Caldwell First Nation
Flood Risk Identification

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Executive Summary

Flooding is a natural occurrence, with specific flood events driven by a wide range of dynamic environmental influences. Flooding has the ability to shape and form the landscape, can be an important driver of ecosystem function, and vital to maintaining habitat. Flooding can be beneficial, however, when floodwaters impact human activities, it can be devastating. The Caldwell First Nation properties, located on Point Pelee (Essex County, Ontario), are characterized by a flat, low lying topography. Much of the Point Pelee region is at or below the long-term average Lake Erie water level.

In 2018, the River Institute was retained by Caldwell First Nation to perform a preliminary flood risk assessment and mapping exercise for two Caldwell First Nation properties deemed to be at an elevated risk. From this initial assessment, it was recommended that efforts be made to perform an assessment on the remaining Caldwell First Nation properties, such that flood risk can be incorporated into future development planning.

Based on the assessment of overland flood risk and risks associated with flash flooding due to severe precipitation, it was found that several of Caldwell First Nation's properties are at High or Very High risk of flooding. Properties found in the southeastern portion of Point Pelee, as well as those to the south of Hillman Marsh, were found to be at highest risk. The primary driver of this risk is the low elevation of these properties relative to nearby Lake Erie or Hillman Marsh. These properties rely on the maintenance of protective berms and a network of drainage canals to mitigate against flooding. In the event that the existing flood management infrastructure is compromised, these properties are at greatest risk.

This report outlines our assessment of the risk that faces Caldwell First Nation with respect to localized flooding. Furthermore, interpretation of this report should serve only as a guidance on potential risks and may not be fully inclusive of all factors which contribute to flood risk. Given the unique spatial context of the Caldwell First Nations properties, located in close proximity to Lake Erie and at such a relatively low elevation, the risk of flooding will perpetually be elevated compared to other areas where these factors do not play a significant role. As a result, it is recommended that Caldwell First Nation continue to work with local and regional partners responsible for water resources to maintain flood management infrastructure and take steps to mitigate the risks that flooding presents to potential future development on the Caldwell First Nation properties.

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Introduction

Flooding is a natural occurrence, with specific flood events driven by a wide range of dynamic environmental influences. Flooding has the ability to shape and form the landscape, can be an important driver of ecosystem function, and vital to maintaining habitat. Flooding can be beneficial, however, when floodwaters impact human activities, it can be devastating. Some flood events are highly frequent and predictable, reoccurring on a seasonal basis. These floods if managed appropriately, are tolerated, allowing human activity to work around them. Other flood events are highly infrequent, and difficult to predict, but require the coalescence of several factors (e.g., snowmelt, severe precipitation, high water levels, and failure of water management infrastructure). These floods are difficult to manage and often result in devastation to areas affected. Beginning in the 1800s, significant efforts have been made to alter the hydrology of the landscape to increase the amount of useable land, while also attempting to limit the risks of devastating floods. While these historical water management strategies have been generally effective, in the face of a changing climate, communities are facing increases in extreme weather and factors which drive the occurrence of flooding. This changing environment challenges existing infrastructure and exposes new communities to unprecedented flooding.

Over the past decade, communities throughout Canada are already bearing witness to this increased flooding risk. In 2013, as a result of heavy rainfall and a rapidly melting snowpack in the eastern foothills of the Rocky Mountains, the Elbow and Bow Rivers flooded. The result was that more than 80,000 people were displaced, with the flooding causing an estimated $5 Billion in damages. The Great Lakes basin has experienced record flooding in both 2017 and 2019. A combination of heavy precipitation and a rapid snowpack melt throughout the Great Lakes basin resulted in a one in 100-year flooding event in the Ottawa River, causing more than $500 million in damages. Similar increases in water level were observed throughout the Great Lakes, resulting in shoreline flooding in both Lake Ontario and Lake Erie. Water levels have remained high in the Great Lakes since 2017, with record high water levels for Lake Ontario, Erie and Michigan/Huron observed in 2019 (Lake Superior had water levels equal to the second-highest ever recorded). The result is that shoreline communities throughout the Great Lakes are experiencing prolonged flooding, with no expected decrease in water levels in the near future. Numerous other communities (e.g., Fredericton New Brunswick, Muskoka, Ontario) have experience unprecedented flooding this decade. Communities must adapt to the new reality that the risk of flooding both minor and severe is increasing.

The traditional lands of Caldwell First Nation are located in southwestern Ontario, along the north shore of Lake Erie. As the result of a land claim settlement, Caldwell First Nation is working towards the procurement of properties throughout Point Pelee in the County of Essex. These properties have significant historical, cultural and/or economic value to the community. Moving forward, it is the goal of Caldwell First Nation to preserve, protect and develop these properties for the benefit of the community. Caldwell First Nation is still in the plan development phase for these properties but recognized significant development potential exists, which may include housing, commercial enterprises, agriculture or restoration. Given the range of potential opportunities for these lands, it is important that plans be implemented to develop the properties in a responsible manner to maintain them for future generations.

