Summary: Preliminary project scaling assessment

Scaling assessment purpose

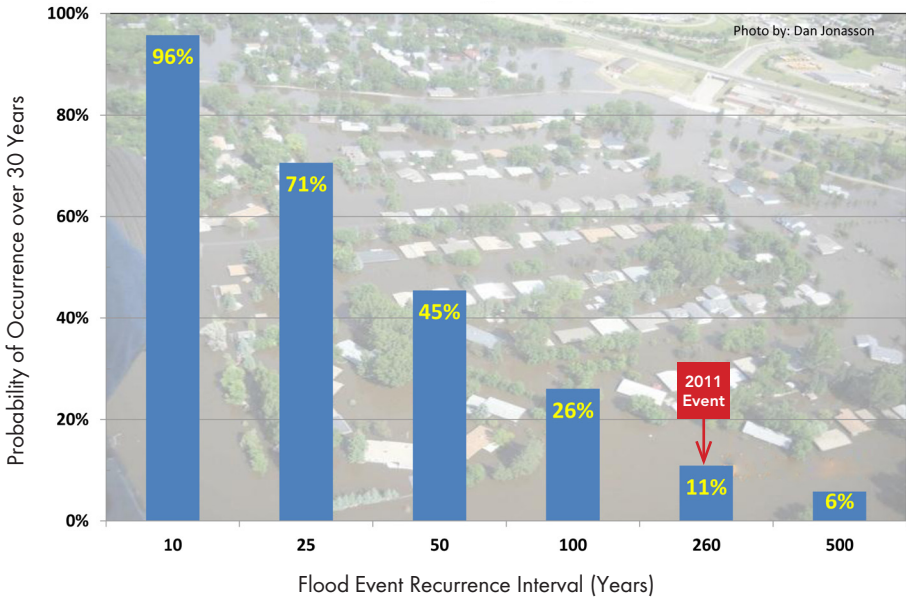
In the aftermath of the destructive 2011 flood, the North Dakota State Water Commission retained an engineering team to develop a plan that could better protect the Mouse River community from future flooding events of similar magnitude (27,400 cfs). The resulting preliminary engineering report (PER) outlined a preliminary alignment for levees and floodwalls, as well as engineering, environmental, and cost considerations for implementation (Barr 2012).

Following the PER development, the Minot City Council passed a resolution adopting the PER project footprint and raised questions about the cost-saving potential of designing to a lesser flow. The purpose of this project scaling assessment is to evaluate the feasibility of decreasing project costs by reducing the design flows to 10,000, 15,000, and 20,000 cfs. In addition to costs, flood risk must also be considered when designing flood risk reduction measures to lower design flows (Figure 1).

PER alignment

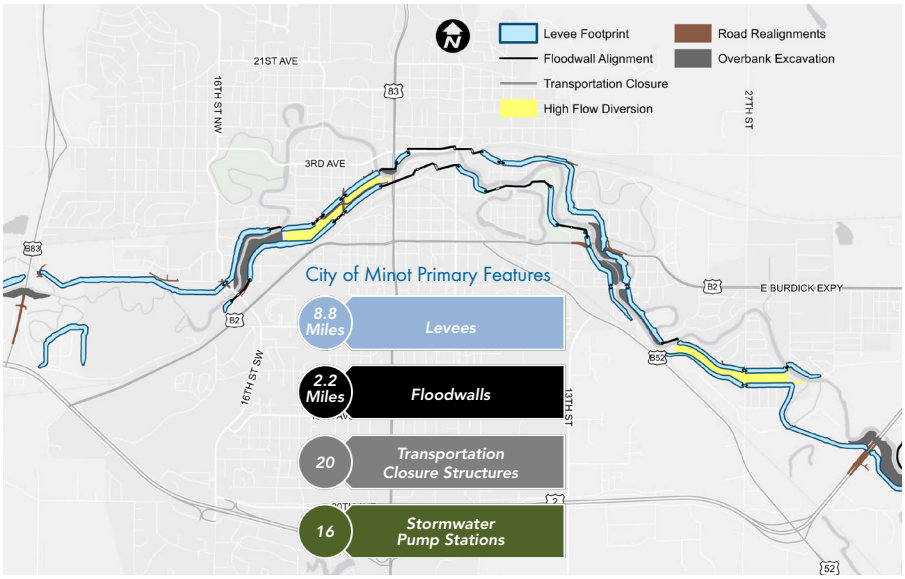
The preliminary alignment extends from Burlington to Velva, including Mouse River Park. Levees comprise almost 90 percent of the alignment, totaling 21.6 miles. The remainder of the alignment consists of 2.8 miles of floodwalls and 30 transportation closure structures. In addition, the project would require 33 stormwater pump stations. The alignment of the project through the City of Minot and corresponding flood reduction features are shown in Figure 2.

