five Delineated by Difference in Total Days between With and Without Diversion, for Wheat and Sugarbeets, 500-year Flood Event

	Time from Activation of Staging Area until the Effects of Flooding are over ^a			Per Acre Losses for Individual Crop							
Hydrology Group	WO	W	Difference in Total Days	No Loss	\$0 to \$25/acre ^b Loss	\$26 to \$50/acre ^b Loss	\$51 to \$75/acre ^b Loss	\$76 to \$100/acre ^b Loss	\$101 to \$125/acre ^b Loss	\$126 to \$150/acre ^b Loss	Over \$150/acre ^b Loss
	----- days -----			----- Based on 10,000 replications from Monte Carlo Simulation -----							
				Wheat							
3	21.6	23.6	1 to 5	25.6%	74.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	16.5	24.0	6 to 10	40.4%	17.4%	25.6%	16.6%	0.0%	0.0%	0.0%	0.0%
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	18.4	16 to 20	59.4%	26.4%	9.5%	3.6%	1.0%	0.2%	0.0%	0.0%
5	0	22.1	Over 20	40.4%	25.6%	16.7%	10.6%	4.8%	1.6%	0.4%	0.0%
				Sugarbeets							
3	21.6	23.6	1 to 5	25.6%	42.1%	32.3%	0.0%	0.0%	0.0%	0.0%	0.0%
3	16.5	24.0	6 to 10	40.4%	8.9%	7.8%	10.2%	12.1%	20.6%	0.0%	0.0%
5	na	na	11 to 15	na	na	na	na	na	na	na	na
5	0	18.4	16 to 20	59.4%	16.5%	8.9%	5.9%	4.1%	2.2%	1.4%	1.6%
5	0	22.1	Over 20	40.4%	14.7%	10.1%	8.5%	7.6%	6.5%	4.1%	8.1%
Na=not applicable. There were no storage areas in those categories. WO=Without Diversion, W=With Diversion ^a Total days are defined as the sum of 1) days from staging activation until land becomes inundated, 2) days of inundation, and 3) 10-day dry-down. Zero days mean the storage areas do not flood with existing conditions, but zero days do not necessarily mean conditions in the region are suitable for planting. ^b The range of losses per acre represent an average of all storage areas within the groups.											

Appendix C
Low, Average and High Per-Acre Revenue Losses by Crop Due to Diversion,
Hydrology Groups 3 and 5

Appendix Table C1. Per-Acre Revenue Losses, by Crop, due to Diversion (High and Low 5% of Observations and Average), Hydrology Group 3						
	10-year	25-year	50-year	100-year	500-year	1997-Like
----- Corn -----						
Least (5%)	\$0	\$0	\$0	\$0	\$0	\$0
Average	-\$0.75	-\$5.46	-\$6.16	-\$9.16	-\$5.54	-\$12.61
Maximum (5%)	-\$5.08	-\$21.65	-\$22.66	-\$28.68	-\$18.23	-\$29.64
----- Wheat -----						
Least (5%)	\$0	\$0	\$0	\$0	\$0	-\$0.01
Average	-\$1.35	-\$8.72	-\$9.63	-\$13.21	-\$8.60	-\$16.63
Maximum (5%)	-\$6.66	-\$23.47	-\$24.13	-\$30.06	-\$20.06	-\$29.34
----- Sugarbeets -----						
Least (5%)	\$0	\$0	\$0	\$0	\$0	-\$0.02
Average	-\$0.44	-\$18.25	-\$20.61	-\$28.65	-\$18.95	-\$36.68
Maximum (5%)	-\$2.61	-\$51.81	-\$53.84	-\$68.22	-\$44.73	-\$64.73
----- Soybeans -----						
Least (5%)	\$0	\$0	\$0	\$0	\$0	\$0
Average	\$0	-\$0.01	-\$0.02	-\$0.07	-\$0.03	\$0.56
Maximum (5%)	\$0	-\$0.30	-\$0.45	-\$1.33	-\$0.63	-\$7.04

Appendix Table C2. Per-Acre Revenue Losses, by Crop, due to Diversion (High and Low 5% of observations and Average), Hydrology Group 5						
	10-year	25-year	50-year	100-year	500-year	1997-Like
----- Corn -----						
Least (5%)	\$0	\$0	\$0	\$0	\$0	\$0
Average	-\$2.99	-\$6.94	-\$6.84	-\$8.96	-\$9.81	-\$18.03
Maximum (5%)	-\$29.98	-\$49.60	-\$48.73	-\$57.66	-\$61.10	-\$79.77
----- Wheat -----						
Least (5%)	\$0	\$0	\$0	\$0	\$0	\$0
Average	-\$5.89	-\$12.76	-\$12.06	-\$15.76	-\$17.22	-\$27.63
Maximum (5%)	-\$51.07	-\$76.23	-\$73.12	-\$84.10	-\$88.28	-\$102.45
----- Sugarbeets -----						
Least (5%)	\$0	\$0	\$0	\$0	\$0	\$0
Average	-\$1.81	-\$27.25	-\$25.60	-\$33.67	-\$36.75	-\$58.81
Maximum (5%)	-\$16.77	-\$163.08	-\$156.50	-\$179.97	-\$188.08	-\$219.31
----- Soybeans -----						
Least (5%)	\$0	\$0	\$0	\$0	\$0	\$0
Average	\$0	\$0	\$0	-\$0.01	-\$0.01	\$0.09
Maximum (5%)	\$0	-\$0.05	-\$0.07	-\$0.14	-\$0.16	-\$1.73

These tables show the range of per-acre values observed given study data and averaging techniques of the statistical output from the model. Average values mask the variability observed in the analysis so low and high values are reported as well. Observing at five percent eliminates potential low probability events whether the loss is low or high.