Central Platte NRD Hazard Mitigation Plan: Grand Island Region Flood Risk Assessment

Prepared by:

John Callen, PE, CFM:
jcallen@jeo.com
402.474.8765

Chris Shultz, PE:
cshultz@jeo.com
785.806.9733

JEO Consulting Group, Inc.
11213 Davenport St., Suite 200
Omaha, NE 68154
402.934.3680; Fax 402.934.3681

Offices in Nebraska, Iowa, and Kansas

JEO Project No. 191602.00

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1.0 BACKGROUND AND EVALUATION PURPOSE

The City of Grand Island (City) in Hall County, NE (County) experienced significant flooding in May 2005, causing an estimated $15 - $20 million in damages to the City, County, and agricultural landowners. During this period, an effort was underway by the Central Platte NRD (NRD) to evaluate flood risk for the City and develop a flood risk mitigation strategy. The flood of May 2005 gave momentum to implementation of the flood risk reduction strategy for Upper Prairie, Silver, and Moores Creeks near the City which resulted in development of a multi-year, multi-phase flood risk reduction project consisting of four upland dry dams, a large lowland detention cell, and a levee intended to provide flood risk reduction for the City. An overview of the Upper Prairie Silver Moores Flood Risk Reduction project (UPSM project) can be seen on Figure 1.1.

As this project was being completed and final elements finishing construction, a significant region wide flood event occurred in March 2019. The UPSM project performed well and provided significant flood risk reduction to the City and the surrounding region. However, due to the size and scale of the flooding event as well as unexpected flooding impacts from flood water originating outside the Silver Creek Watershed, there were areas along Silver Creek and Moores Creek near the City impacted by flooding. After the event, the NRD recognized that due to limitations of prior flood modeling combined with previously unknown or unclear flood risk sources that caused impacts due to the magnitude of the flood event, there was a need to identify regions of residual flood risk even with the UPSM project in place and develop a targeted flood risk reduction strategy for these regions. To facilitate the development of a targeted flood mitigation strategy through a localized flood risk assessment in the regions with residual flood risk, the NRD requested and was allocated additional funding through the FEMA Pre-Disaster Mitigation Grant (PDM) program as part of the NRD's Multi-Jurisdictional Hazard Mitigation Plan (HMP) 2022 update.

Based on the flooding observations and impacts experienced during the March 2019 flood event as provided by the City, County, and NRD as well as nearby potential impact areas, additional risk assessment was completed for selected areas along Silver Creek and Moores Creek. An overview of the areas of interest is shown on Figure 1.2, and an overview of the Hall County damage assessment observations from March 2019 is shown on Figure 2.4. A summary of these locations and known flooding impacts is provided below:

1. Area 1 - Residential properties near Silver Creek along W. Airport Road and North Road just north of Highway 2, northwest of Grand Island. Some of these properties were impacted by flooding from Silver Creek and Prairie Creek during the flood of March 2019.
2. Area 2 – Residential properties near Moores Creek along St. Paul Road and E. White Cloud Road northeast of Grand Island. There were not any known impacts to these properties due to the March 2019 flooding, but their location near Moores Creek suggests they could be at risk of future flood damages.
3. Area 3 – Commercial properties near the Grand Island Airport northeast of Grand Island. These properties are near drainage area that contributes to Moores Creek. In March 2019, this area was impacted by flooding; however, it is unclear whether the flooding originated from nearby stream channels or was from localized pluvial impacts generated by direct rainfall.

To support the flood risk assessment for these regions, JEO obtained available flood risk models and utilized them to develop additional flood risk scenarios based on March 2019 flooding observations. These included adding in considerations such as overflows from Prairie Creek to Silver Creek and Wood River to Silver Creek. This was completed to ascertain the scope of these impacts on the areas of interest and to support adequate identification of potential flood risk reduction mitigation actions.

JEO also utilized these flood risk models in conjunction with best available LiDAR, parcel and building footprint GIS data to complete an assessment of the potential for flooding impacts to buildings in the areas of interest. This evaluation was supplemented by a field visit which focused on verification of field conditions for the buildings such as step counts from existing grade to the first floor and a review of flood impact vulnerabilities. The analysis and field visit observations were combined to produce an assessment of flood impact risk and frequency for each building in the areas of interest.

The findings of the flood risk modeling and building risk assessment were then used to identify both structural and nonstructural flood risk reduction recommendations for the areas of interest. A summary and reference of this report will be incorporated into the 2022 NRD HMP. The City, County, and NRD will provide final approval on the flood risk reduction recommendations to be included in their respective mitigation strategy of the HMP.

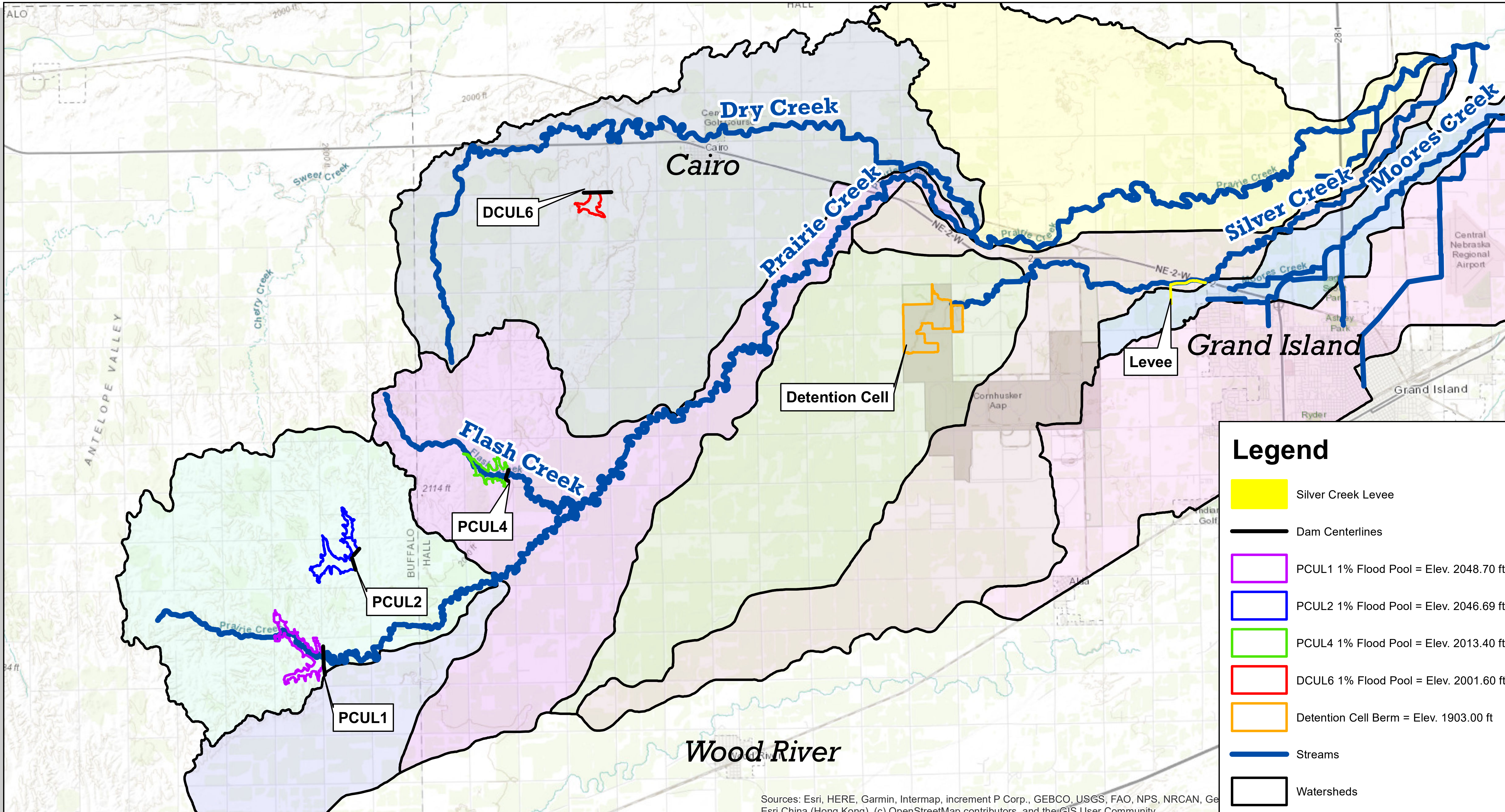

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Figure 1.1: Project Locations

Upper Prairie/Silver/Moores Creek Flood Control Project

0 1 2 4 Miles

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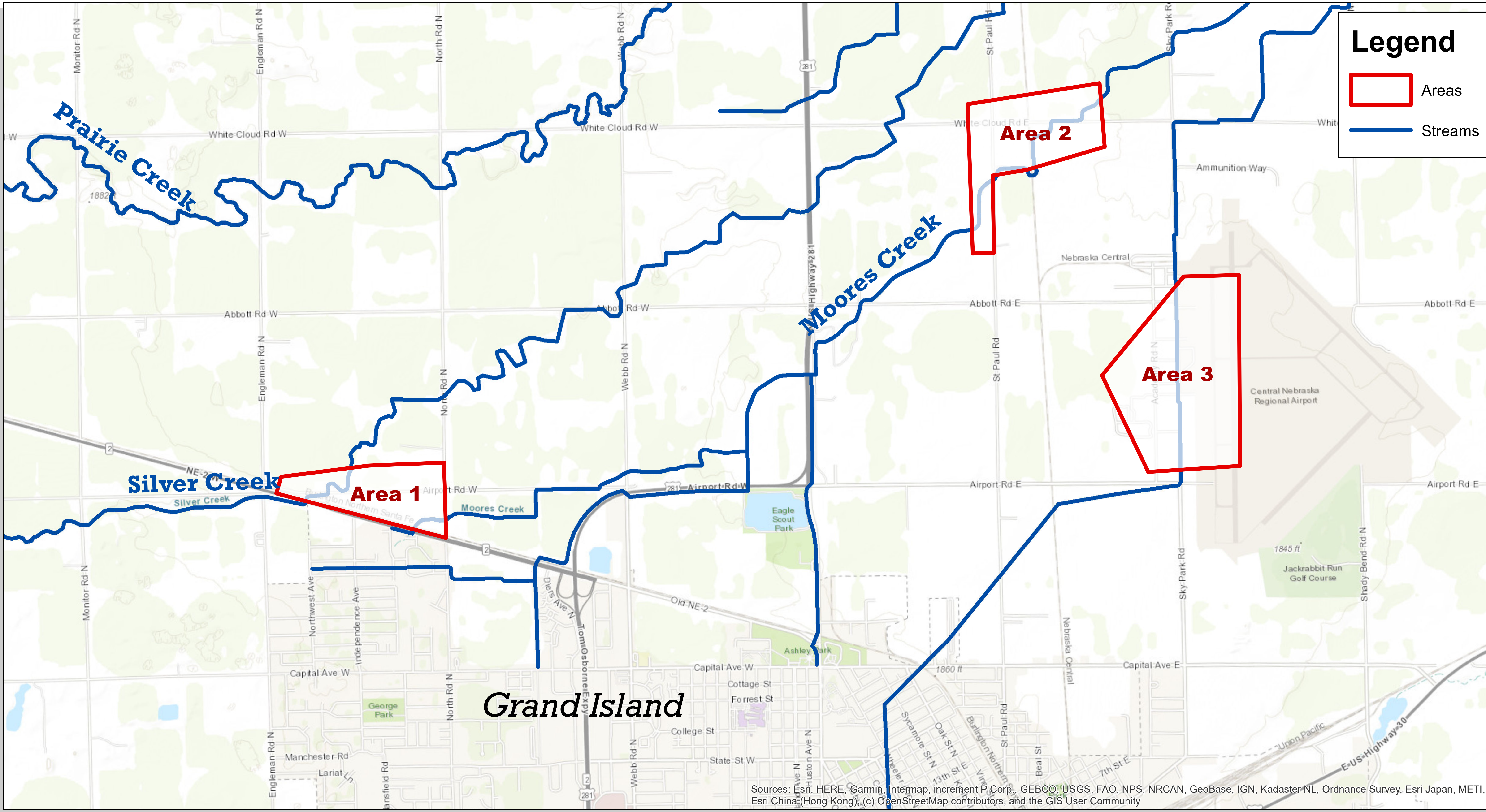

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Figure 1.2: Areas of Interest

Hall County, Nebraska

0 0.25 0.5 1 Miles

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2.0 BACKGROUND DATA REVIEW

To support flood risk assessment and set mitigation action priorities, JEO reviewed the best available flood risk modeling and mapping along with observations from the flooding of March 2019 for the region of the UPSM project and downstream. JEO also completed a field visit to identify any observations with the potential to support or modify conclusions reached through the flood model review, and to assist with the identification of potential flood risk reduction alternatives.

2.1 EFFECTIVE FIRM AND PRIOR MODELING

As part of the risk assessment background review, the effective FEMA Flood Insurance Rate Map (FIRM) floodplain was used as a guide and comparison for the model throughout the project. As part of past project work, a Letter of Map Revision (LOMR) was completed on Silver Creek based on the UPSM project benefits simulated within a HEC-HMS hydrology model and 1-Dimensional (1D) HEC-RAS hydraulic model; this LOMR is currently the effective FIRM for the primary benefit region of the UPSM project. Figure 2.1 shows the current effective floodplains for portions of Prairie Creek, Silver Creek, and Moores Creek north of Grand Island as shown on the LOMR/FIRM. At the time of development, the HMS and 1D RAS models used to develop the effective floodplains were the typical standard flood study approach and aligned with typical FEMA floodplain mapping. However, HMS based stream routing and 1D hydraulic models have potential limitations in accurately modeling split flows and basin overtopping, especially in low relief terrain such as in the Grand Island region. These limitations may have important ramifications, most importantly the potential for the model to overestimate or underestimate distribution of flows within a particular basin or region and therefore flooding extents.

2.2 OTHER FLOODING BACKGROUND DATA AND UTILIZATION

Flooding in March 2019 caused widespread damage across Nebraska including within the NRD and the Grand Island region of Hall County. The extent of damage was reduced by the substantially completed UPSM project. However, due to the size and scale of the flooding event as well as unexpected flooding impacts from flood water originating outside the Silver Creek Watershed, there were areas along Silver Creek and Moores Creek near Grand Island impacted by flooding. Observations from the flooding were obtained and used as much as possible to inform the flood risk assessment discussed in Section 3.0.

Despite the lack of stream gages within the project area, multiple observations taken by City, County, and NRD staff during the March 2019 flood event provided critical information about where the flooding occurred and location of flows during the event. One critical observation from the flooding was a video taken from a drone along the UPSM project levee. The video, taken well above the ground, shows the widespread inundation which was used to adjust and validate the modeling to the extent possible with available data. The video briefly shows one of the areas described below and continues upstream along the levee, assisting in identifying the source of the flows.

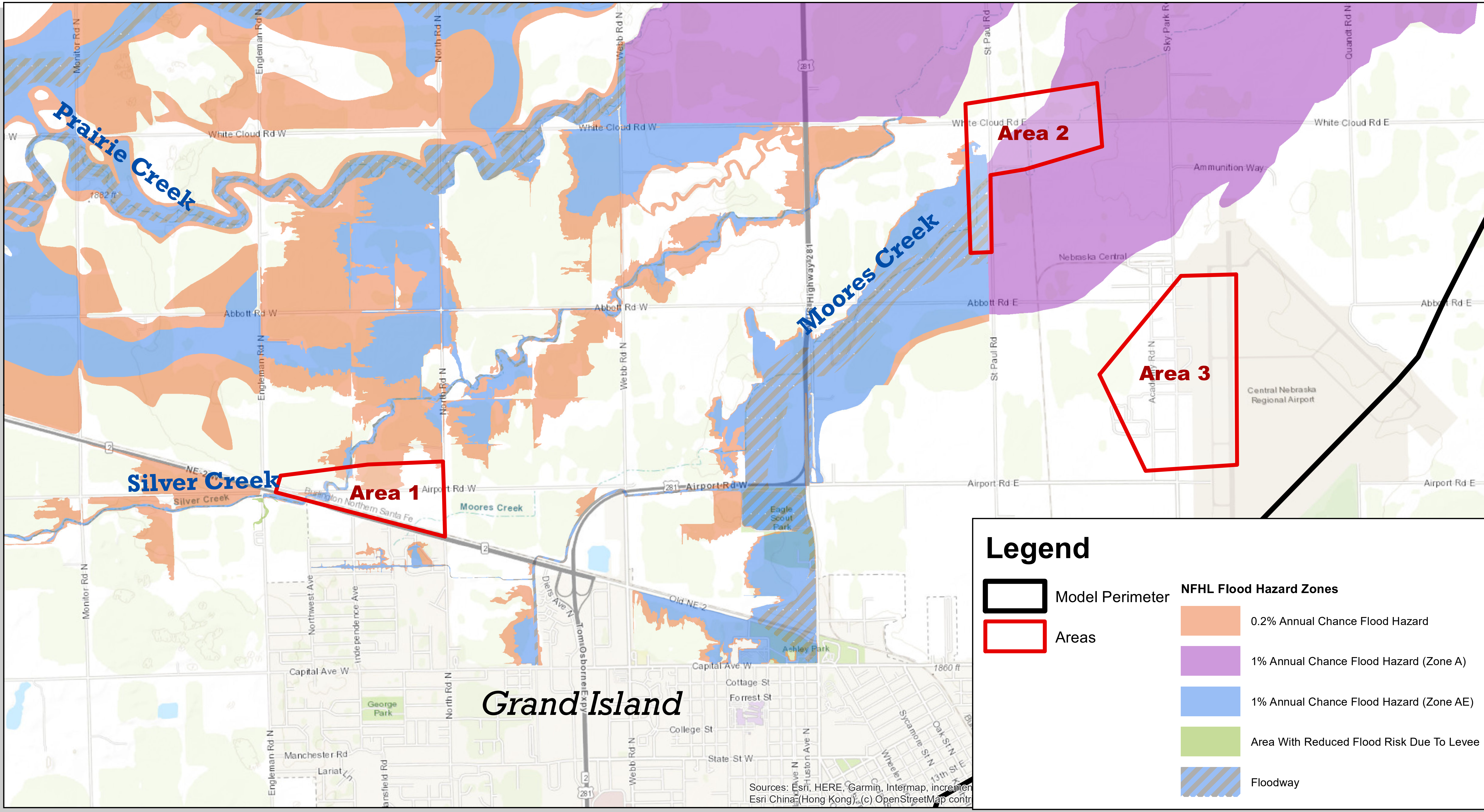

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Figure 2.1: Effective FEMA Floodplain Map

Hall County, Nebraska

0 0.25 0.5 1 Miles

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One of the most concentrated areas of flooding during the March 2019 event was in a neighborhood near Silver Creek along W. Airport Road and North Road just north of Highway 2 (discussed later as Area 1). Flooding occurred in several homes and outbuildings within the area. A still image taken from a drone flight on March 15th, 2019 is shown in Figure 2.2. The still image is looking northeast approximately above (downstream of) the crossing of Highway 2 over Silver Creek. Since the March 2019 flood, Hall County constructed a berm along Silver Creek between W. Airport Road and the Railroad tracks to protect a neighborhood that was affected by flooding. The top of the berm was surveyed which enabled it to be added to the model to simulate its flood risk reduction effects for future flooding as part of the flood risk assessment. Figure 2.3 shows simulated 100-Year flooding with and without the existing berm.