Figure 1: Likelihood of a given flood event occurring over a 30-year average mortgage



There is a 26% chance that the 5,000 cfs (FEMA's effective 1% annual chance event) flow will occur over the standard 30-year mortgage time frame. FEMA has classified the 2011 Mouse River flood event as a 260-year event in Minot. The annual exceedance probability for this event is 1/260, or 0.38%. Since the probabilities of annual occurrence accumulate over time, the probability of the 260-year event occurring over a 30-year time span (the average length of a home mortgage) is about 11 percent.

Figure 2: PER alignment and features through the City of Minot



The design water surface elevation used in the PER to define the required height for levees and floodwalls shown here was based on the record flow of 27,400 cfs. In addition, 3 feet of freeboard was incorporated into the PER design.

Figure 3: PER Opinion of cost breakdown
Total project cost per reach and itemized cost for Minot

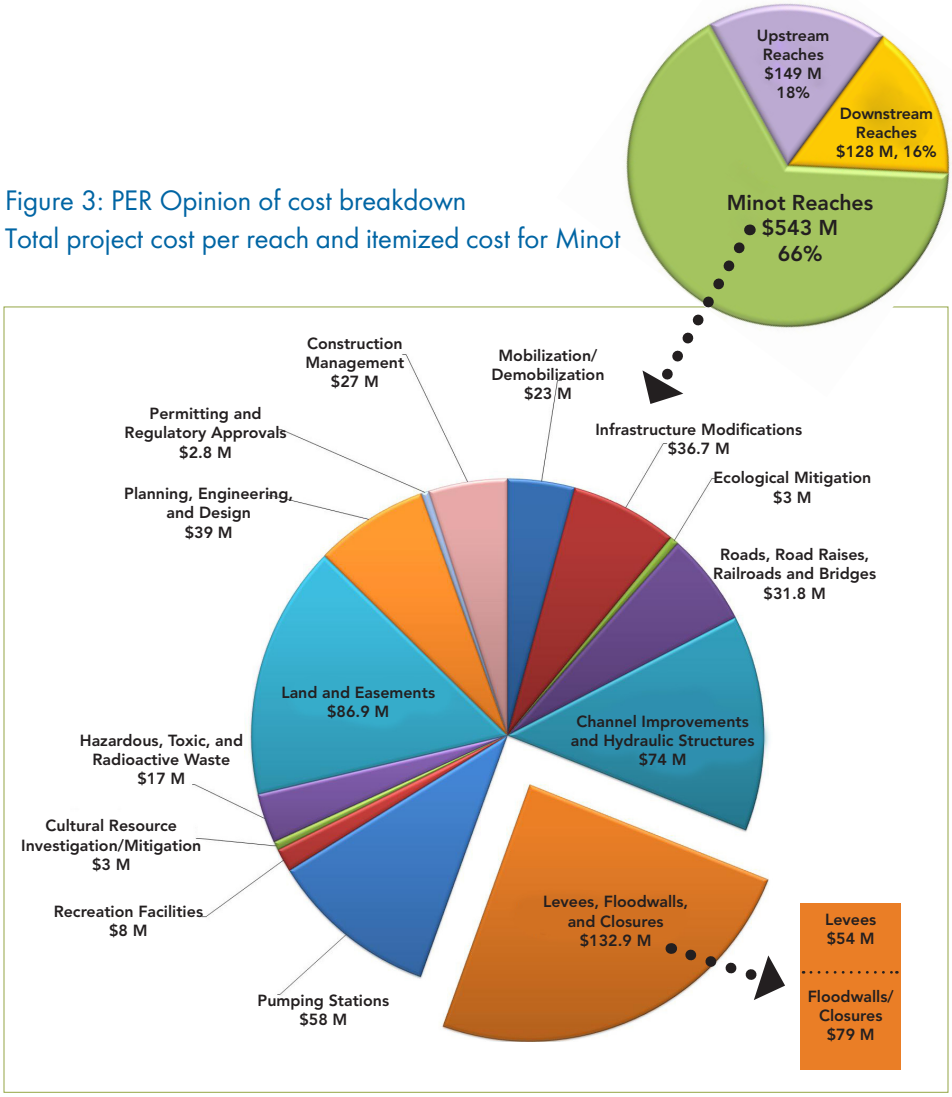
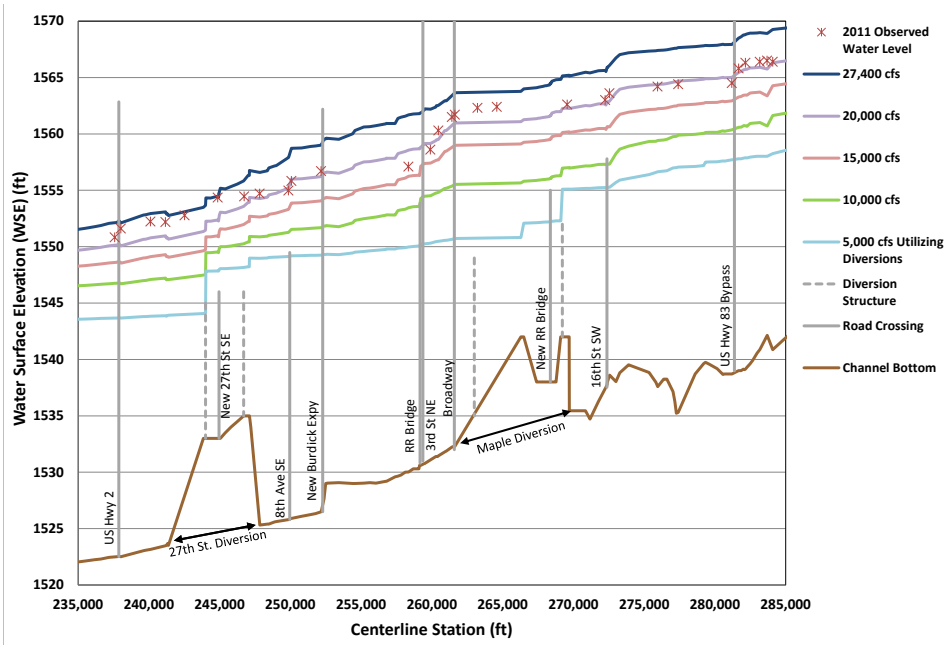


