

**BASIN TECHNICAL AND SCIENTIFIC ADVISORY COMMITTEE
(BTSAC)**

**Impacts of Subsurface Agricultural Drainage on Watershed
Peak Flows**

Briefing Paper #1



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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 defensible 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 defensible 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

- Subsurface drainage generally increases total water output (yield) from a field.
- Subsurface drainage can lower the water table and associated capillary fringe (subsurface layer in which the groundwater seeps up from a water table); therefore, subsurface drainage can decrease the amount of surface runoff leaving a field, either through additional storage in the soil profile or an alternate flow path.
- Row crops – as opposed to perennial vegetation - will increase the amount of water leaving the field with subsurface drainage.
- There is little documentation of the extent and design of installed and planned subsurface drainage systems in the Red River Basin.
- In clay soils, subsurface drainage tends to extend the period of time over which a watershed will discharge in response to precipitation.
- In clay soils with subsurface drainage, desiccation cracks during dry periods can greatly accelerate the response time for tile outflows.
- There is little research 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); 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 hydrology downstream 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; 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 over and during the same time period, scientific efforts to identify the effects of drainage alone are confounded and difficult.

The composite effect 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 the subsurface drainage 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. All 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 on peak flows.

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

- 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 tiles 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 RRRRA 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

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Academia (NDSU).....	Hans Kandel
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