Hall County and the NRD also provided a written record and maps of flooding that occurred during the March 2019 event with dates and times. This information was important to establish the timing of basin overflows from Wood River and, alongside USGS gage 06772100 (Wood River at Grand Island, Nebraska), helped to establish the duration of the overflow. Additionally, Hall County made available their emergency management reported damage, which provided information about the location and scope of water damage at homes and businesses as well as overtopping of roads. Figure 2.4 shows the reported damage by type, north of Grand Island, near the areas of interest. It should be noted that much of the damage shown on the figure impacted public infrastructure such as docks on a lake and roadway overtopping (many of the points marked as Major Damage outside of Area 1). The damage assessment data provided served as a resource to compare observed flooding to modeled flooding throughout the modeled area. While some of the areas show little reported damage, the overtopped damage reporting validates the locations of out of bank flooding.

GOES satellite imagery was also reviewed to compare to simulated inundation over a large scale. While there was cloud cover (and therefore no available data) for the peak flooding, data from surrounding days helped validate the extent of flooding produced by the model. However, generally low resolution of the imagery relative to what is needed to see riverine flooding as well as impacts from vegetation above the height of the water surface significantly reduced the accuracy of the imagery and made it difficult to heavily rely on it for model adjustments.

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Figure 2.2: Drone Image 03/15/2019
Area 1: HWY 2 and Airport Road

Hall County, Nebraska

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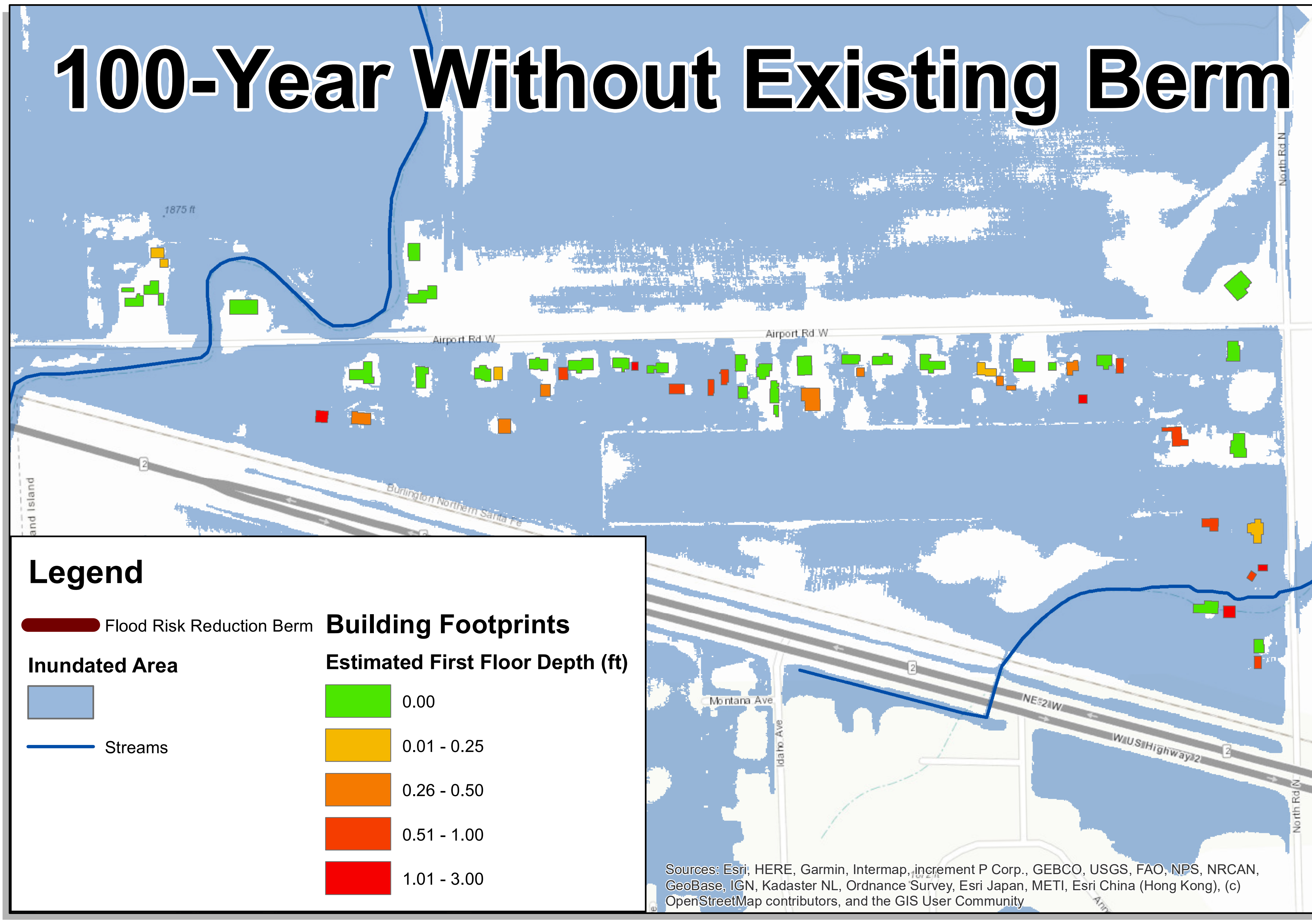

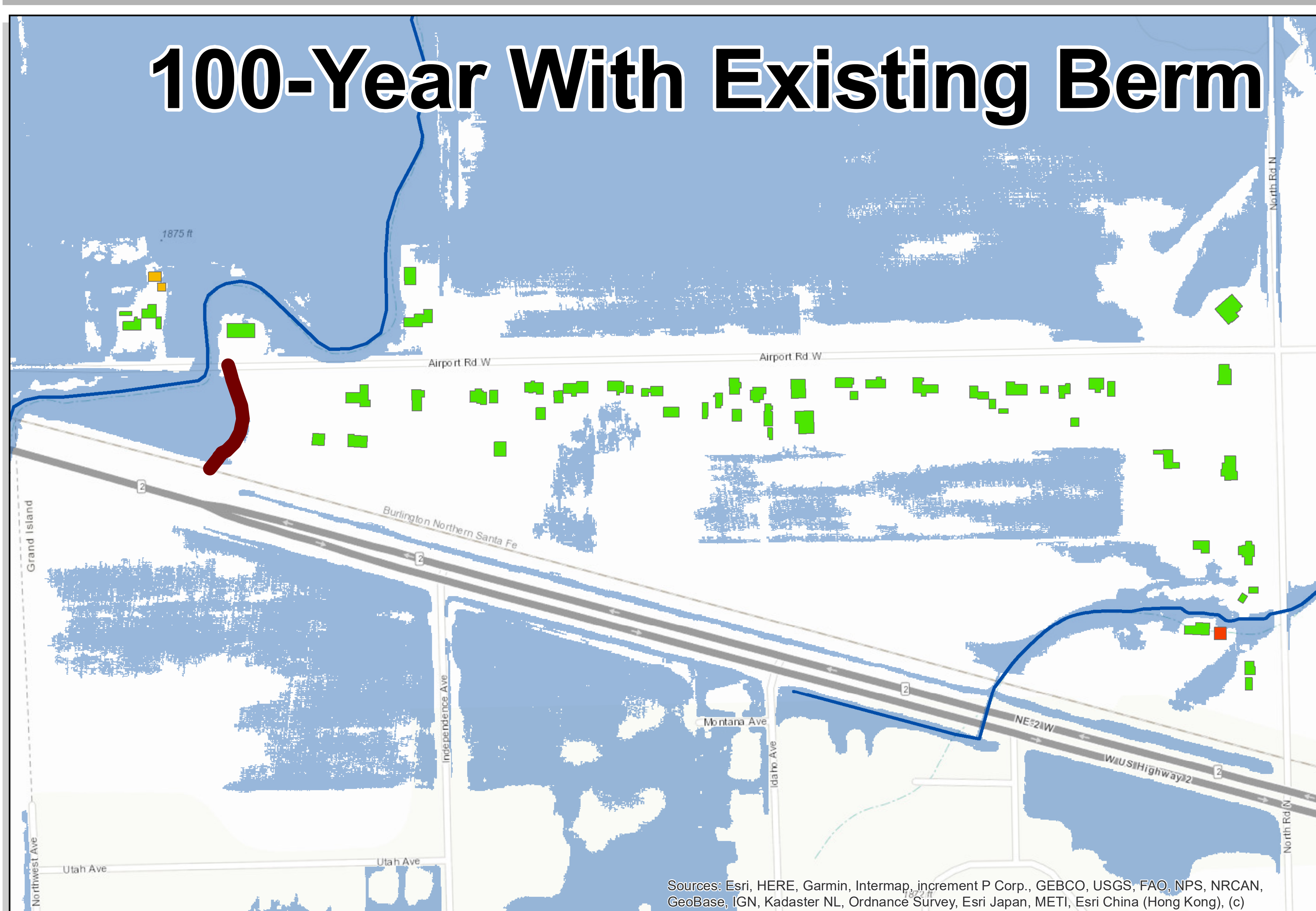

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Figure 2.3: With and Without Existing Berm

Area 1: HWY 2 and Airport Road

Hall County, Nebraska

0 125 250 500 Feet

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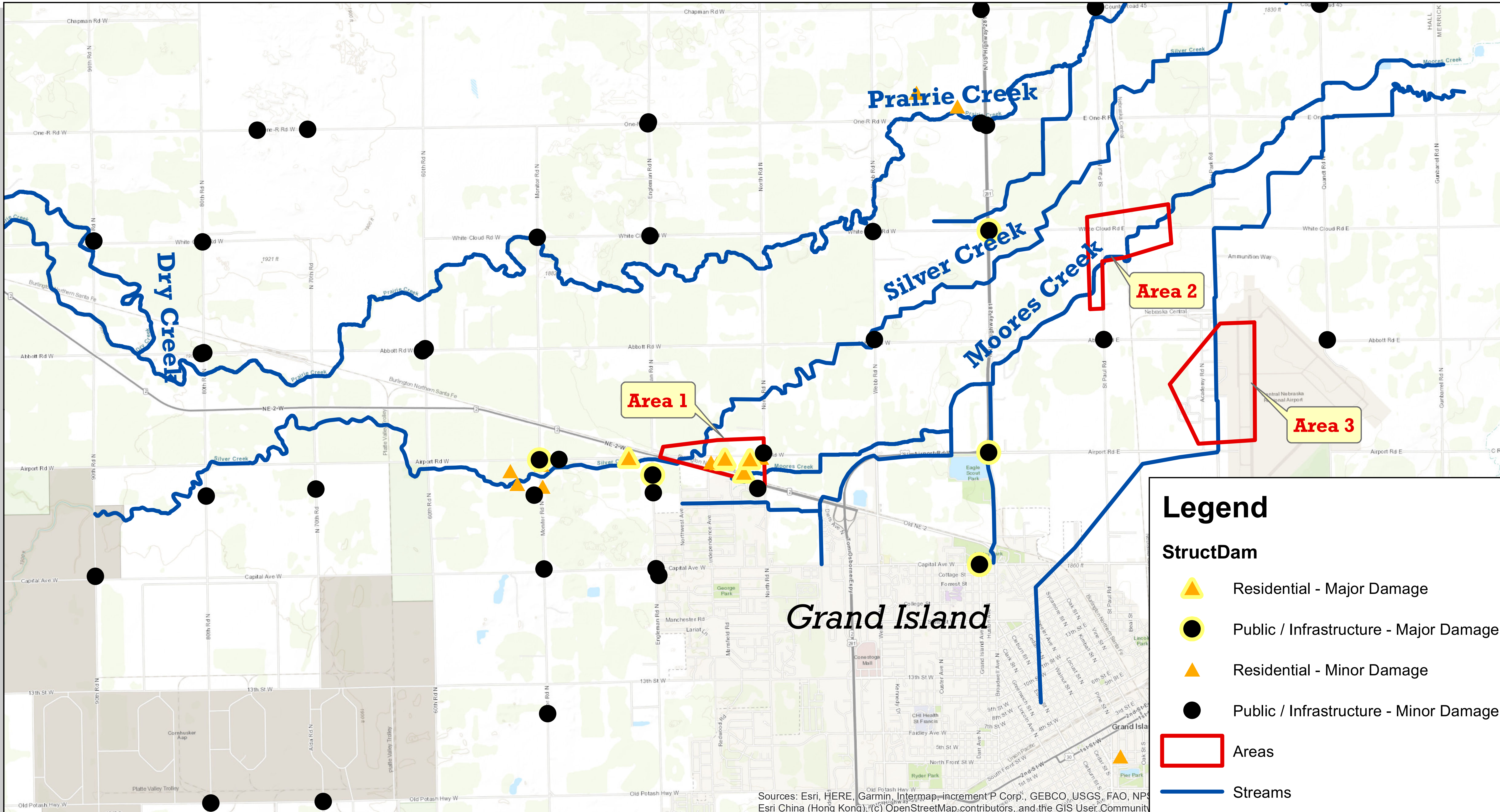

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Figure 2.4: Hall County Damage Assessment March 2019 Event

Hall County, Nebraska

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3.0 FLOOD RISK ASSESSMENT

3.1 AREAS OF INTEREST

Based on these flooding observations and impacts experienced during the March 2019 flood event as well as nearby potential impact areas, an additional risk assessment was completed for selected areas along Silver Creek and Moores Creek. An overview of the areas of interest is shown in Figure 1.2. A summary of these locations and known flooding impacts is provided below:

1. Area 1 - Residential properties near Silver Creek along W. Airport Road and North Road just north of Highway 2, northwest of Grand Island. Some of these properties were impacted by flooding from Silver Creek and Prairie Creek during the flood of March 2019. Flooding in Area 1 is shown in Figure 2.3. As shown in the figure, much of the flood risk observed during the March 2019 is already being mitigated by the addition of the berm. However, some residual risk remains as discussed in Section 4.2.1.
2. Area 2 – Residential properties near Moores Creek along St. Paul Road and E. White Cloud Road northeast of Grand Island. There were not any known impacts to these properties due to the March 2019 flooding, but their location near Moores Creek suggests they could be at risk of future flood damages. Also, based on discussion with the City, County, and NRD it is believed this region was impacted by flooding in May 2005. However, specific data sets or flooding observations supporting this were not immediately available for review.
3. Area 3 – Commercial properties near the Grand Island Airport northeast of Grand Island. These properties are near drainage area that contributes to Moores Creek. In March 2019, this area was impacted by flooding; however, it is unclear whether the flooding originated from nearby stream channels or was from localized pluvial impacts generated by direct rainfall. Data regarding structure flooding impacts from this flood event is limited and there were not any known significant damages.