The Caldwell First Nation properties, located on Point Pelee (Essex County, Ontario), are characterized by a flat, low lying topography. Much of the Point Pelee region is at or below the long-term average lake

Figure 1. Aerial view of Hillman Marsh and surrounding lands, which include several Caldwell First Nation properties.

level for Lake Erie. As a result of this topography, the Point Pelee region was historically a large wetland complex, with periods of frequent inundation from Lake Erie. Although altered, representation of the historic landscape conditions is maintained in the Point Pelee National Park and Hillman Marsh areas of the point which support wetland habitat for a range of aquatic fauna and flora (Figure 1).

Through the 1800s, efforts were made to convert much of the Point Pelee land area to agricultural lands. To drain the landscape, a network of pumps and canals was created as well as a series of permanent berms on the boundaries of Lake Erie and Hillman Marsh to limit inundation through overland flooding. A consequence of the installation of water management infrastructure is that much of the land area between Point Pelee National Park and the Hillman Marsh (an area known as the East Marsh), is several meters below Lake Erie (Figure 5).

Given the topographical realities of the Point Pelee area, flooding has been an ever-present risk for property owners in the region. This flood risk can primarily be broken down into two categories[1]: overland flooding due to high water levels in Lake Erie and flash flooding due to severe precipitation.

Overland flooding within the Point Pelee context occurs when the berms surrounding Point Pelee are breached by water from Lake Erie (or Hillman Marsh). The most common source of overland flooding, is a result of a temporary change in lake level as a result of wave action, atmospheric pressure or seiche events. In each of these instances, the unique geography of Lake Erie can allow for water in Lake Erie to be pushed up against one end of the lake. The result is that water levels can temporarily rise at one end of the lake, and fall in the other. The western basin of Lake Erie, where Point Pelee is located, is of increased vulnerability to short term water level rises, as the basin is relatively shallow compared to the eastern basin, resulting in a reduced ability to buffer the water moving into the basin. Often combined with seiche events, are increased wave action on the surface of Lake Erie. This combination can result in water breaching the top of the berms which surround Point Pelee, and cause localized flooding, typically in shoreline areas. Instances of overland flooding can increase significantly, if short-term water level

[1] Lavalle. P.D. 1989. Space Time Monitoring of Beach Morphodynamics: A Black Box Approach. In: Applications in Coastal Modeling. Eds. Lakhan, V.C. and Trenhaile, A.S. Elsevier Oceanography.

changes (e.g., wave action or seiches), are combined with longer-term total water level increases as a result of cyclical climate-driven water level fluctuations.

Flash flooding is a result of heavy precipitation occurring over a short duration. Precipitation in the form of rainfall is generally able to infiltrate soil, or runoff from the land and drained through drainage ditches and canals. In instances where rainfall exceeds the ability for water to infiltrate or runoff, it can create localized flooding conditions. Flash flooding can be difficult to predict, as it requires a combination of severe precipitation and soil conditions which have insufficient capacity to shed water from the landscape as a result of infiltration or runoff. These conditions are presented in the spring, as seasonal snowmelt can cause soils to saturate, or in periods of summer drought conditions, as severely dry soil has a limited ability to uptake water. In both instances, if a severe precipitation event (or melt of an existing snowpack) were to occur, the landscape is restricted in its ability to facilitate infiltration and can lead to the development of standing water or flood conditions.

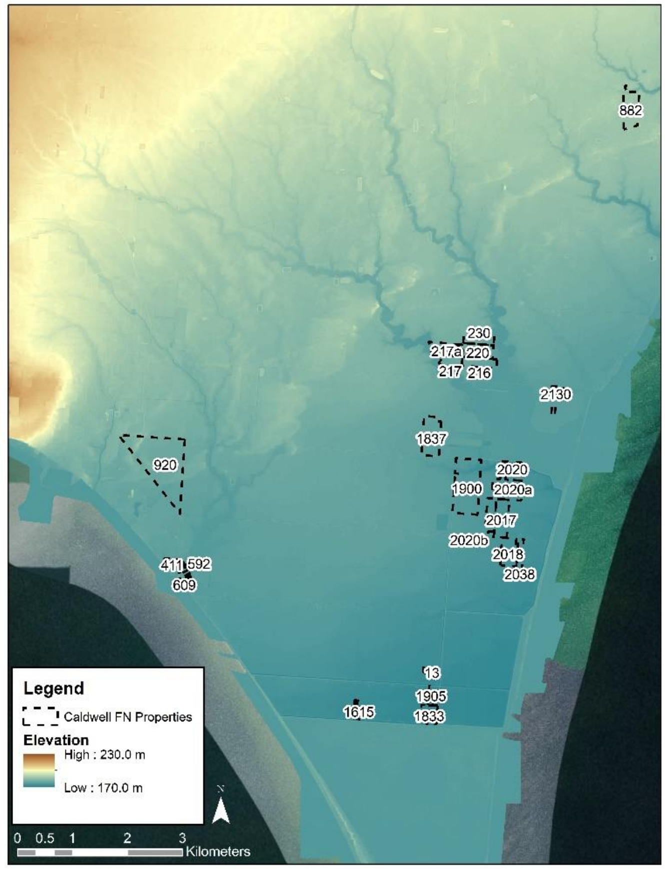


Figure 2. Topographical map outlining the elevation of the Point Pelee area including the Caldwell First Nation properties.

