Key Results and Conclusions of the Waffle Project

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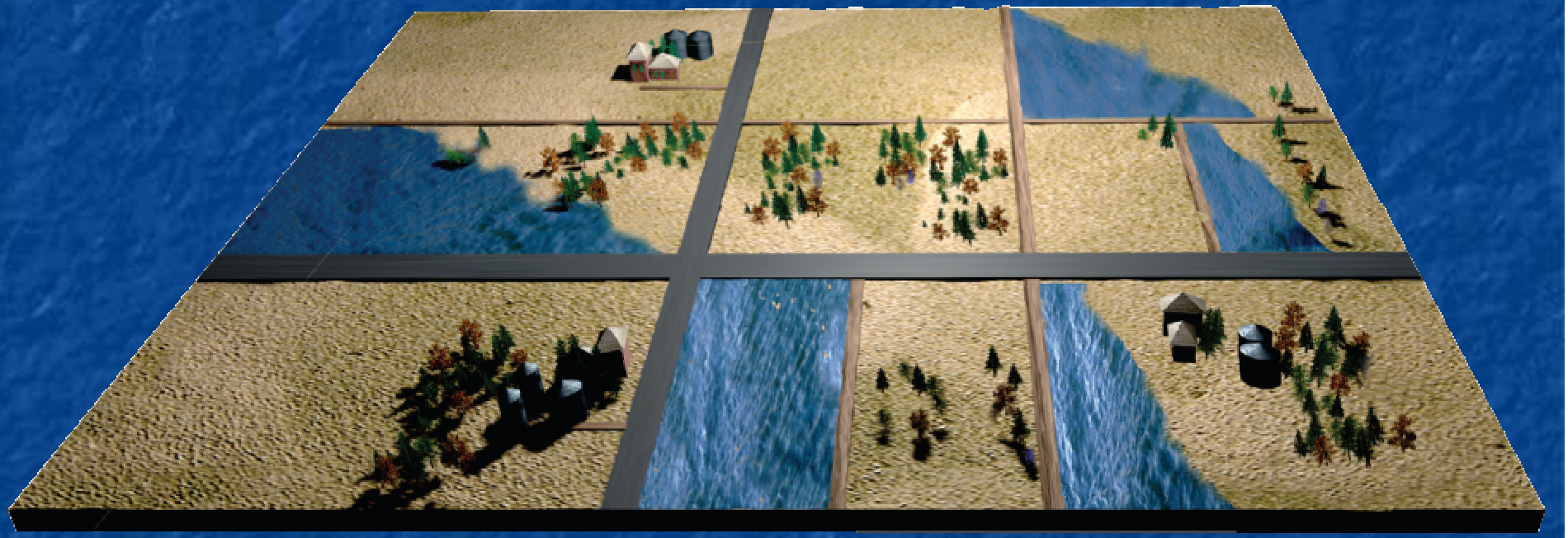
Waffle Concept



Waffle Concept

Gated Culvert with Overflow Standpipe

Key Assumptions Used in this Feasibility Assessment

- The concept would only employ storage to mitigate large, spring-time floods and would not likely be implemented every year.
- Water storage on ag land may cause a delay in planting, but not prevent planting.
- Participation would be voluntary and compensation would be based on average cash rental rates.

Waffle Storage Estimates

- Waffle storage volumes were determined using Geographic Information Systems (GIS) coupled with the best available digital data.
- Original storage estimates were close to 3.3 million acre-feet.
- However, these estimates were reduced to account for the 1997 floodplain, freeboard and natural storage (small depressions that naturally retain water).

Waffle Storage Estimates

- Conservative estimate:
  583,400 acre-feet
- Moderate estimate:
  2.19 million acre-feet
- The flood reduction effects of these storage volumes, as well as varying percentages of these volumes, were evaluated using models.