3.2 HYDROLOGY AND HYDRAULICS

A 2-Dimensional (2D) HEC-RAS model was developed for the Upper Prairie, Silver, and Moores watersheds in order to evaluate past projects and current flooding risk. Figure 3.1 shows the geographic area used for the modeling, which covers the extents of the Prairie, Silver, and Moores creeks watersheds along with additional drainage that flows into the airport region (Area 3). The model mesh was created at a base 150 ft. by 150 ft. resolution with breaklines used to enforce high ground for roads, railroads, dams, etc. Major culverts and bridges near the areas of interest were added into the model as 2D Connections to ensure conveyance and backwater caused by the structures is accurately modeled. Special consideration had to be made for the numerous small culverts and bridges which were not included as crossings in the model but would impede water without being represented in the model. In these cases, numerous burns were made into the HEC-RAS terrain to simulate the flows through the culverts/bridges. The burns were sized based on visual inspection of imagery and street view, using the measure tool in HEC-RAS.

The 2D model was developed using rain-on-grid precipitation with simulated infiltration losses using the Green-Ampt method. The most recent baseline data was used for the modeling including 2018 LiDAR, 2019 NLCD land cover, and soils from Web Soil Survey. Generally, these data sets were updated compared to what was used for the LOMR and effective FIRM. Model terrain was based on the 2018 LiDAR with previous project areas overwritten with design surfaces for the dams, detention cell, and levee to ensure an accurate representation of the recent UPSM project. Manning's calibration regions were used to override stream Manning's roughness from the land use to ensure they were accurately represented.

The transition from the models used for the regulatory floodplain such as 1D models of the streams with HEC-HMS performing the hydrology separately, to 2D rain-on-grid with built in hydrologic calculations, coupled with available flood risk observation data from 2019, increased accuracy and reliability of the model results. The increased accuracy of the Manning's Equation compared to transform methods used in HEC-HMS for routed reaches resulted in higher peak stages and flows in higher relief areas of the model, while integrating infiltration with the rainfall, runoff, and hydraulic surface routing enables the model to go beyond floodplain evaluation and examine the effects of pluvial and flash flooding.

Once the 2D model was developed, it was reviewed and refined to ensure its accuracy and ability to replicate impacts from past flooding. One of the areas examined was Area 1, along Silver Creek near Airport Road. Here, flooding extended far beyond the extent of the regulatory floodplain, indicating that the source of floodwater may have originated outside of the Silver Creek basin. It was apparent due to the quantity of flows and inundated areas that overtopping from another basin must have occurred, either from Prairie Creek to the north or Wood River to the south. Careful evaluation of March 2019 observations informed model geometry adjustments (addition and enforcement of model breaklines) to ensure simulated flooding matched the observations. Prairie Creek is within half a mile of Silver Creek for a short distance upstream of the observed location, separated only by a highway embankment. The HEC-RAS model geometry was adjusted near Prairie Creek to ensure that the model correctly simulated the adjacent high ground; this altered the simulated overtopping and pushed flows into Silver Creek as observed. There were also likely basin overflows from Wood River into the Silver Creek Watershed; however, based on field observations during the 2019 flood, those overflows did not enter the Silver Creek drainage until after peak flows occurred along Silver Creek and therefore did not have a major effect on flooding. This finding does not necessarily indicate that Wood River overflows aren't important to flood risk considerations; however, it does appear that for the 2019 flood event and in general Prairie Creek overflows are the most immediate flood risk to the areas of interest. These observations, along with damage reports provided by Hall County proved crucial in refining and validating flooding throughout the modeled area.

Figure 3.2 shows areal inundation for the Silver Creek drainage area with and without Prairie Creek with FEMA effective flood zone classifications also shown for comparison. This shows that a large portion of the inundated area in and around Silver Creek is directly caused by the overflows from Prairie Creek, which was not considered in previous 1D floodplain modeling. The modeling indicates that of the approximately 2,220 cfs that is simulated to flow under Highway 2 in Silver Creek during the 100-Year event almost 75% of the peak flows result from basin overflows from Prairie Creek. It should be noted, Prairie Creek only contributes about 25% of the total flow volume of Silver Creek due to the short duration of the basin overflows. It also should be noted that these figures show flooding associated with floodplains for Silver and Prairie Creek, but also show pluvial flooding around the creeks associated with smaller drainages and overland flow; therefore, inundation in these maps will inherently not match regulatory floodplains. As shown in the table and maps in Figure 3.2, findings for Silver Creek only approximately align with the prior LOMR that focused on Silver and Moores Creek only. With the benefit of the March 2019 flooding observations and expanding the hydraulic modeling area of interest, additional detail regarding Prairie Creek overflows and associated impacts was identified.

While past efforts such as the UPSM project have helped significantly with flooding in the area (discussed in the next section), problem areas remain where flooding still poses a risk of loss of life and property. The three areas described above provide opportunities to reduce localized flooding and related flood damage. Using the refined flood model, ongoing and future flood impacts can be addressed. Table 3.1 shows the individual runs simulated with the modeling along with associated flow events. The Existing model run includes current conditions with the UPSM and the addition of the berm in Area 1, while With UPSM Project does not include the berm that was constructed after the March 2019 flooding. Without UPSM Project simulates the region and potential flooding impacts without the project levee, dams, or detention. All other runs are based on the Existing model with the berm included.

Table 3.1: Simulated Model Runs

Run Name	Flows Simulated
UPSM Project Assessment	
Existing Conditions	500-Year, 100-Year, 50-Year, 25-Year, 10-Year
With UPSM Project	500-Year, 100-Year, 50-Year, 25-Year, 10-Year
Without UPSM Project	500-Year, 100-Year, 50-Year, 25-Year, 10-Year
Sensitivity Assessment	
No Prairie Creek Overflows	100-Year
Saturated Soil	100-Year
Dry Soil	100-Year
Wood River Overflow	100-Year
Wood River High Overflow	100-Year
Mitigation Actions	
Modified Area 1 Berm	100-Year (Existing and Saturated Soil)
Prairie Creek Overflow Reduction Levee	100-Year
Highwater Railroad Bridge	100-Year
Area 1 Channel Realignment	100-Year
Area 1 Channel Cleaning	100-Year
Area 2 Improvements	100-Year
Area 3 Culvert	100-Year

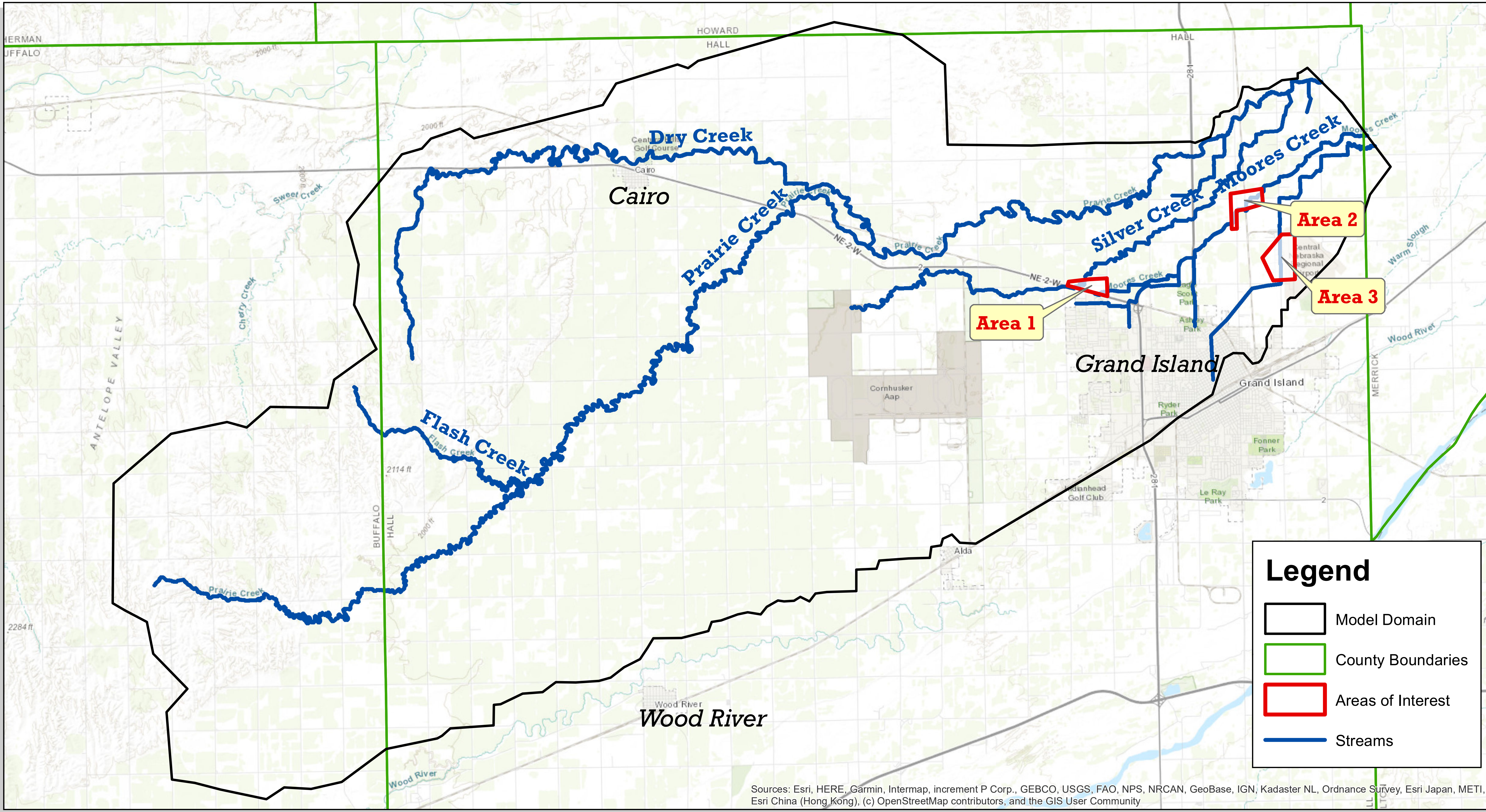

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Figure 3.1: 2D Model Domain

Hall County, Nebraska

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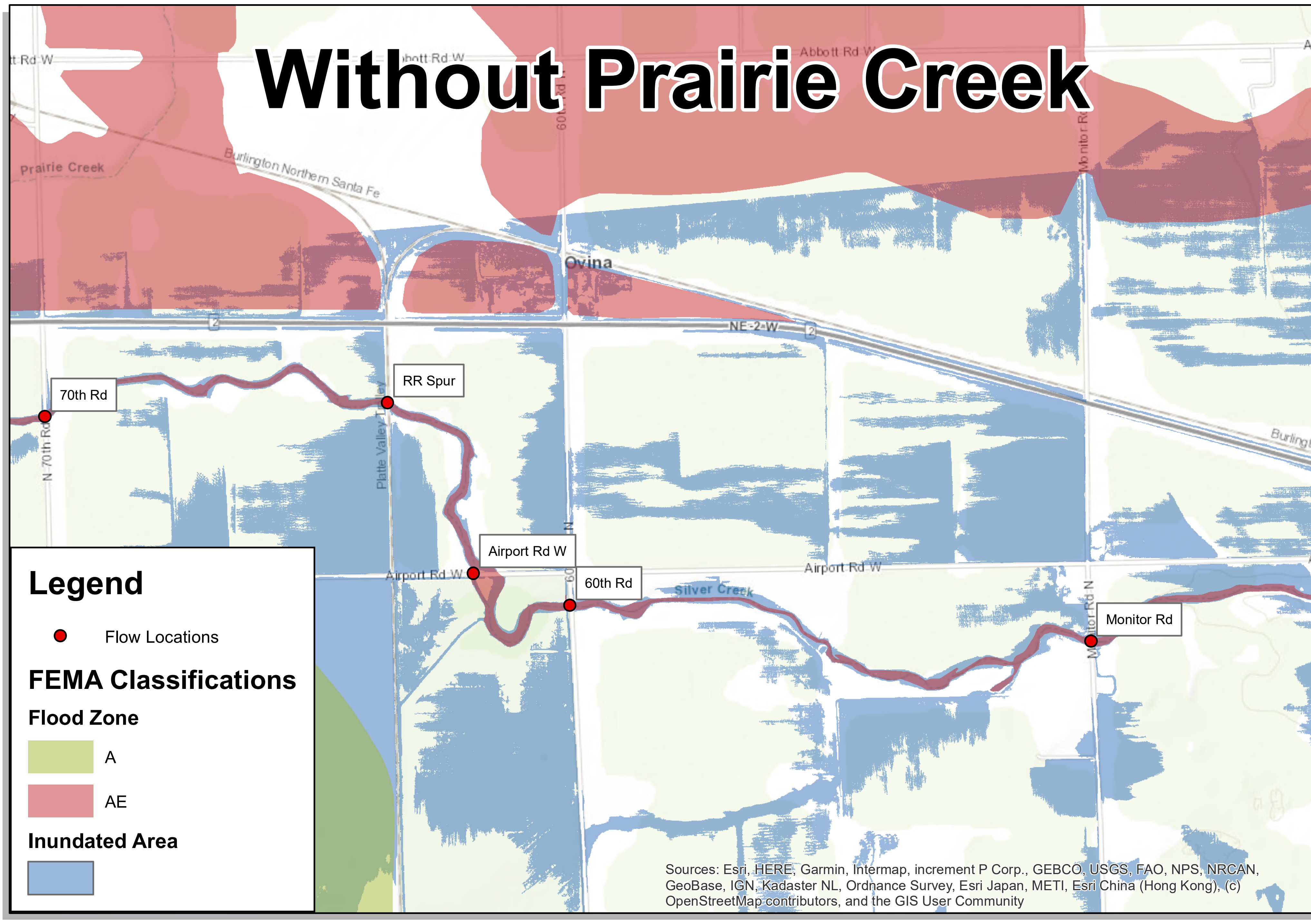

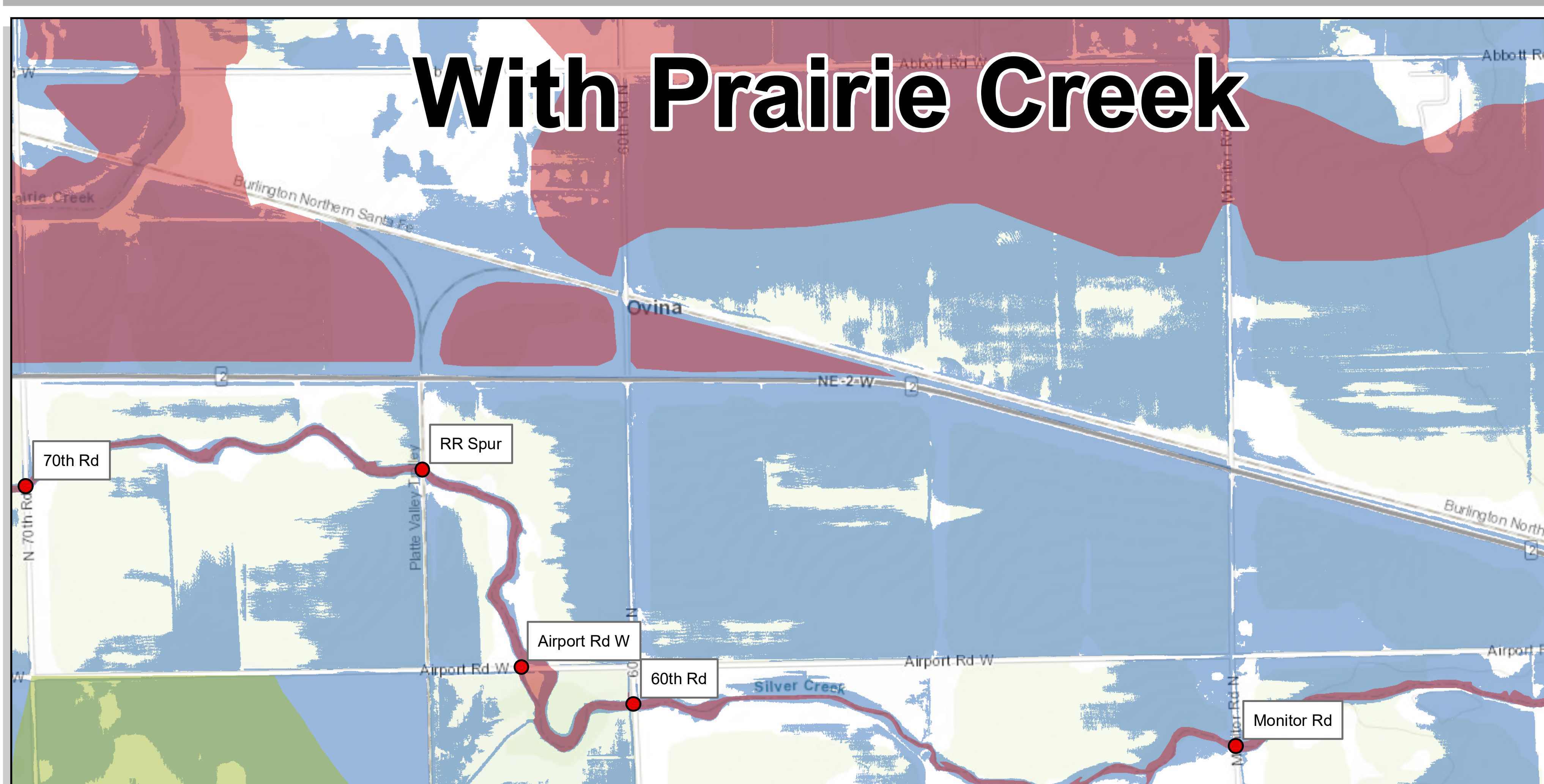

Site	Without Overflow		With Overflow	
	Peak Flow (cfs)	Peak Stage (ft)	Peak Flow (cfs)	Peak Stage (ft)
70th Rd	714.13	1,891.39	800.49	1,891.45
RR Spur	717.56	1,889.14	812.26	1,889.38
Airport Rd W	714.58	1,888.20	808.66	1,888.33
60th Rd	881.19	1,886.70	1,312.49	1,886.92
Monitor Rd	898.64	1,881.64	2,417.91	1,882.33
HWY 2	899.84	1,875.82	2,216.88	1,877.35
N North Rd	818.58	1,869.08	2,260.77	1,870.15
N Webb Rd	915.32	1,862.18	1,671.47	1,863.53
HWY 281 - Silver	914.01	1,855.53	2,576.00	1,856.85