Figure 4: Water surface profile through Minot with PER alignment



Costs

The engineer's opinion of probable cost (OPC) for the PER alignment and associated features is $820 million, based on February 2012 price levels. The portion of the project that is within the City of Minot accounts for $543 million, or 66% of the overall cost (Figure 3). Approximately $133 million (24%) of the Minot cost is for construction of levees, floodwalls, and transportation closures. Floodwalls and closures account for $79 million; $54 million is for levees. These costs can be expected to decrease with a reduction in design flow.

Costs related to planning, engineering, and design ($39 million) and construction management ($27 million) would also be affected by a change in levee height, but not in direct proportion to the reduced height or construction quantities. Combined with levees, floodwalls, and closures, these costs account for approximately $199 million, or 27% of the Minot reaches. The remaining 63% of costs related to Minot reaches would not be directly affected by lowering the design elevations of the flood risk reduction features.

Design elevations of flood risk reduction features

The calibrated HEC-RAS hydraulic model developed for the PER was used to estimate the water surface profiles for the reduced design flows and resulting top-of-feature elevations through Minot (see Figure 4). Water surface profiles were developed for the following flows:

Design Flow (CFS)	Average Feature Height	Average Height Reduction
10,000	7 feet	7 feet
15,000	9 feet	5 feet
20,000	11 feet	3 feet
27,400	14 feet	N/A

Three feet of freeboard was assumed for all design flow scenarios.

Flood risk reduction corridor

In April 2012 the Minot City Council passed a resolution to adopt the alignment/footprint developed for the PER. This project scaling assessment assumes that the project corridor would not change from the PER footprint, including the clear zone area between the levees and the outside limits of land acquisition.

It is also assumed that the extents and costs of property acquisition through Minot will be those presented in the PER. It's important to note that a reduction in the levee footprint would not, necessarily, result in significantly fewer acquisitions (and subsequent cost savings). Because the project needs to provide the ability to ultimately reduce the risk of flooding for flows up to 27,400 cfs, a reduced footprint for the permanent features would still need to be supplemented with adequate space to build the project to the flood of record at some time in the future.

