BASIN TECHNICAL AND SCIENTIFIC ADVISORY COMMITTEE

(BTSAC)

Impacts of Agricultural Drainage on Watershed Peak Flows

Briefing Paper #1

CONTENTS

INTRODUCTION 3
BASIN TECHNICAL AND SCIENTIFIC ADVISORY COMMITTEE (BTSAC) 3
STATUS AND TRENDS IN AGRICULTURAL DRAINAGE 4
LITERATURE REVIEW 4
Conclusions from the Literature Review 4
STATEMENTS AND RECOMENDATIONS 5
NEXT STEPS 6
BTSAC STAKEHOLDER REPRESENTATIVES 7

INTRODUCTION

During and after the 2009 Red River of the North flood, there were numerous public statements inferring that the region's flooding problems were caused by the extensive network of surface and subsurface agricultural drainage systems. Although the statements could well be dismissed as rhetoric or opinion, the fundamental issues and underlying questions posed are valid and have largely been unanswered in the Red River Basin using objective and defendable scientific methods.

Members of the ND Red River Joint Water Resources Board (RRJWRB) and the MN Red River Watershed Management Board (RRWMB) formed a Joint Drainage Subcommittee to frame the questions regarding the hydrologic impacts of agricultural drainage on peak flows and to establish an objective and defendable process to answer them.

- What are the impacts of agricultural drainage on peak watershed flows?
- How should agricultural drainage systems be designed to maximize benefits while minimizing adverse impacts?

The efforts of the Joint Drainage Committee were transferred to the Red River Retention Authority (RRRA) after it was formed through a joint powers agreement between the RRJWRB and the RRWMB. The RRRA is charged with working across political jurisdictions to reduce flood damages through floodwater retention projects in the Red River Basin.

BASIN TECHNICAL AND SCIENTIFIC ADVISORY COMMITTEE (BTSAC)

The RRRA asked the International Water Institute (IWI) to establish a Basin Technical and Scientific Advisory Committee (BTSAC) and establish an objective process to address the questions posed by the Joint Drainage Committee. The IWI contacted Red River Basin stakeholders asking them to appoint a technical representative to the BTSAC and participate in efforts to review available literature, develop study plans, and conduct necessary scientific research to better understand the impacts of agricultural drainage on peak flows.

BTSAC membership includes technical representatives from watershed districts, water resource districts, cities, environmental organizations, universities, and state/federal natural resource and agriculture agencies. The role of the BTSAC is to utilize science and best professional judgment to address technical issues and questions posed by officials in the Red River Basin who are responsible for managing water resources.

In response to the questions posed by the joint Drainage Committee, the BTSAC has undertaken efforts to:

- Obtain and/or develop scientifically-based information documenting the relationship between agricultural drainage and peak flows.
- Identify agricultural drainage design criteria and policies that maximize benefits while minimizing downstream impacts.
- Prepare a report with recommendations for the RRRA.

STATUS AND TRENDS IN AGRICULTURAL DRAINAGE

In the past, surface drainage has been the dominant method used to reduce farmland wetness and flooding in the Red River Basin. Drainage improvements have traditionally included field leveling, field ditches, outlet ditches, and altered natural channels which resulted in extensive artificial drainage systems serving most of the lands that are currently or likely to be farmed. However, crop damage from flooding remains extensive and poses a great economic burden on agriculture in the Red River Basin.

In recent years, subsurface drainage (i.e., tile drainage) has become increasingly popular in the region. The current and increasing trend is the addition of subsurface drains to augment and replace the existing surface drainage systems within agricultural fields. The agronomic benefits of adding subsurface drainage are readily demonstrated. However, installers often rely on design guidelines and landowner direction which may or may not be most appropriate in the unique environment of the Red River Basin. Efforts to improve the current surface drainage networks, as well as the widespread addition of subsurface drainage systems, are expected to continue into the foreseeable future.

LITERATURE REVIEW

The IWI and BTSAC members conducted a review of existing scientific literature investigating impacts from agricultural drainage. Over 45 published research papers were reviewed along with University of Minnesota and University of Iowa Agricultural Extension websites. In addition, technical information from ongoing tile drainage research and modeling efforts was presented to the BTSAC by Dr. Gary Sands, Charlie Anderson, and Dr. Tom Scherer.

Conclusions from the Literature Review

- Subsurface drainage may increase total water output (yield) from a field.
- Subsurface drainage lowers the water table and associated capillary fringe (nearly saturated subsurface zone above the water table) allowing air to enter the larger pores of the soil profile above the drain; therefore, subsurface drainage can decrease the volume and rate of surface runoff leaving a field, by providing additional infiltration and storage in the soil profile and an alternate flow path.
- The rate and volume of surface and subsurface tile flow are smaller for perennial vegetation than for row crops.
- There is little documentation in the Red River Basin of the extent and design of installed and planned subsurface drainage systems in the Red River Basin.
- In poorly drained soils, subsurface drainage tends to extend the period of time over which a watershed will discharge in response to precipitation.
- In soils with higher clay contents and subsurface drainage, desiccation cracks during dry periods can decrease the response time for tile outflows.
- There is little research in the Red River of the North Basin of subsurface drainage hydrology during non-growing months (i.e., late fall, winter, and early spring).
- There is little comprehensive research of subsurface drainage affects on hydrology at the watershed scale (i.e., flood peaks in the Red River of the North Basin or its major subwatersheds); however, available research indicates that field drainage effects are likely

to dominate downstream hydrology for small and medium storms while channel improvements dominate downstream hydrology during large runoff events.