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Figure 3.2: Prairie Creek Overflow

Hall County, Nebraska

0 500 1,000 2,000 Feet

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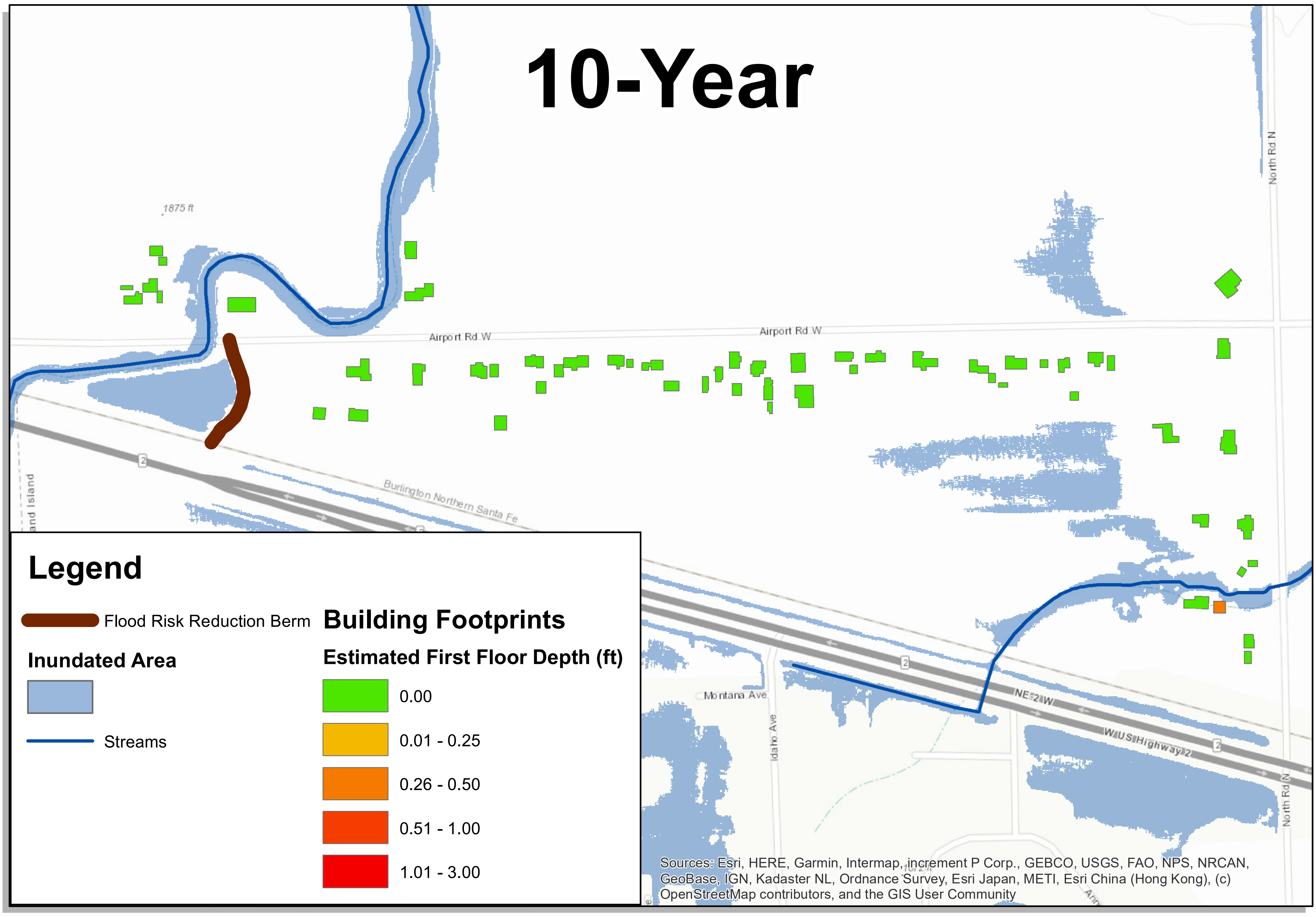
3.3 BUILDING FLOOD RISK ASSESSMENT

JEO utilized these updated flood risk models in conjunction with best available LiDAR, parcel and building footprint GIS data to complete an assessment of the potential for flooding impacts to buildings in the areas of interest. Using LiDAR estimated grade and building step counts from field observation, the estimated first-floor elevations of the buildings was established. The first-floor elevation was then compared to simulated water surface elevations for multiple frequencies of flooding: 10-Year, 25-Year, 50-Year, and 100-Year to determine the flood impact risk and frequency for the buildings within each area. Using the Hall County emergency management damage reports, the 100-Year simulation was validated against the March 2019 events, showing similar depths of flooding at the houses and outbuildings within Area 1.

Buildings in Area 1 on the south side of Airport Road suffered severe flooding both in March 2019 and in the 100-Year model simulation given the 2018 LiDAR that was used as the model terrain. As mentioned above since the March 2019 flooding, the County added a berm next to Silver Creek to reduce flood risk for the buildings to the east. The berm follows natural high ground, elevating natural grade by one to two feet but does not continue to the elevated railroad line on the south end, instead returning to preexisting grade at the railroad's ditch. While the south end of this berm allows some water to overtop, it is very effective at preventing potential property damage that is anticipated without the berm. Figure 3.3 shows current conditions (with the existing berm) for the 10-Year and 100-Year events.

An additional region of homes in Area 2 showed potentially significant flooding within the updated flood model. The homes are along St. Paul Road and E. White Cloud Road, shown in Figure 3.4. These homes surround Moores Creek, but flooding is also impacted by overtopping from Silver Creek nearby. As shown in the 100-Year flooding map, given the flat terrain of the area, floodwater easily exits the creek banks and travels overland either following the creek or traveling the general slope of the land to the east until to reaches the next adjacent stream.

Flooding in Area 3 is shown in Figure 3.5. Here, parts of the natural depression have been cut off by roadway embankments with flows following ditches to the west of the airport. The airport buildings have been constructed on natural grade leaving them prone to flooding.



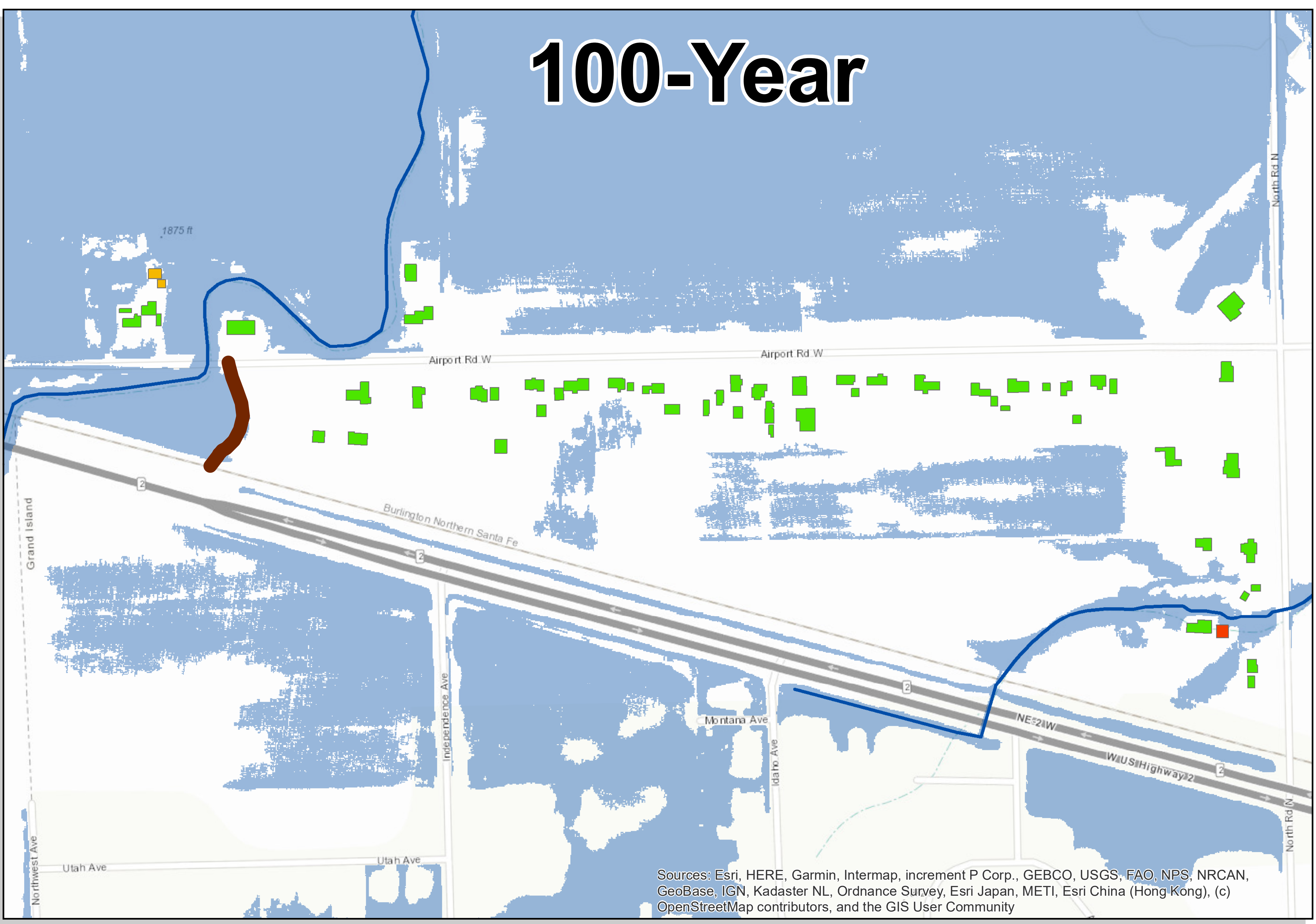


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Figure 3.3: 10-Year vs. 100-Year
Area 1: HWY 2 and Airport Road

Hall County, Nebraska

0 125 250 500 Feet

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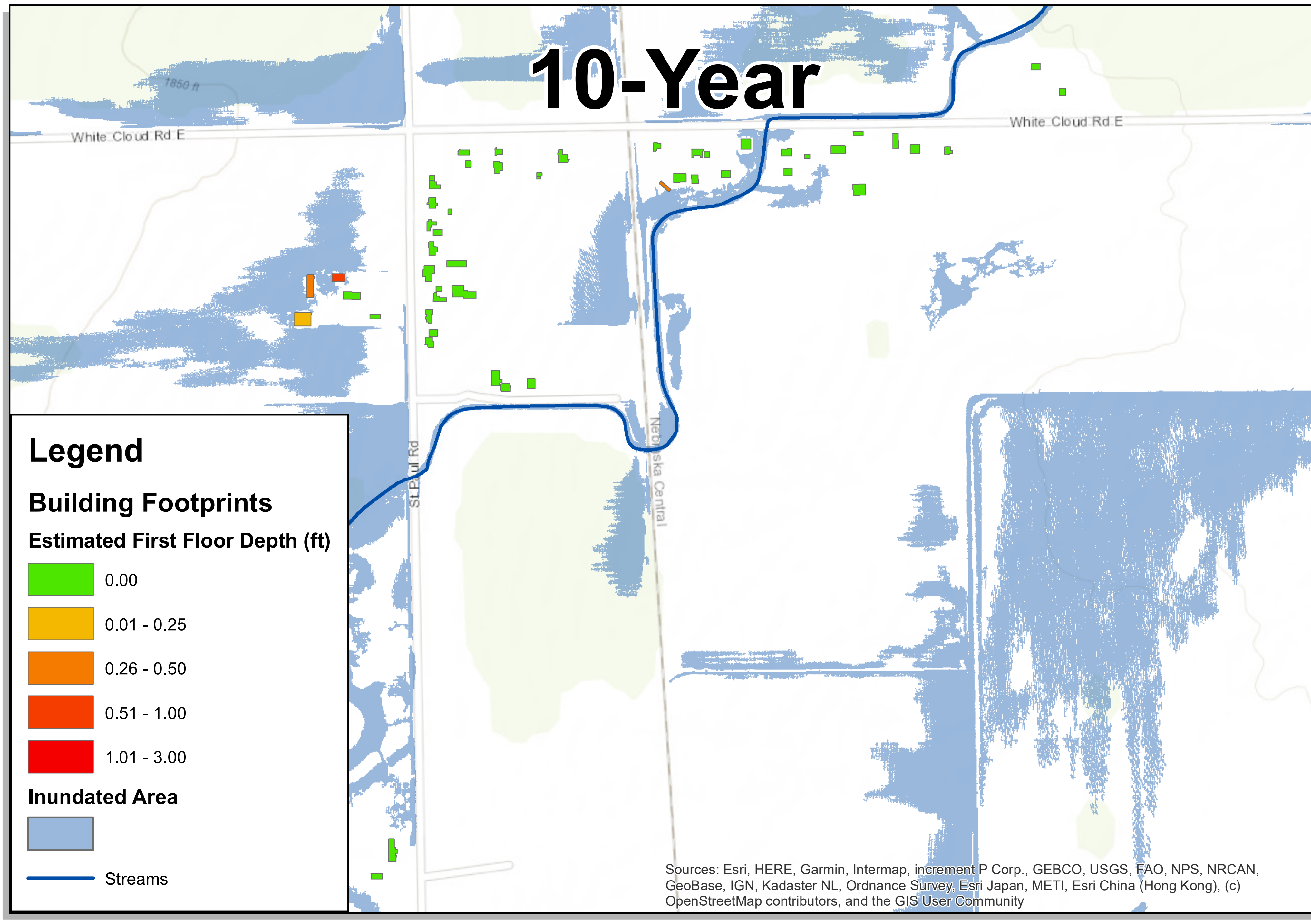

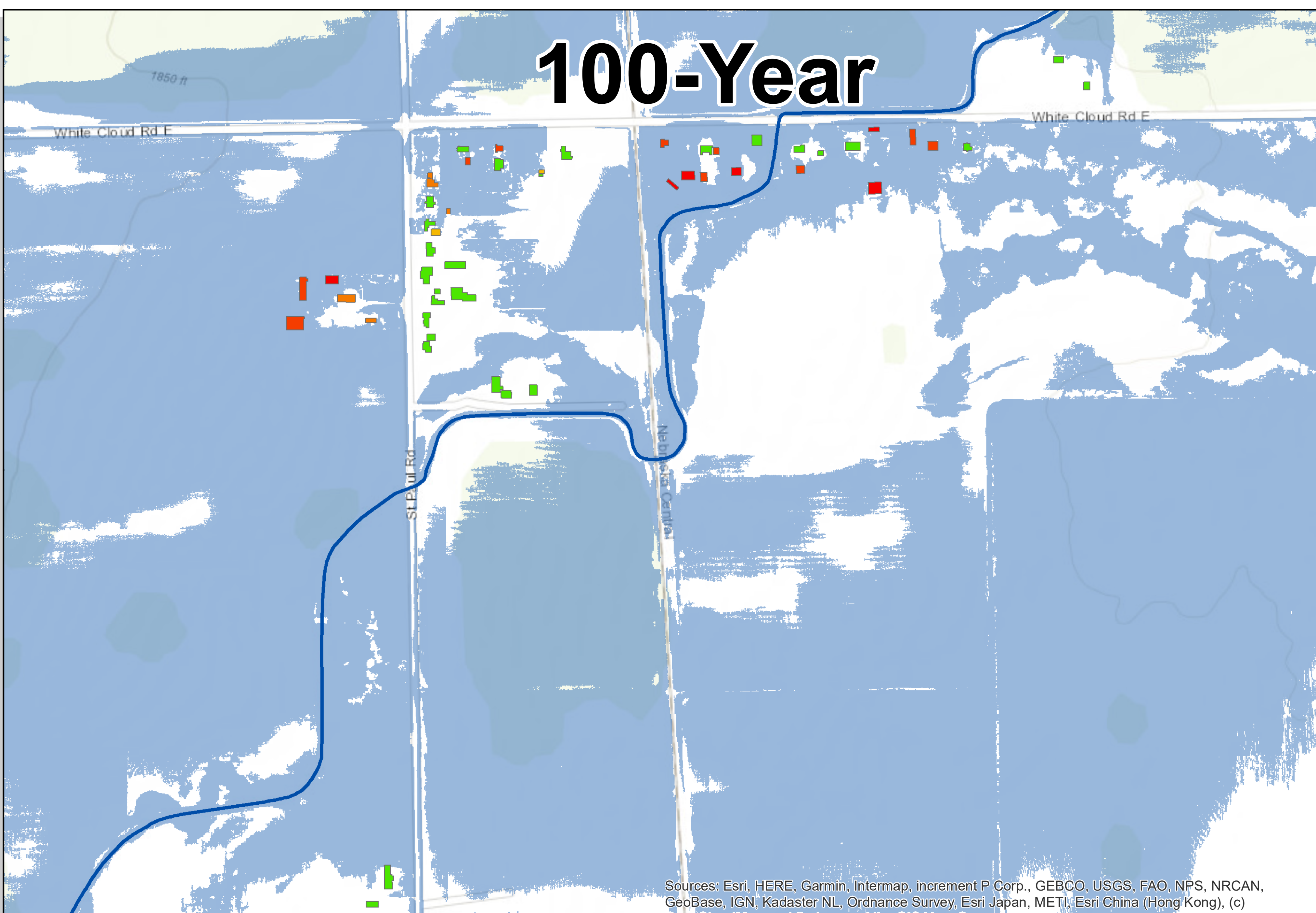

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Figure 3.4: 10-Year vs. 100-Year
Area 2: White Cloud Road