Scaling scenarios

Two reduced levee geometry scenarios and one reduced floodwall scenario were considered for this assessment. The first levee geometry assumes that only the permanent levee top elevation would be reduced (Figure 5). For this geometry, emergency flood fighting would require building up the cross section atop the permanent levee section.

The second levee geometry assumes the top-of-permanent-levee elevation and the cross section on the dry side are changed (Figure 6). For this geometry, emergency flood fighting would require building up the cross section atop the permanent levee section and along the dry side of the section.

In both cases, the top elevation assumed is based on the water surface elevation modeled for the revised design flow, plus 3 feet of freeboard.

Figures 7 and 8 show costs for both levee geometries, with and without reductions in floodwall elevations.

Figure 5: Levee geometry A

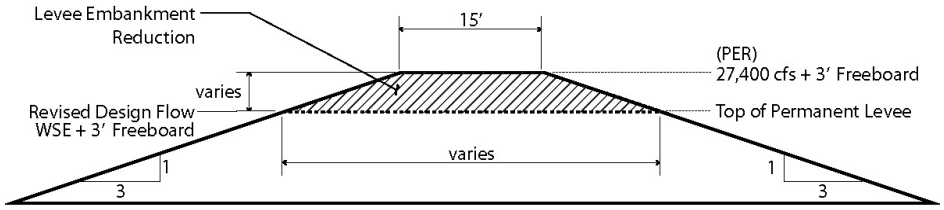


Figure 6: Levee geometry B

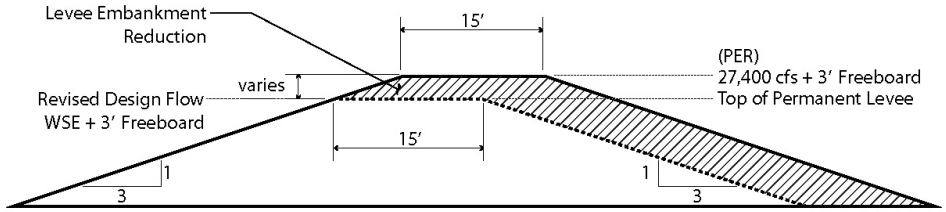
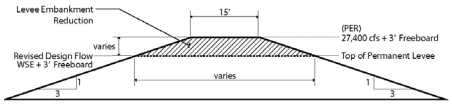


Figure 7: Levee geometry A costs



Levee scaling only

Design Flow (CFS)	Cost ($) Millions	Reduction from PER
10,000	534.6	-1.6%
15,000	538.7	-0.8%
20,000	541.0	-0.4%

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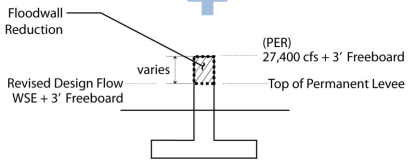

Floodwall scaling only

Design Flow (CFS)	Cost ($) Millions	Reduction from PER
10,000	528.3	-2.7%
15,000	535.8	-1.3%
20,000	538.8	-0.8%

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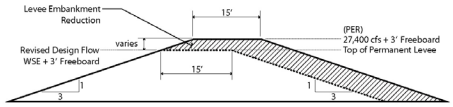
Levee and floodwall scaling

Design Flow (CFS)	Cost ($) Millions	Reduction from PER
10,000	519.8	-4.3%
15,000	531.4	-2.1%
20,000	536.9	-1.1%

Figure 8: Levee geometry B costs



Levee scaling only

Design Flow (CFS)	Cost ($) Millions	Reduction from PER
10,000	527.1	-2.9%
15,000	531.5	-2.1%
20,000	535.9	-1.3%

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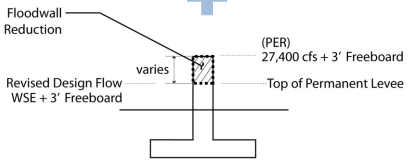

Floodwall scaling only

Design Flow (CFS)	Cost ($) Millions	Reduction from PER
10,000	528.3	-2.7%
15,000	535.8	-1.3%
20,000	538.8	-0.8%

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Levee and floodwall scaling

Design Flow (CFS)	Cost ($) Millions	Reduction from PER
10,000	512.3	-5.6%
15,000	524.3	-3.4%
20,000	531.7	-2.1%

As shown in Figure 7 and 8 above, the reduction in costs for levee and floodwall scaling are estimated to be less than 6 percent of the project cost for PER Minot reaches (OPC of $543 million).