STATEMENTS AND RECOMENDATIONS

Drainage systems and practices are part of a complex web of land use changes that affect downstream hydrology at the field, watershed and basin scale. Many landscape-scale changes have occurred in addition to agricultural drainage that can increase or decrease downstream flood flows including; conversion of perennial prairie systems to cultivated crop systems, drained or restored lakes and wetlands, urbanization, on and off channel dams, channelization, and road and field crossing culverts. When these landscape-scale changes occur together over the same time period, it becomes difficult to identify and quantify the effects of individual practices such as drainage.

The cumulative effects of extensive drainage on the flood hydrograph of large watersheds (i.e. the Red River of the North Basin) is complex and depends on many factors including the type of drainage (e.g. surface or subsurface), location of drainage features (both surface and subsurface) within a watershed or basin, topography, soil type, design criteria for the drainage system (e.g. 2, 5, or 10 return period), and the extent of the drainage infrastructure within a watershed, antecedent moisture of the system, and the nature of the precipitation or snowmelt events that are creating the flooding conditions. These factors and others must be carefully considered to understand the potential impacts of subsurface drainage on peak flows at different scales, and to develop guidance to minimize the negative and maximize the positive impacts of increased subsurface drainage on peak flows.

The BTSAC agreed to endorse the following preliminary statements to the RRRA:

- Agricultural drainage is essential to the region's agricultural industry and is a key component of the Basin's infrastructure and economy.
- Any general statement implying that subsurface drainage decreases (or increases) flood peaks is strongly discouraged because it oversimplifies the complex processes involved.
- Timing and volume of runoff from different areas of a watershed or basin are key variables affecting peak flows and duration of flooding.
- The cumulative impacts of tile/subsurface drainage on future peak flows in the Red River Basin are currently unclear.
    - Comprehensive investigations have not been conducted in the Red River Basin to understand the relationships between surface drainage, subsurface drainage and other landscape changes that impact peak flows.
- Retrospective analysis of empirical data and the use of sophisticated modeling could help quantify the impacts of past drainage on the hydrology of the Red River Basin; however, the most purposeful use of knowledge, resources, and technologies available today is to analyze the effects of current, rather than historic trends in drainage and develop guidelines to beneficially refine those trends in the future.
- Multiple purpose drainage management must be a key component of future watershed management, for reasons of adequate agricultural drainage, flood damage reduction, water supply and water quality.
- Requiring control structures on subsurface drainage that would enable the system to essentially be turned on or off is one potential way to ensure that the widespread addition of pattern tile does not make peak flows worse than the existing condition. However, this approach would necessitate substantial investments in control structures, operation and

enforcement. These considerations and the available literature indicate the need to better understand the effects of subsurface drainage at the watershed and basin scales to address this concept.
- The effects of subsurface tile drainage coefficients on flood peaks is another topic for which further research, analysis and discussion are needed.

NEXT STEPS

BTSAC proposes a 2-phased approach to investigate tile/subsurface drainage impacts on peak flows with the goal of developing policy recommendations for the RRRA that reduce the amount of water contributing to the peak period of flood hydrographs.

PHASE 1 - The BTSAC proposes to undertake efforts to expand on the DRAINMOD (DM) study underway by Gary Sands. BTSAC will work with the UMN and NDSU extension to perform DM simulations at the field scale.

Tasks

1. Develop study plans for essential research
2. Examine and update DM input parameters (4 updated Red River Basin soil parameters and 3 different cropping patterns).
3. Examine different DM scenarios of holding water on the field to better understand discharge and agronomic impact).
4. Prepare interim report

Estimated Time to Conclusion – 4 months

PHASE 2 – Once the field scale impacts of a drainage practices have been identified using DM. BTSAC proposes to determine how field scale subsurface drainage practices affect flood flows at the watershed scale using the simple timing concept of early-middle-late contributing areas of the watershed. If necessary, the effects of drainage can be more precisely determined utilizing hydrologic modeling techniques.

Tasks

1. Develop Study plans for essential research
2. Validate and apply field scale simulations to a larger hydrologic system (affects of tile drainage - timing on early, middle, late water).
3. Prepare final report with recommendations

Estimated Time to Conclusion – 20 months

Estimated Cost – $60,000

For more information contact
Charles Fritz
Charles.fritz@ndsu.edu
Office: 701 231-9747/Cell: 7017 388-0861

InternationalWaterInstitute
Flood research and watershed education for the Red River Basin

BTSAC STAKEHOLDER REPRESENTATIVES

STAKEHOLDER	REPRESENTATIVE
ND State Water Commission	Bill Schuh
MN Department of Natural Resources	Jim Solstad
MN Board of Water and Soil Resources	Al Kean
ND Natural Resources Conservation Service	Dennis Reep
MN Natural Resources Conservation Service	Dave Jones
US Army Corps of Engineers	Scott Jutila
MN Center for Environmental Advocacy	Henry VanOffelen
City of Fargo, ND	Mark Bittner
City of Moorhead, MN	Bob Zimmerman
US Geological Survey	Rochelle Nustad
US Fish and Wildlife Service	Josh Eash
MN Red River Watershed Management Board	Charlie Anderson
MN Red River Watershed Management Board	Dan Thul
MN Red River Watershed Management Board	Nate Dalager
ND Red River Joint Water Resources Board	Randy Gjestvang
ND Red River Joint Water Resources Board	Chad Engels
MN Department of Agriculture	Rob Sip
Academia (NDSU)	Xinhua Jia
Academia (NDSU)	Tom Scherer
Academia (NDSU)	Hans Kandel
Academia (UMN)	Gary Sands