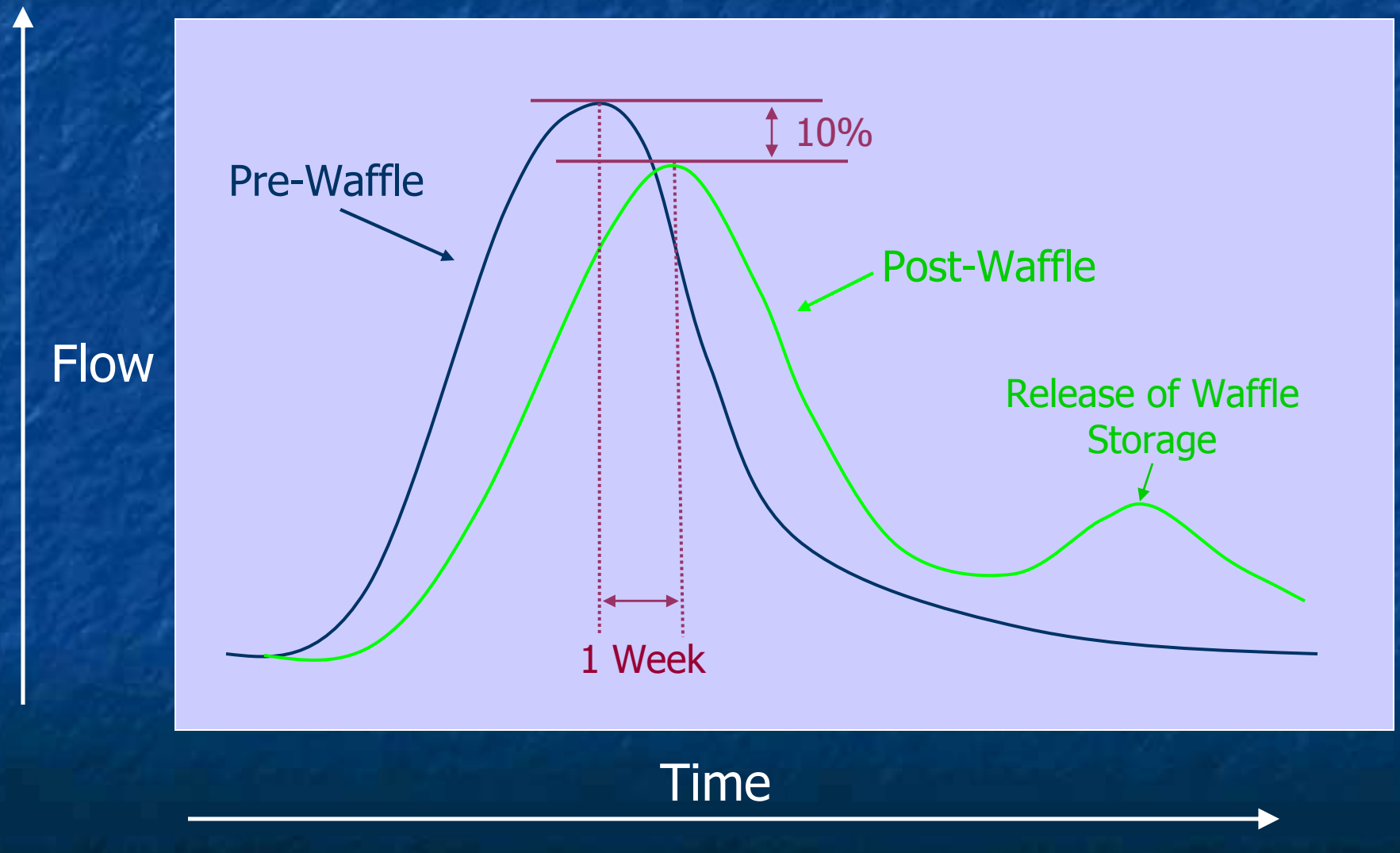
Modeling Goals

- To determine how much Waffle storage would reduce peak flows at various points along each of the Red River tributaries.
  - Soil and Water Assessment Tool (SWAT)
- To evaluate how peak flow reductions in the RRB tributaries would impact Red River flood stage during various flood events.
  - Hydrologic Engineering Center's River Analysis System (HEC-RAS)
  - Developed jointly with the Army Corps of Engineers

Estimated Peak Flow Reductions in the Tributaries During a 1997-Type Flood

- Moderate storage estimates
  - Average peak flow reduction of 33%
  - Ranged from 6% to 96%
- Conservative storage estimates
  - Average peak flow reduction of 13%
  - Ranged from <1% to 59%

Example Post-Waffle Hydrograph: Peak Flow and Timing Changes



Estimated 1997 Red River Flood Peak Stage Reductions

Location	Stage Reduction (feet)		
	Moderate Storage Estimate		Conservative Storage Estimate
Wahpeton	1.5		0.3
Fargo–Moorhead	4.5		3.6
Grand Forks	5.0		2.0
Drayton	2.3		1.0

Economic Analysis

- Conducted by economists at North Dakota State University (NDSU).
- Goals:
  - Provide a first assessment of the cost-effectiveness of the Waffle.
  - Develop estimates of potential mitigated flood damages (benefits) of the Waffle.
  - Develop estimates of the costs of implementing and maintaining the Waffle.