Hall County, Nebraska

0 250 500 1,000 Feet

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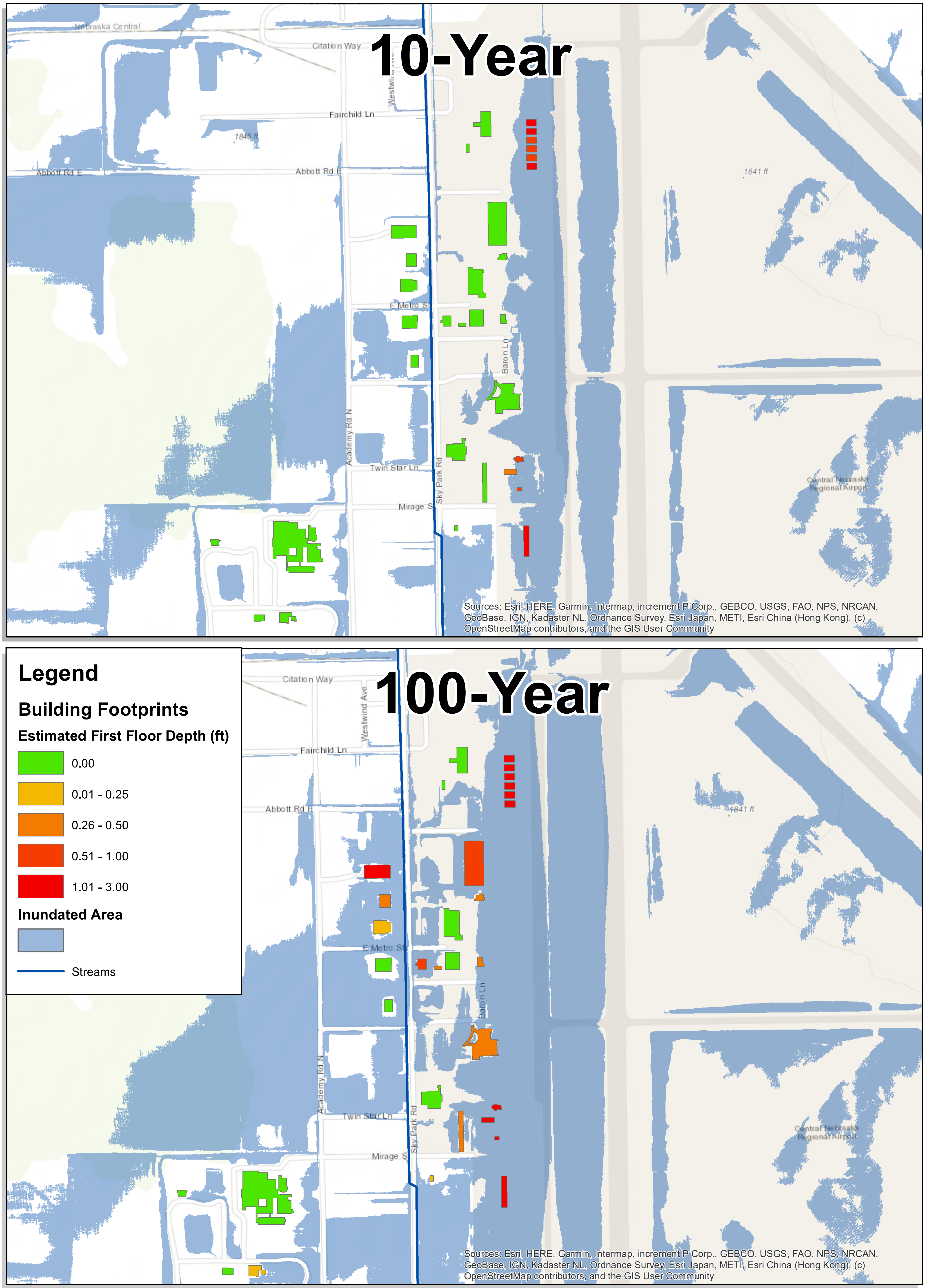

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Figure 3.5: 10-Year vs. 100-Year

Area 3: Airport

Hall County, Nebraska

0 250 500 1,000 Feet

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4.0 FLOOD MITIGATION ACTION ASSESSMENT

4.1 PAST MITIGATION ACTIONS AND EFFECTIVENESS

Due to the change in flood modeling approach to 2D, an effort was made to affirm effectiveness of previously completed mitigation actions on the flood modeling. Figure 4.1 shows the change in inundated area for a 100-Year event with and without the UPSM project alongside locations where flows and stages are extracted from the model and displayed in Table 4.1. The figure shows a widespread reduction in inundated area particularly in and around Grand Island. The addition of dams and detention in the upper portions of the watershed allows for flood water to be held in storage, diminishing peak flows and inundation for all areas downstream. Additionally, the levee constructed along Silver Creek on the north side of Grand Island prevents flood water from entering the north part of the city by moving from the Silver Creek watershed into the Moores Creek watershed. Table 4.1 shows a general overall reduction in floods and peak stages due to the project; however, there are selected locations (highlighted in red in the table) which have higher flows and stages. These increases are generally small to moderate in the case of the Highway 2 crossing on Silver Creek and are caused by flows being prevented by the levee from traveling from Silver Creek to Moores Creek through Grand Island. While floodway no-rise procedures were followed for the UPSM project floodplain permitting, the evaluation was based on steady flows using a 1D model that did not consider Prairie Creek overflows. The current evaluation considers both Prairie Creek overflow impacts and unsteady flows which results in a localized impact near the UPSM levee system. Outside of this region near Grand Island, flows and stages are the same or lower downstream of Grand Island all the way to the downstream end of the flood model area. This is due to effects of the detention on total flows that leads to less water flowing in all three creeks as they exit the modeled area. With the simulation of the Prairie Creek overflows, the existing levee was reviewed to determine freeboard to peak water surface elevation for the 100-Year event. Generally, freeboard remains between 1.5 to 2.0 feet for the majority of the levee. However, for several hundred feet just upstream of the Silver Creek crossing under N. Engleman Road (near Highway 2 and N. Engleman Road) the existing freeboard is limited to less than a foot, ranging from 0.9 to 1.0 ft. This limited freeboard is caused by a combination of backwater from the culvert under N. Engleman Road as well as basin overflows originating from Prairie Creek overtopping W. Airport Road just west of the intersection with N. Engleman Rd.

To support understanding of the benefits of the project and remaining vulnerabilities, an economic analysis was performed to analyze the benefits of implementing the UPSM project for the region. Using flood inundation depth grids output from the model simulations crop losses were calculated using USDA CropScape data from 2021 and building losses were calculated using the FEMA HAZUS tool, evaluating damage by census blocks using General Building Stock (GBS) as well as by individual structure using User Defined Facility (UDF), with the value of the buildings taken from county parcel data.

Table 4.2 shows results from the HAZUS building loss analysis; income losses calculated in the GBS runs were not included in the values in the table. The UDF HAZUS runs yielded losses about half as much as the GBS runs, with across-the-board differences in building loss, content loss, and inventory loss, indicating that GBS method is potentially over predicting the value of the buildings within the census blocks. It should be noted that the flood inundation using HEC-RAS did not simulate any conveyance of stormwater within the existing storm sewer in Grand Island, meaning there is likely an overprediction of building damage in both with and without project conditions. However, that overprediction is likely similar in both runs so much more weight should be given to the difference in damages between the with and without project conditions than individual damage totals. The relative project benefits are similar for both analyses.

The crop loss damage assessment is shown in Table 4.3. The analysis shows, while the project was not solely targeting crop loss damage, the detention of flood water reduced crop losses by about 10% compared to pre-project levels. Overall, including both building and crop losses, annualized losses prevented by the project are estimated at between $822,000-$923,000 per year, with building damage representing 91-92% of the damage reduction and crop loss prevention representing the other 8-9%.

Table 4.1: Stages and Flows Along Major Streams With and Without UPSM Project

Stream	Site	Without Project		With Project	
		Peak Flow (cfs)	Peak Stage (ft)	Peak Flow (cfs)	Peak Stage (ft)
Silver Creek	70th Rd	1,990	1,893.3	800	1,891.5
Silver Creek	RR Spur	1,974	1,890.9	812	1,889.4
Silver Creek	Airport Rd W	1,164	1,889.2	809	1,888.3
Silver Creek	60th Rd	3,010	1,888.0	1,313	1,886.9
Silver Creek	Monitor Rd	4,483	1,883.3	2,418	1,882.3
Silver Creek	Hwy 2	1,506*	1,876.9*	2,218*	1,877.3*
Silver Creek	Airport Rd	1,438*	1,875.4*	2,030*	1,875.7*
Silver Creek	N North Rd	2,026*	1,870.1*	2,119	1,870.1*
Silver Creek	N Webb Rd	1,659	1,863.5	1,644	1,863.5
Silver Creek	HWY 281 - Silver	2,542	1,856.8	2,498	1,856.8
Prairie Creek	HWY 281 - Prairie	2,032	1,850.9	1,695	1,850.7
Prairie Creek	Sky Park Rd	2,291	1,832.6	2,144	1,832.6
Prairie Creek	Near Quandt Rd N	2,239	1,825.1	2,104	1,825.1
Urban/Moores Creek	Independence Ave	1,050	1,876.5	45	1,873.2
Urban/Moores Creek	Idaho Ave	1,123	1,876.2	62	1,871.6
Urban/Moores Creek	Lee St	1,210	1,876.1	65	1,870.9
Urban/Moores Creek	McNeils Pl	1,120	1,875.7	70	1,869.5
Urban/Moores Creek	S North Rd	1,152	1,875.5	75	1,868.5
Urban/Moores Creek	Old HWY 2 West	1,108	1,870.8	265	1,863.7
Urban/Moores Creek	RR West - Moores	1,079	1,869.3	265	1,863.3
Urban/Moores Creek	W Airport Rd W	1,125	1,866.1	271	1,860.3
Urban/Moores Creek	HWY 281 Frontage Rd	1,365	1,856.3	283	1,853.5
Urban/Moores Creek	Sky Park Rd	2,061	1,836.2	1,405	1,836.2
Urban/Moores Creek	One R Rd and N Quandt Rd	2,128	1,829.1	1,505	1,829.0
Urban/Moores Creek	N Gunbarrel Rd	2,010	1,823.0	1,408	1,822.8

*Without Project floodwater historically entered Grand Island and flowed through the Moores Creek tributary under Highway 2, these flows have now between redirected to flow through Silver Creek under Highway 2. In both cases, flows enter and cause flooding in Area 1.

Table 4.2: Capital Losses With and Without UPSM Project

	Total Capital Stock Losses					
	10-Year	**25-Year**	**50-Year**	**100-Year**	**500-Year**	**Annualized**
GBS Without	$21,008,000	$28,466,000	$40,395,000	$80,663,000	$153,905,000	$4,024,202
UDF Without	$11,635,062	$17,626,704	$29,236,580	$67,870,744	$179,024,950	$3,177,651
GBS With	$20,943,000	$27,772,000	$34,336,000	$41,469,000	$108,090,000	$3,275,971
UDF With	$11,635,062	$17,358,651	$23,787,247	$29,748,181	$110,131,664	$2,328,730
GBS Annualized Project Benefit						**$748,231**
UDF Annualized Project Benefit						**$848,921**

Table 4.3: Crop Losses With and Without UPSM Project

	Total Crop Losses					
	10-Year	**25-Year**	**50-Year**	**100-Year**	**500-Year**	**Annualized**
Without Project	$5,152,106	$7,334,485	$9,136,770	$11,011,155	$15,360,121	$776,255
With Project	$4,706,202	$6,646,505	$8,291,111	$9,817,499	$13,749,178	$702,265
Annualized Project Benefit						**$73,990**

4.2 Potential Future Mitigation Actions

Potential mitigation actions were evaluated in each area including structural and nonstructural solutions. Due to the distance between the areas of interest and separate drainages, each area had their own unique solutions to localized flooding, with the local area specific mitigation actions having little to no effect on flooding outside of the area. A summary of the structural mitigation actions is shown in Figure 4.2. Concept level costs were determined for each of the structural alternatives and are included in the discussion.

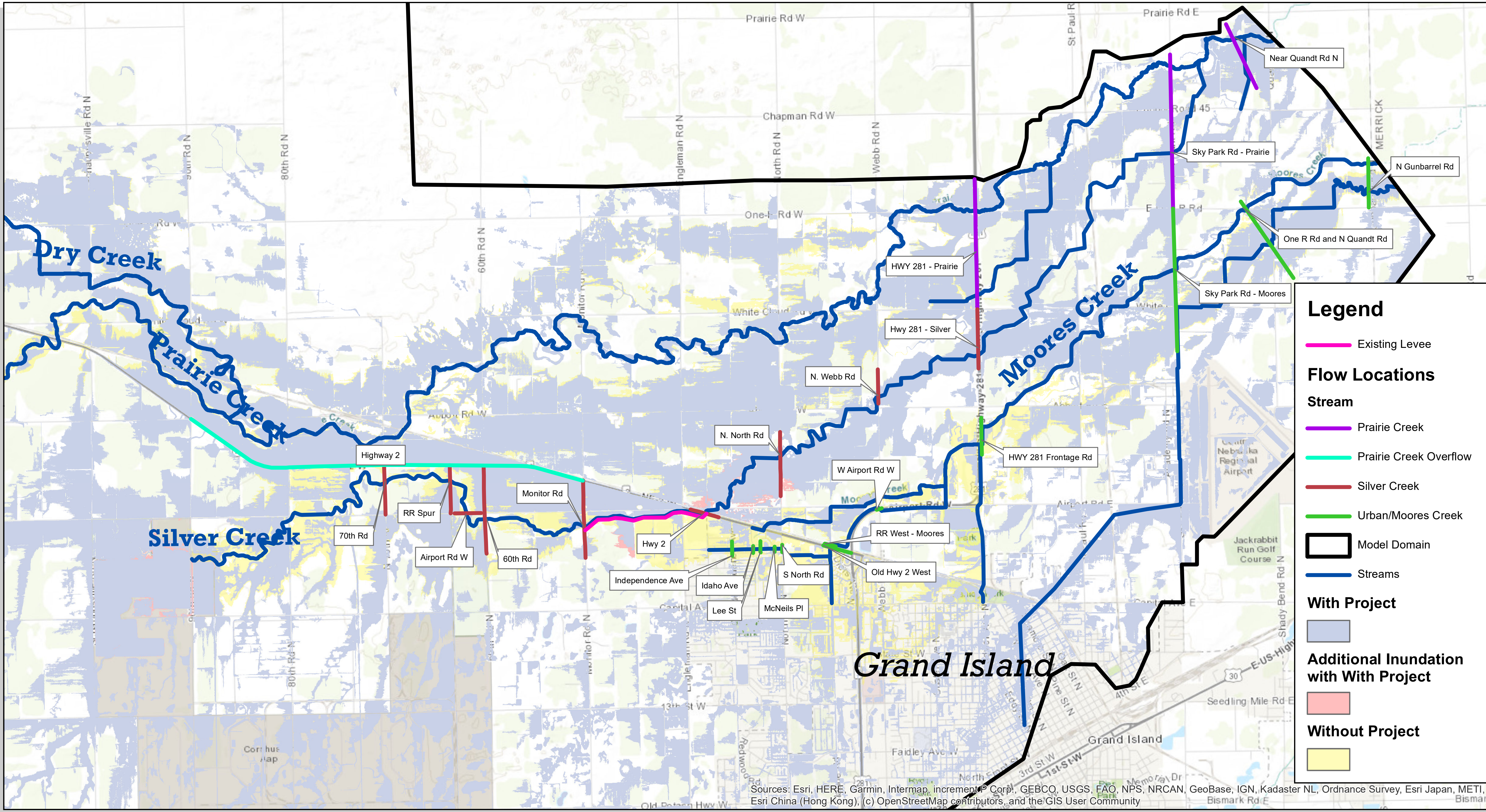

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Figure 4.1: With and Without UPSM Project
100-Year Event

Hall County, Nebraska

0 0.5 1 2 Miles

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4.2.1 Area One

Structural - As noted above, flooding in Area 1 occurred near Silver Creek along W. Airport Road and North Road just north of Highway 2 and a berm has been placed adjacent to Silver Creek since the flooding has occurred. Using a survey of the berm obtained from Hall County, the berm was added into the models existing condition runs assuming a berm top width of 10 ft and 3:1 side slope. As shown in Figure 2.3, the berm is very effective at preventing flood damage, though some water appears to overtop the berm during the 100-Year event. Moreover, a sensitivity analysis was performed on the 100-Year event to evaluate the potential for changing in flooding risk and impacts due to altered conditions including dry antecedent soil conditions, saturated antecedent soil conditions, 300 cfs flows from Wood River overflow, and 1,000 cfs flows from Wood River overflow corresponding to Dry Soil, Saturated Soil, Wood River Overflow, and Wood River High Overflow, respectively as shown in Table 3.3. With the berm already beginning to overtop in the base conditions, the higher flows due to saturated soil or additional flows from Wood River all result in floodwater overtopping the berm and inundating area behind the berm; the results from saturated soil conditions compared to the base conditions are shown in Figure 4.3. To prevent these overflows, the berm could be optimized to both close gaps and make it more resilient to potential flooding conditions. Possible modifications include raising the north end to prevent water from flowing through the roadway ditch, raising on the south end, and setting back the south end to avoid the ditch where the berm ties into the railroad embankment and follows natural high ground. These modifications were simulated in the model and shown in Figure 4.4 illustrating that it would prevent berm overtopping and provide1 to 2 feet of freeboard to the peak water levels for the 100-Year flows given base soil initial conditions and 0.75 to 1.75 feet of freeboard for saturated soil initial conditions. Based on the adjustments made to the berm about 183 CY would be needed to construct the adjustments to the berm, assuming a 10 ft top width and 3:1 side slopes. These adjustments to the existing berm would cost in the range of $15,400 in 2022 dollars.