Flood fighting implications for a scaled-down project

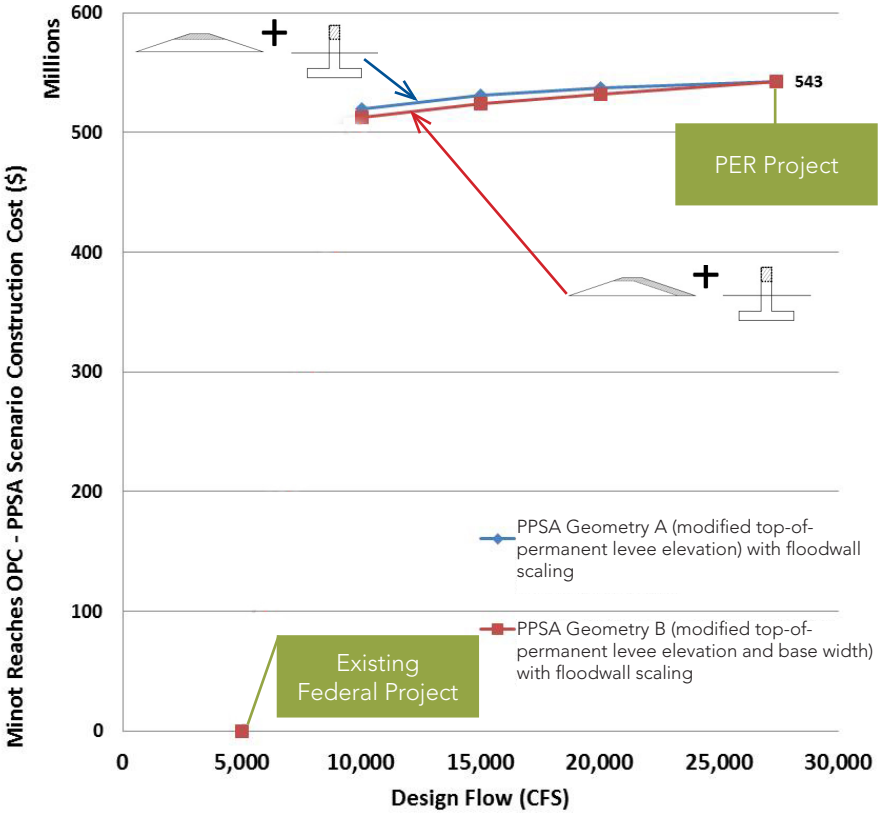
- **Modifications on short notice will be difficult:** Modifications to floodwalls, closure structures, pump stations, and other "hard" structures may not be possible on compressed timelines, such as during an emergency flood fight.
- **Little time/few resources available:** In a scenario similar to the 2011 event, the time to conduct a flood fight is likely to be very short (less than a week). Suitable material to raise more than 8 miles of levees may be difficult to find and deliver to needed locations on short notice, especially as property development continues in the Minot area.
- **Public complacency:** During a dry cycle, the public perception of flood risk may be greatly reduced. As time passes, and with immediate and pressing needs for resources, there may be a failure to recognize the need for further upgrading the flood risk reduction system. In addition, there could be a reluctance to go through the disruption of a flood fight until it is too late to be effective (i.e., the flood waters are too high).

Conclusion

The maximum estimated cost savings from reducing the permanent levee and floodwall top elevation for the Minot portion of the Mouse River flood risk reduction project from a design flow of 27,400 cfs to 10,000 cfs is less than 6 percent ($30.7 million). The assumptions for this assessment include the provision to allow future build out, up to 27,400 cfs. Therefore, it is necessary to retain the same project alignment and right-of-way acquisition that was used in the PER. By reducing the design flow, the area and number of properties without permanent flood risk reduction is greatly increased. There will also be significantly increased levels of effort, cost, and time associated with emergency efforts to raise these levees during a flood fight. Figure 9, below, illustrates the relatively small proportion of cost savings associated with the reduced top elevations of flood risk reduction features.

Figure 9

Estimated total project costs
Minot reaches OPC: Levee geometries A and B with floodwall scaling



Reference:

Barr Engineering Co. 2012. Mouse River Enhanced Flood Protection Preliminary Engineering Report .