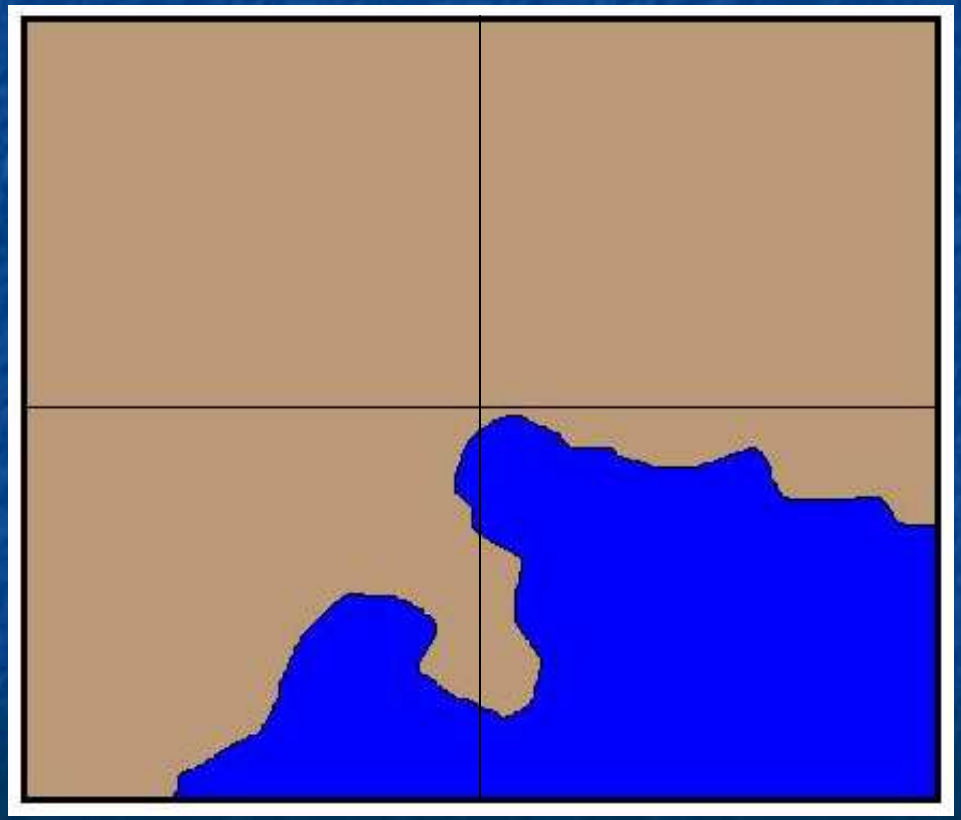
Waffle Cost Estimates

Included:

- Landowner reimbursements
  - Retainer payments
  - Water storage payment
- Estimated expenses for structural modifications
- Site maintenance
- Administrative cost
- Enrollment expenses

Payment Acreage Estimates

Include flooded acreage *plus* land that may be inaccessible as a result of water storage.



Waffle Cost Estimates

- Determined over a 50-year time period and adjusted for inflation accordingly.
- Evaluated three scenarios – a baseline scenario, plus an optimistic and a pessimistic scenario.

Example Input Values for Key Variables and Parameters for Baseline, Optimistic, and Pessimistic Scenarios on Waffle Costs, 50-year Period			
	Value Used for Input Variables		
Input Variable	**Optimistic Scenario**	**Baseline Scenario**	**Pessimistic Scenario**
Enrollment Cost per Section (start-up)	$1000	$1500	$2000
Landowner Retainer Payment per Acre per Contract (% of cash rent)	100%	125%	150%
Length of Enrollment Contract	10 years	10 years	10 years
Landowner Payment per Acre When Water Is Stored (% of cash rent)[a]	125%	175%	250%
Average Administrative Expenses/Year	$200,000	$250,000	$350,000

[a]Payments made only when water is stored.

Waffle Benefits

- Based on U.S. Army Corps of Engineers' flood stage/damage functions.
- Modeling results were used to determine the stage reductions (and resulting damages avoided) at key locations along the Red River, including Wahpeton–Breckenridge, Fargo–Moorhead, Grand Forks–East Grand Forks, and Drayton.

Estimated Net Waffle Benefits

- The net benefits were positive in 106 of the 108 scenarios evaluated.
- Close to half of the scenarios had net benefits in excess of $500 million; 85% had net benefits in excess of $300 million.
- The primary beneficiary was Fargo.
- Potential local benefits (such as reduced damage to roads or to smaller communities) were not included.

Key Conclusions

Conclusions

- Waffle storage could significantly reduce peak stream flows and river stages during major springtime floods.
- The Waffle could provide an augment for existing means of flood protection and provide flood relief for rural areas.
- Only a small percentage of land (1.5% to 5.3% of the RRB) would be used for water storage.

Conclusions

- The total volume of runoff would be reduced (by an average of 38% in the field trials) as a result of infiltration and evaporation.
- The Waffle appears to be economically feasible to mitigate flooding in larger cities. An economic evaluation should be conducted to determine the economic benefits of the Waffle for mitigating localized damages.