Several other structural approaches to resolve flooding in Area 1 were also investigated. Channel cleaning and realignment scenarios were also simulated in the modeling. Here, the channel could be cleaned to reduce roughness and increase conveyance of water through the area, or the channel could be realigned due to sharp bends also reducing conveyance. However, both scenarios had little beneficial effect on flooding reduction. An alternative levee scenario was run with a levee being constructed on the north side of Highway 2 between where the railroad spurs to the south and the convergence of Highway 2 and the railroad, with the levee turning north and blocking the drainage between the railroad and the highway. This levee would be effective at preventing basin overflows from Prairie Creek into Silver Creek; however, it is significantly larger than the localized berm at approximately 5,000 feet in length and would likely need to be extended further to meet freeboard requirements. This larger levee would cost an estimated $1,557,000 in 2022 dollars. Adding this levee segment would provide an initial line of defense for flooding along Silver Creek and would reduce the impact of freeboard reduction considerations for the Silver Creek Levee. Additional discussion on this is provided in Section 4.2.4 Furthermore, the benefits of reduced flooding in the Silver Creek watershed are countered by increased flooding in the Prairie Creek watershed. Beyond constructing a levee to prevent flows from overtopping Highway 2 into Silver Creek, if bridges under the railroad were added or expanded at key locations for additional conveyance in the floodplain of Prairie Creek this would have the effect of reducing overflows as well. An additional scenario was run, creating a bridge to convey highwater flows through the railroad. This scenario did not eliminate basin overtopping into Silver Creek but significantly reduced it. Due to the quantity of flows needed to be conveyed, the bridge would need to be 1,000 feet wide and would cost an estimated $42,067,000 in 2022 dollars.

Nonstructural – the potential for nonstructural flood risk reduction actions such as elevation, acquisition, and retrofitting were considered. The building flood risk assessment was reviewed for existing conditions and proposed conditions on the basis of the existing berm. Based on this review and considering the flood mitigation action already constructed with the berm in place, only one building remains at notable flood risk. Since this building is a residential garage, there is limited need to pursue site specific nonstructural recommendations. If desired closures or flexible barriers could be considered for the garage doors. Homeowners in the region should also be encouraged to store valuable items in an elevated location within outbuildings, as flood depths are low even for larger magnitude, infrequent floods.

4.2.2 Area Two

Structural - Area 2 posed unique challenges in flood prevention due to the immediate proximity of the buildings to Moores Creek and the large amount of overland flooding that is occurring during the larger events. This meant that no single solution was capable of preventing flooding for the buildings. A run was performed examining the effectiveness of multiple small berms placed at critical overtopping locations that effect the buildings in the region: 1) along St. Paul Road from the intersection of St. Paul Road and E. White Cloud Road to the south, 2) along the left bank of Moores Creek just upstream of E. White Cloud Road, 3) along the right bank of Moores Creek just upstream of E. White Cloud Road, and 4) a short extension of existing high ground to prevent flows from bypassing the channel all together. Additionally, a bypass channel was also included to restore access to the natural floodplain. The combined effect of these mitigation options is shown in Figure 4.5. The berm improvements to Area 2 is estimated to cost a total of $458,400 in 2022 dollars, while the bypass channel is estimated to cost $1,073,000 in 2022 dollars.

Nonstructural – the potential for nonstructural flood risk reduction actions such as elevation, acquisition, and retrofitting were considered. The building flood risk assessment was reviewed for existing conditions and proposed conditions on the basis of the existing berm. Based on this review and building types at risk, it was noted that most of the buildings in this risk region are out buildings. If desired closures or flexible barriers could be considered for doors. Homeowners in the region should also be encouraged to store valuable items in an elevated location within outbuildings, as flood depths are low even for larger magnitude, infrequent floods. There are a few homes at risk for low depth flooding within this region; these homeowners could consider retrofitting actions such as basement fill or efforts to floodproof low points around the perimeter of the residence.

4.2.3 Area Three

Structural - Area three is unique in that there is no major channel running through the area but a significant percentage of impervious area which can quickly generate large amounts of runoff. Additionally based on field observations, many of the buildings were constructed at grade, making them susceptible to localized flooding. Based on the modeling, only a few of the buildings were impacted during large floods, often in separate areas of the region. A simulation was performed in the modeling, adding a culvert under the runway near E Airport Road and Sky Park Road but it had minimal effect on building flooding. Therefore, in this area, nonstructural individual site solutions are likely the best approach. Additionally, more monitoring is needed to more accurately determine where the flooding is coming from, and which buildings are being affected. This information could then be used to inform future model runs and potentially address Area 3 wide flooding concerns.

For this region, it is also recommended to complete a review and update, as needed, the on-site storm drainage infrastructure such as road and driveway culverts. Undersized road culverts or impacts of long-term maintenance deficiency such as silting or debris blockage will likely contribute to flood risk and impacts, especially for intense, localized storms.

Nonstructural – the potential for nonstructural flood risk reduction actions such as elevation, acquisition, and retrofitting were considered. The building flood risk assessment was reviewed for existing conditions and proposed conditions on the basis of the existing berm. Based on this review it was noted that the majority of at-risk buildings near the airport are metal/industrial storage buildings. If desired closures or flexible barriers could be considered for doors. Property owners in the region should also be encouraged to store valuable items in an elevated location within at-risk buildings, as flood depths are low to moderate even for larger magnitude, infrequent floods. If a building is modified or removed/rebuilt or new buildings are added, it is recommended to consider this flood risk assessment and elevate or floodproof accordingly.

4.2.4 Regional

Prairie Creek overflows can be significant and put pressure on the operational elements of the UPSM project near Grand Island, including the Silver Creek levee. The current levee freeboard is also significantly reduced due to these overflow considerations, specifically along Silver Creek where freeboard is reduced from 3 feet or greater to between 0.9 and 1.5 feet. Due to this potential risk reduction, elements to minimize the amount of overflow and impacts of the overflow were considered. These included a highwater railroad bridge and a levee that reduces Prairie Creek overflow potential. Results of the assessment of effectiveness and impacts of these actions are shown on Figures 4.6 and 4.7. While both of these actions produce flood risk reduction benefits for Grand Island, implementation would need to be considered carefully as they send more flow downstream on Prairie Creek compared to existing conditions and therefore have the potential to transfer impacts. However, these actions have significant benefits, reducing the risk of flooding overtopping or breaching the Silver Creek levee and Area 1 berm. Since the Highway 2 levee entirely prevents overtopping, the existing levee freeboard increases from between 0.9 – 1.5 ft to 3 feet or greater. The highwater bridge reducing the overtopping of Prairie Creek over Highway 2 but does not eliminate it entirely; here, existing levee freeboard increases from between 0.9 – 1.5 ft to 2 – 3 feet. Additionally, both the highwater railroad bridge and the levee would significantly reduce other impacts from the Prairie Creek overflows to the region south of Highway 2 shown on Figure 2.4 including the roadway overtopping and houses surrounded by water depicted by the minor damage points.

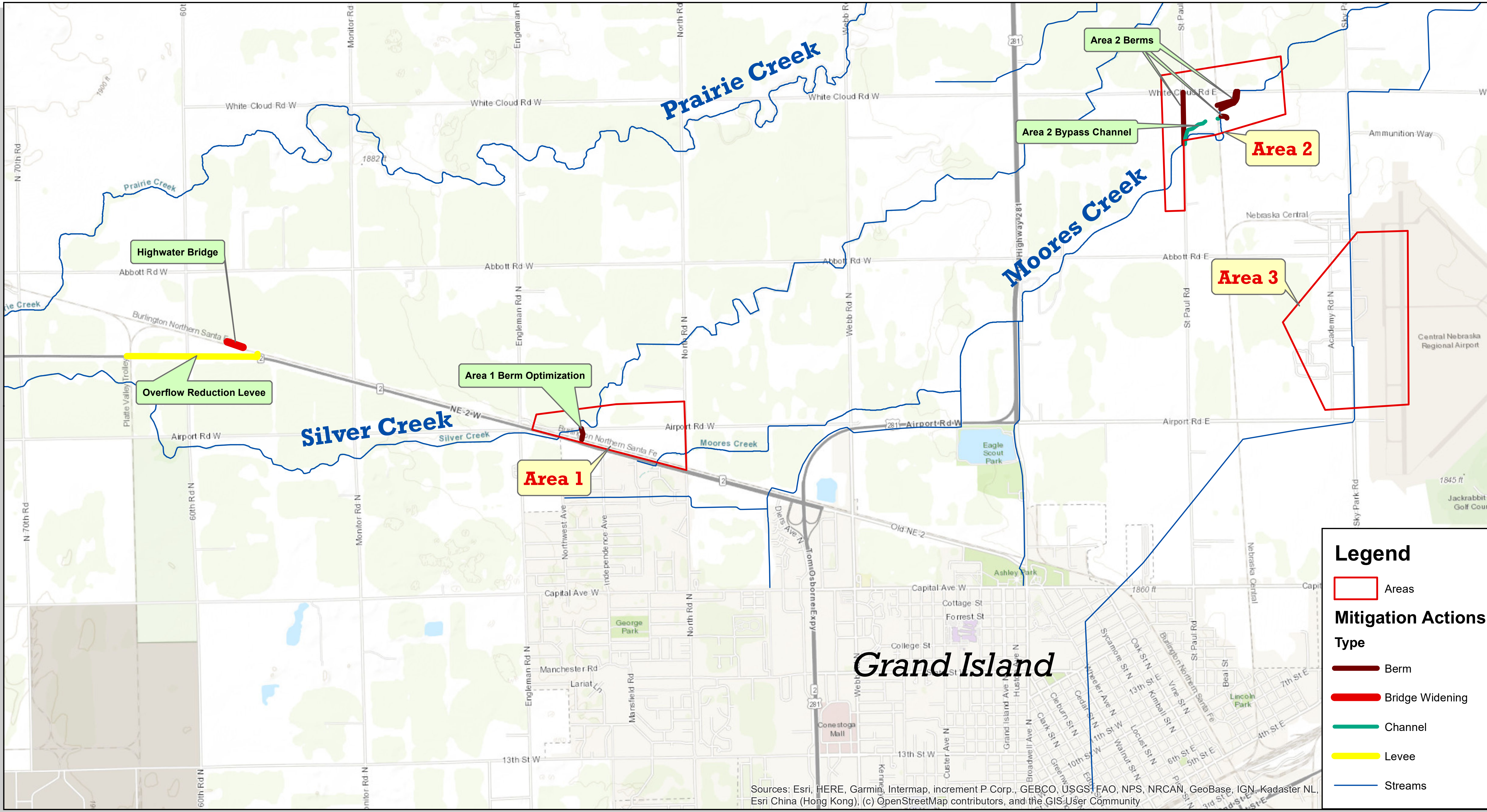

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Figure 4.2: Final Recommendations

Hall County, Nebraska

0 0.25 0.5 1 Miles

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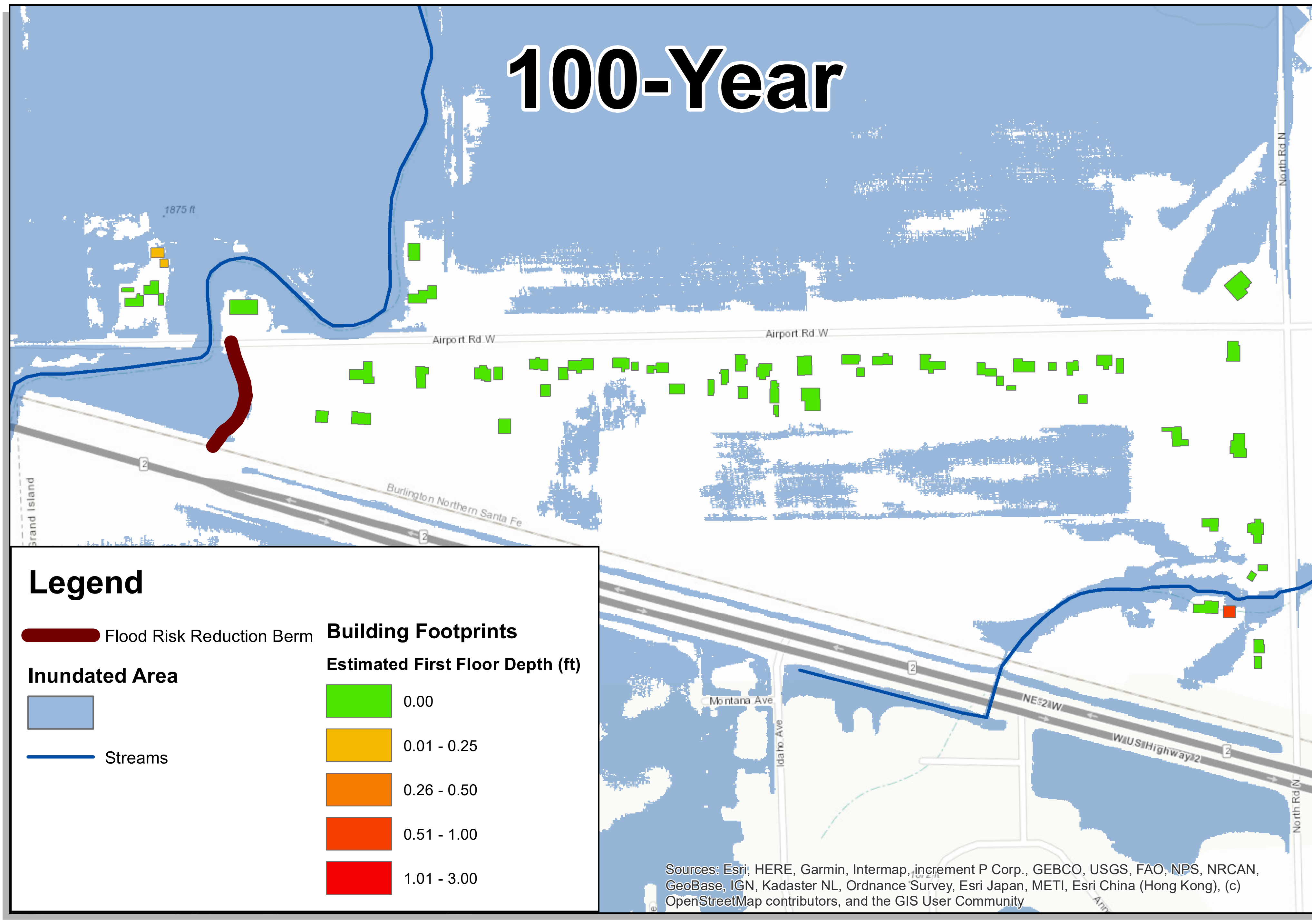

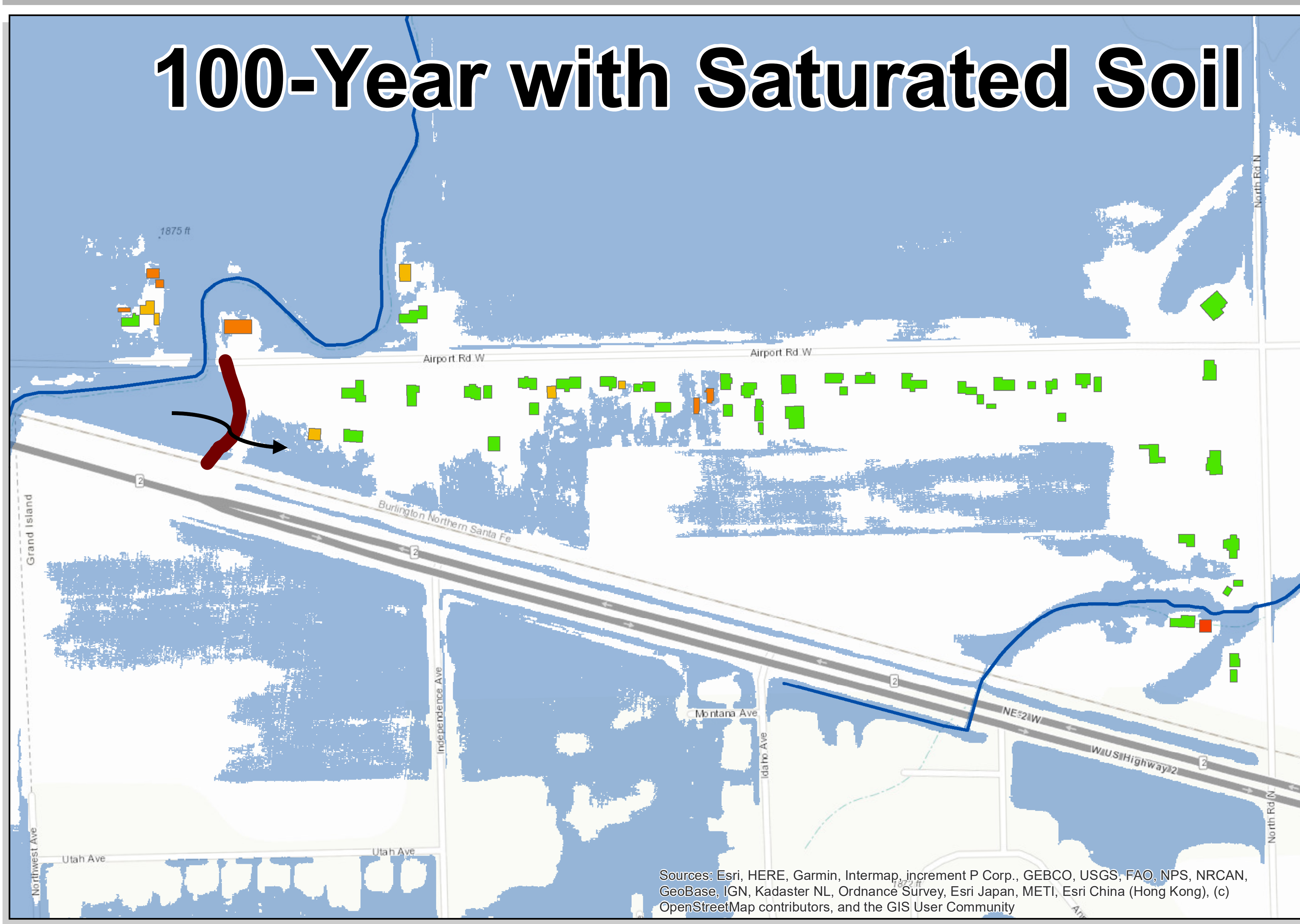

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Figure 4.3: 100-Year Saturation Sensitivity

Area 1: HWY 2 and Airport Road

Hall County, Nebraska

0 125 250 500 Feet

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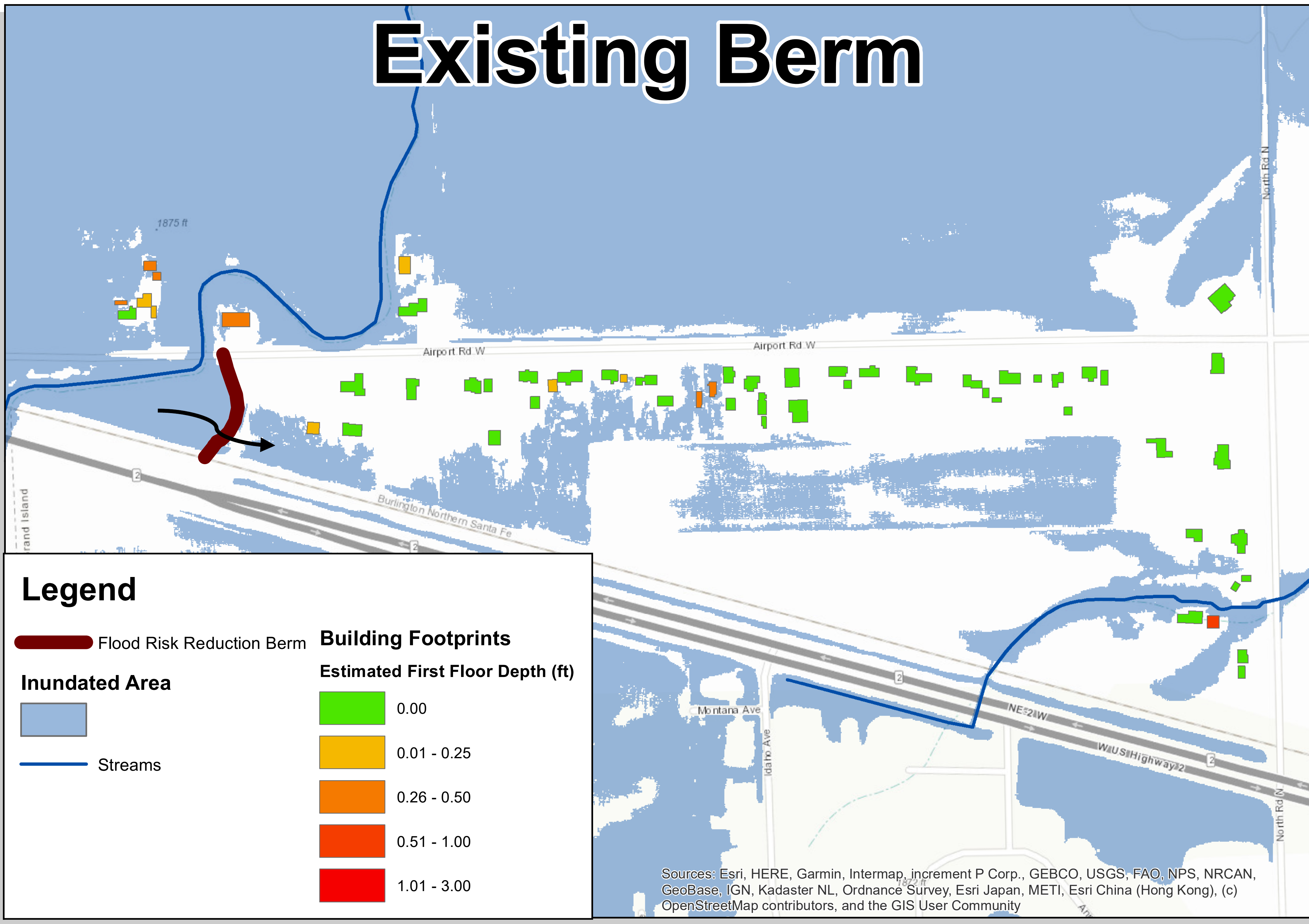

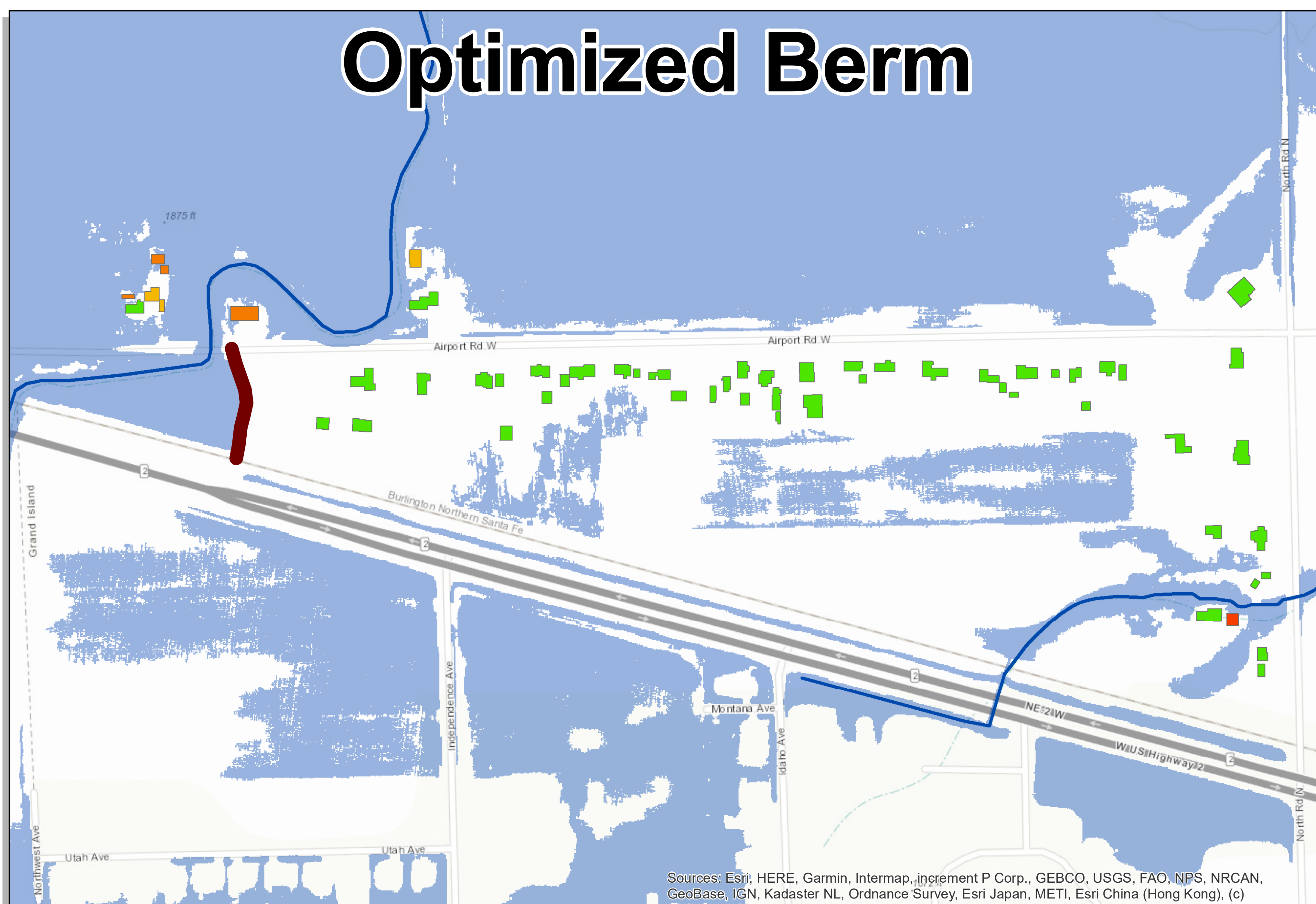

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Figure 4.4: Existing vs. Proposed Saturated Conditions
Area 1: HWY 2 and Airport Road

Hall County, Nebraska

0 125 250 500 Feet

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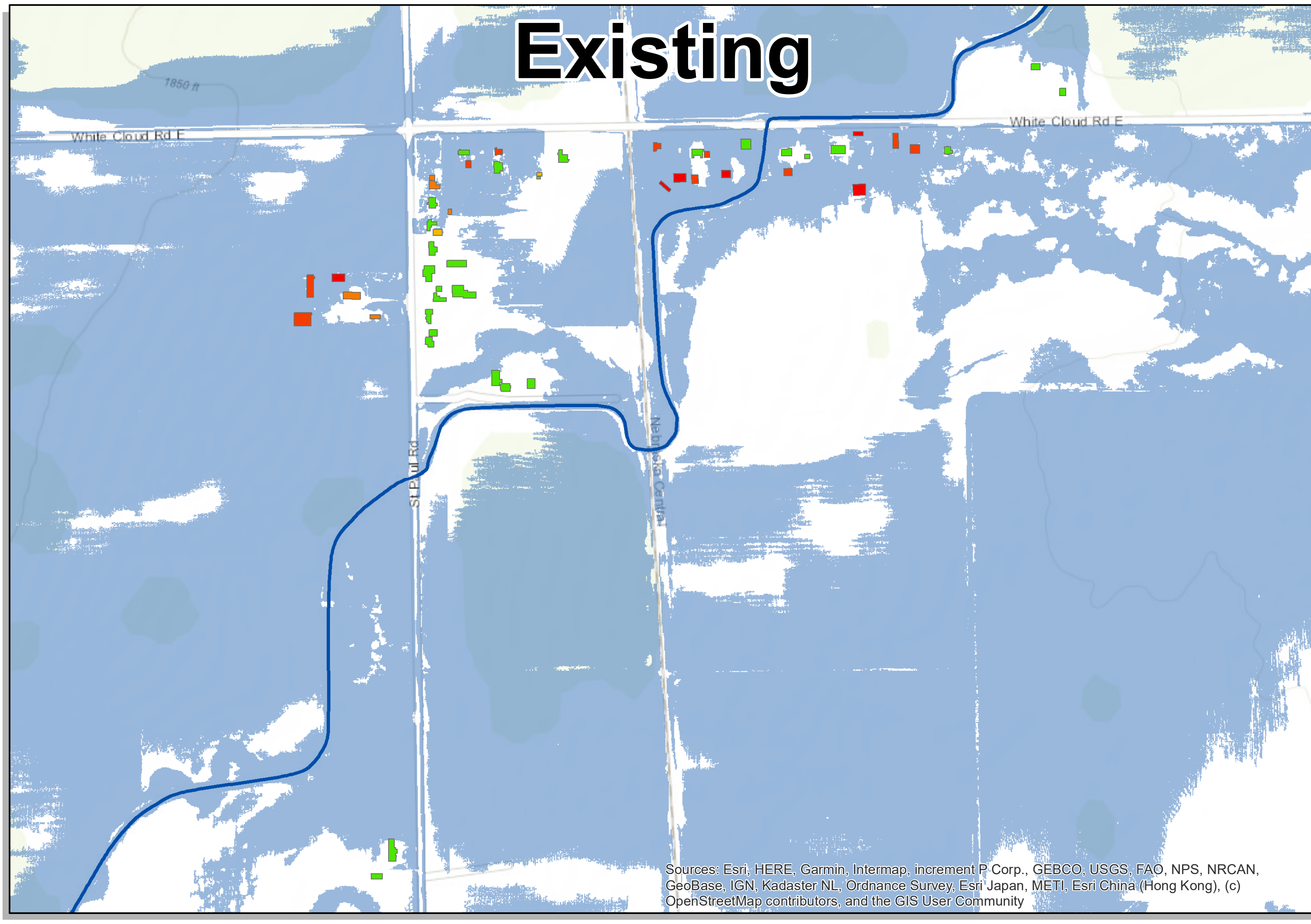

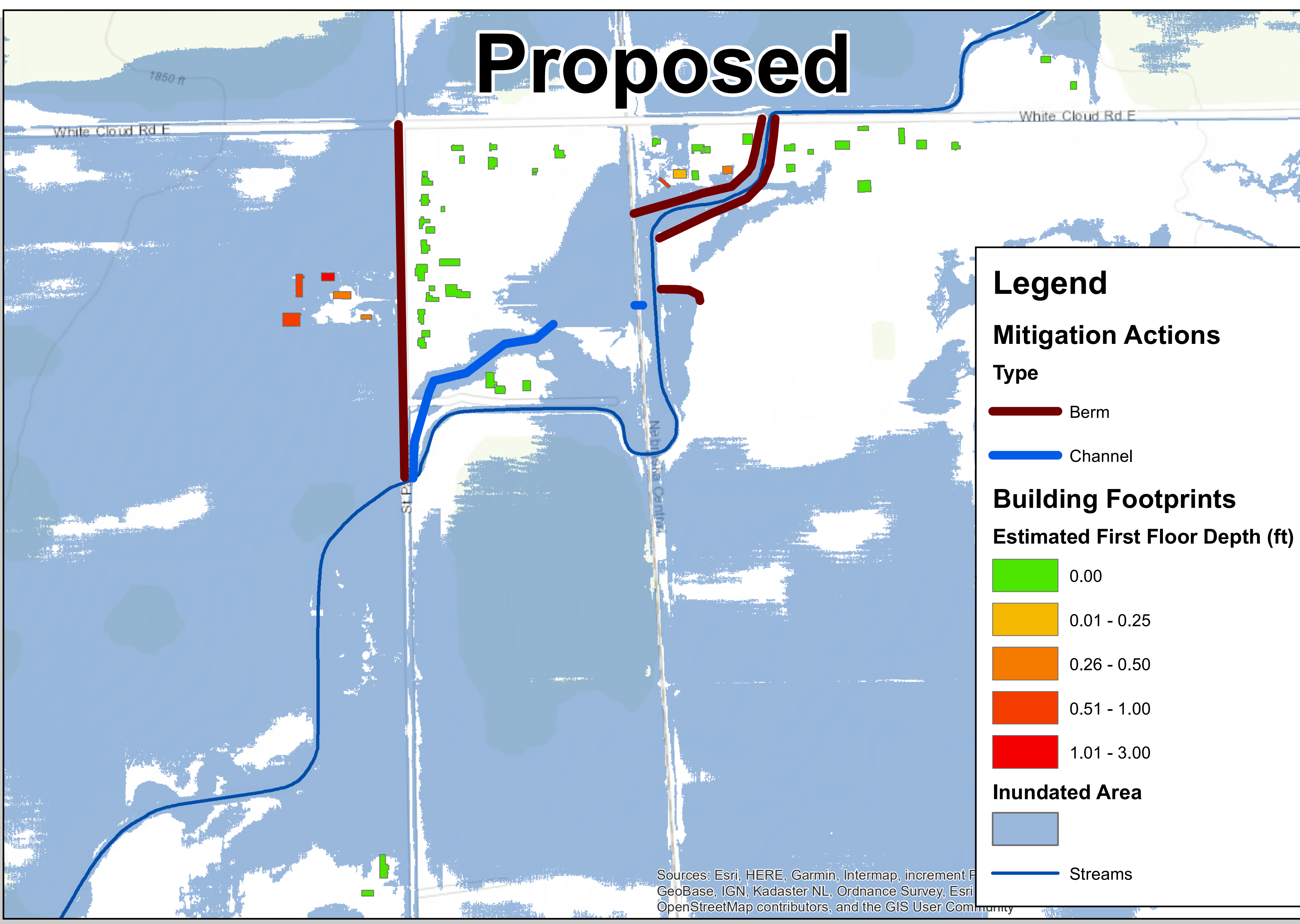

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Figure 4.5: Existing vs. Proposed
Area 2: White Cloud Road

Hall County, Nebraska

0 250 500 1,000 Feet

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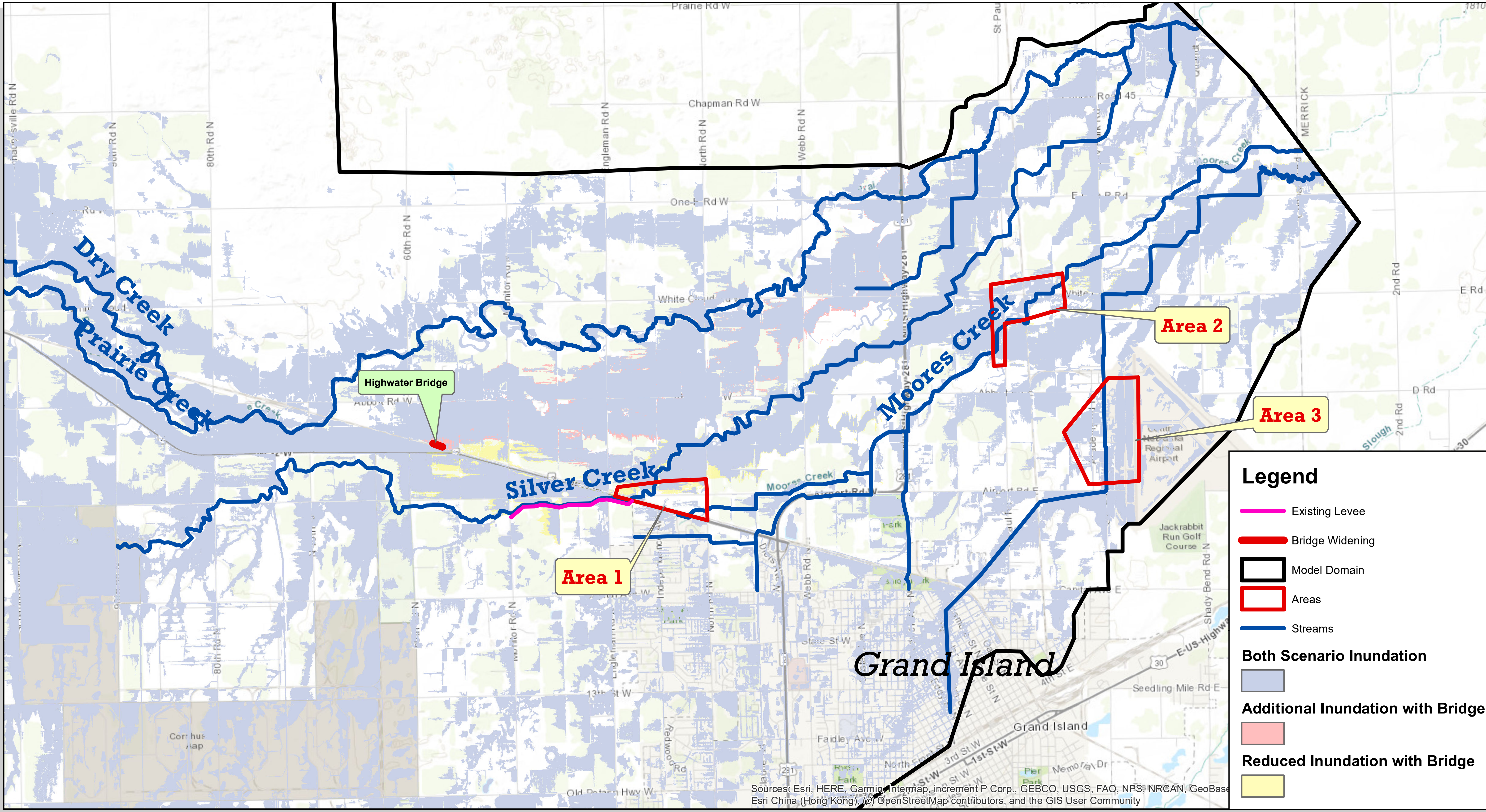

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Figure 4.6: Highwater Railroad Bridge 100-Year Event

Hall County, Nebraska

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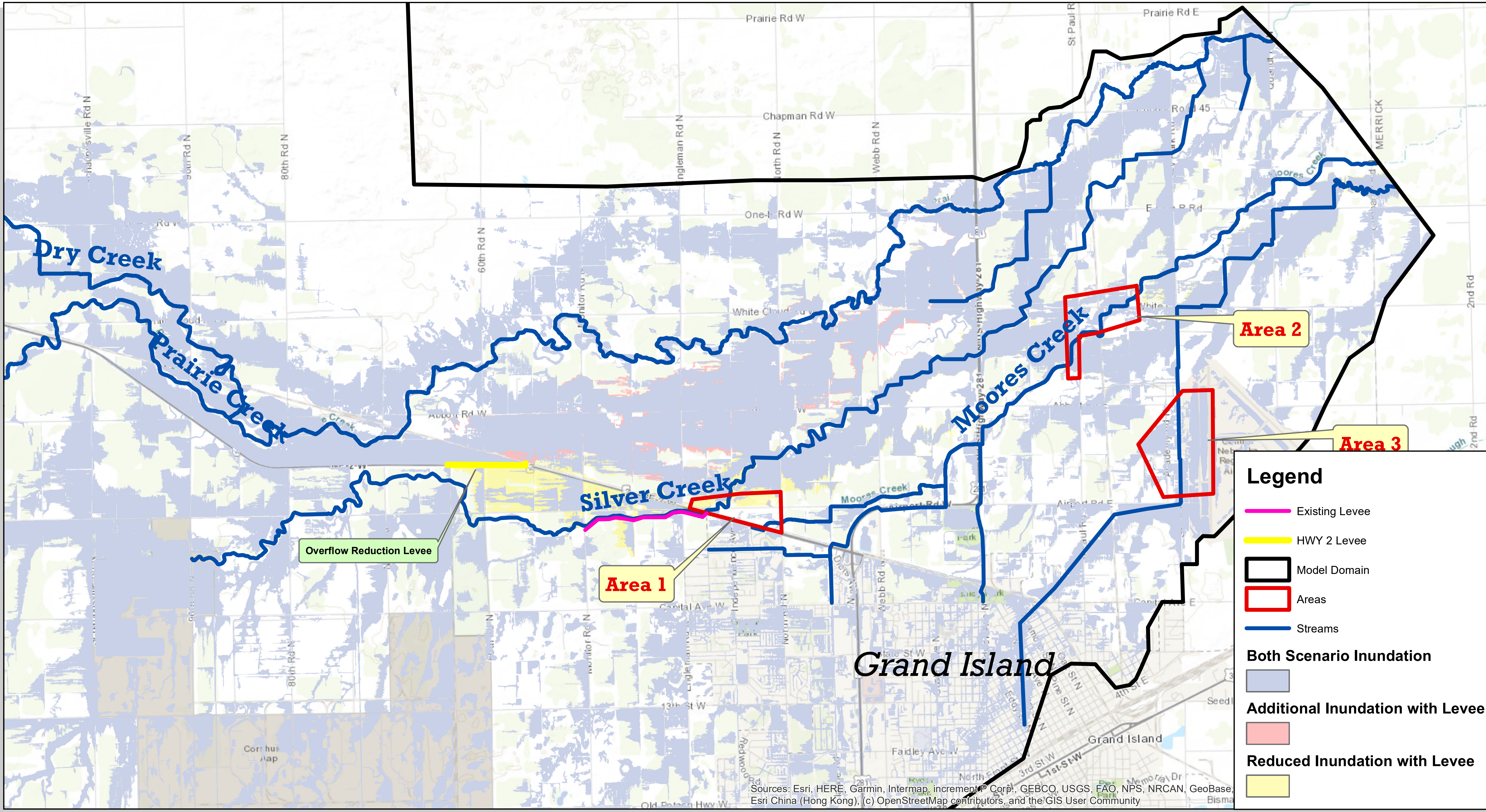

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Figure 4.7: Highway 2 Levee
100-Year Event

Hall County, Nebraska

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5.0 CONCLUSIONS AND NEXT STEPS

5.1 IMPLEMENTATION RECOMMENDATIONS

To move forward on recommended projects and actions, it is recommended that the NRD and City:

1. Coordinate with the County and property owners to design and install the optimized berm for Area 1. Modifications include raising the north end to prevent water from flowing through the roadway ditch, raising on the south end, and setting back the south end to avoid the ditch where the berm ties into the railroad embankment and follow natural high ground. Based on modeling, these modifications would prevent overtopping and provide 1 to 2 feet of freeboard along the berm.
2. Pursue further assessment of potential funding for design and implementation of Prairie Creek overflow risk reduction measures such as a highwater railroad bridge and an overflow reduction levee. The highwater railroad bridge would prevent flows being trapped between the railroad and Highway 2 near Abbott, while the overflow reduction levee would run adjacent to Highway 2 from the railroad spur to the convergence of the railroad and Highway 2. This action could be considered for a potential WFPO project or similar regional effort to further enhance the benefits of the UPSM project with a focus on Prairie Creek. This Prairie Creek overflow risk reduction could also beneficially impact long term levee accreditation of the existing Silver Creek levee by increasing available freeboard through keeping Prairie Creek flood waters from entering Silver Creek.
3. Continue to monitor flood risk and impacts for Areas 2 and 3. Begin the process of implementing localized flood risk reduction actions such as:
    a. Berms for Area 2. These berms should be placed at critical overtopping locations: 1) along St. Paul Road from the intersection of St. Paul Road and E. White Cloud Road to the south, 2) along the left bank of Moores Creek just upstream of E. White Cloud Road, 3) along the right bank of Moores Creek just upstream of E. White Cloud Road, and 4) a short extension of existing high ground to prevent flows from bypassing the channel all together. Additionally, a bypass channel was also included to restore access to the natural floodplain.
    b. On site drainage system O&M and systematic improvement for Area 3.
    c. Nonstructural retrofitting for Area 3.

5.2 FUNDING ALTERNATIVES

<u>Local:</u> The City of Grand Island can utilize local funds to support mitigation actions directly or as cost-share funding for state or federal grants. Partnership building for the purposes of grants can both bolster the grant application potential for funding as well as improve the amount the City has to pay to cost share for projects.

<u>Central Platte NRD:</u> The NRD has a long history of supporting local and regional flood risk reduction and watershed management projects. NRD funding may have the potential to support multiple projects, as well as further planning or design efforts for other alternatives, subject to NRD board approval.

Water Sustainability Fund (WSF): This is a program of the Nebraska Natural Resources Commission. This program can fund a wide range of water resource projects, ranging from data collection to design and construction of flood risk reduction infrastructure.

Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act: This is a new revolving loan program that supports the implementation of flood mitigation actions. The STORM program is most likely to have potential to be used for nonstructural retrofitting. While it was recently funded at the federal level, it is administered at the state level, but as of January 2023, the Nebraska Emergency Management Agency (NEMA) will not be participating in this program due to a lack of capability and staffing. However, it's possible NEMA will have the ability to administer the program in future funding years. More information can be found here: https://www.fema.gov/grants/mitigation/storm-rlf.

FEMA Hazard Mitigation Assistance: FEMA Hazard Mitigation Assistance funding opportunities include Flood Mitigation Assistance (FMA), Building Resilient Infrastructure and Communities (BRIC), and Hazard Mitigation Grant Program (HMGP) opportunities. FMA and BRIC are annual grant funding opportunities that are nationally competitive for most projects, with certain project funding decisions at the state level utilizing a state set aside funding amount for BRIC. HMGP funding is associated with post-disaster circumstances and therefore is variable, although funding is state-specific. BRIC and HMGP programs are administered by the NEMA and FMA is administered by NeDNR. While project eligibility and approval criteria are similar across each grant program, certain programs carry additional stipulations. For example, FMA will not fund levee improvements. Obtaining funding through these programs requires a detailed application process and must meet cost-benefit requirements. Cost-share is 75% federal.

NRCS Watershed Flood Protection Operations (WFPO): This program provides the opportunity for further flood risk reduction planning on a watershed scale. It involves the development of a watershed plan – environmental assessment which can be used to justify project construction. NRCS funds the plan and will potentially fully fund the construction of flood risk reduction actions if they are considered cost-beneficial. The ongoing Wood River WFPO project may be able to provide flood risk reduction actions for residual risk areas impacted by Wood River overflows during large flood events.

USACE Section 205: This program can potentially fund structural or nonstructural flood risk reduction improvements. The first step is a feasibility study which can be federally funded at 100% up to $100,000. Completion of the study process typically requires a cost-share. Implementation requires a BCR above 1.0. Cost-share is 65% federal for all study components beyond the initial $100,000 of the feasibility study. The maximum federal cost for a single project including study, design, and construction is $10 million.

5.3 INTEGRATION WITH 2022 HMP

A flood risk assessment summary and reference to this technical report for the Grand Island region will be integrated into the flood discussion in *Section Four: Risk Assessment* of the 2022 Central Platte NRD Multi-Jurisdictional Hazard Mitigation Plan. Additionally, a summary and reference to this technical report will be incorporated into the participant sections for the NRD, Hall County, and City of Grand Island. Following a discussion and review of this report with the City, County, and NRD, mitigation actions will be added to *Section Five: Mitigation Strategy* and their corresponding participant sections to be prioritized and tracked as part of their overall flood risk reduction mitigation strategy.

APPENDICES

APPENDIX A: PARAMETER TABLES

Table A.1: Model Manning's Roughness and Imperviousness by Land Cover

Land Cover	Manning's Roughness (n value)	Percent Impervious
No Data	0.060	0
Cultivated Crops	0.035	0
Developed, Open Space	0.040	0
Grassland-Herbaceous	0.035	0
Developed, Low Intensity	0.100	20
Woody Wetlands	0.120	50
Developed, Medium Intensity	0.080	40
Emergent Herbaceous Wetlands	0.070	75
Developed, High Intensity	0.150	60
Pasture-Hay	0.030	0
Barren Land Rock-Sand-Clay	0.025	0
Deciduous Forest	0.160	0
Evergreen Forest	0.160	0
Open Water	0.040	100
Mixed Forest	0.160	0
Shrub-Scrub	0.100	0

Table A.2: Model Green-Ampt Parameters

Soil Texture	Wetting Front Suction (in)	Saturated Hydraulic Conductivity (in/hr)	Saturated Soil Water Content	Residual Soil Water Content	Pore Size Distribution Index
Sand	3.980	8.772	0.048	0.020	0.694
Loamy sand	5.150	2.380	0.084	0.035	0.553
Sandy loam	8.608	0.939	0.155	0.041	0.378
Loam	9.646	0.520	0.200	0.027	0.252
Silt loam	14.441	0.268	0.261	0.015	0.234
Sandy clay loam	19.435	0.144	0.187	0.068	0.319
Clay loam	16.829	0.085	0.245	0.075	0.242
Silty clay loam	22.033	0.069	0.300	0.040	0.177
Sandy clay	21.703	0.047	0.232	0.109	0.223
Silty clay	24.108	0.037	0.317	0.056	0.150
Clay	26.309	0.024	0.296	0.090	0.165
Unknown	9.646	0.520	0.200	0.027	0.252
Fine sandy loam	8.608	0.939	0.155	0.041	0.378
Fine sand	3.980	8.772	0.048	0.020	0.694
Loamy fine sand	5.150	2.380	0.084	0.035	0.553
No Data	9.646	0.520	0.200	0.027	0.252