The flood risk becomes greatest when factors are compounded. This was the case in 2019 when record-high Lake Erie water levels combined with high amounts of seasonal precipitation and weather patterns to create conditions that allowed for water to inundate several shoreline properties and others in low lying areas surrounding the Hillman Marsh. As water levels remain at near record-high levels in Lake Erie as well as the other upstream Great Lakes, it is anticipated that the Point Pelee area may be at risk of flooding events for the foreseeable future.

Uncertainty of a Changing Climate

The Great Lakes, including Lake Erie and its tributaries, typically demonstrate a cyclical oscillation in water levels. This pattern is in part driven by global climate patterns (e.g. the North Atlantic Multidecadal Cycle, Pacific Decadal Oscillation, El Nino, La Nina), and is amplified or dampened by the timing of local or regional weather. These patterns result in peaks and valleys in water levels over an 8-12 year period.

A changing climate presents a significant challenge to anticipating future local environmental conditions. In part, this is because changes may occur at a global level, but result in inconsistent effects at local levels. Furthermore, although there is agreement that global air temperatures will increase (including those impacting southwestern Ontario), what is far more uncertain is impacts on rainfall and precipitation, especially through the Great Lakes basin. As a result, there is significant uncertainty regarding the risk posed by flooding in the region. This uncertainty is compounded when other factors influence the water cycle, such as changes in snowpack development, soil freezing as well as timing, intensity and duration of weather events.

Future scenarios for flood risk driven by the changing climate can be quite varied, however, there is significant precedent for flooding in the Point Pelee Region.

Temperature

The temperature throughout the globe is expected to increase over the next 50 years as a result of climate change. In the Point Pelee region, the average annual temperature will increase from 9.6°C (1976-2005) to 11.7°C (2021-2050)[2]. Combined with elevated average temperatures, will be an increase in maximum and minimum annual temperatures, as well as more days above 30°C and fewer days below 0°C. The result of this is an increase in the amount of evaporation from the Lake Erie watershed, an atmosphere that can hold more moisture, leading to less precipitation, and more ice-free days during the winter, resulting in more evaporative losses in the winter. Combined, and increase in temperature should result in a net decrease in flood risk as a result of increases in water export (evaporation) and decreases in water import (precipitation).

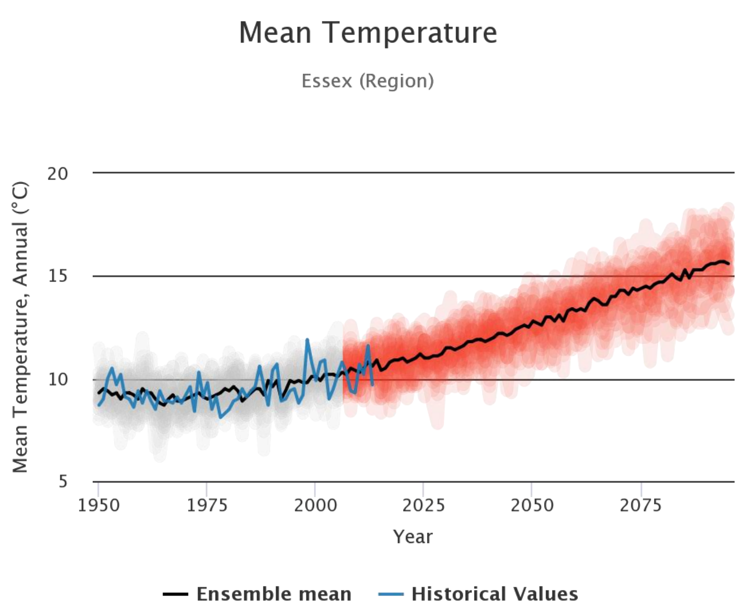


Figure 3. Graph depicting the expected increase in annual average temperature from 1950 until 2095, based on an ensemble of 24 climate models.

Precipitation

Unlike temperature, precipitation has been historically more difficult to predict, depending on air temperature, regional weather patterns and moisture sources. For the point Pelee region, it is expected that annual rainfall will increase with the changing climate. Increases in annual precipitation will be modest, increasing from approximately 825 mm (1976-2005) to 877 mm (2021-2050). However, combined with this, is an expected increase in both extreme rainfall and drought conditions[2]. This means that while there may be long periods of low water conditions, severe events such as the 2018 Windsor-Tecumseh flood, may become more common. During this event, a total of 246 mm of rainfall was recorded in less than six hours. This event goes far beyond the limitations of the hazard scenarios in this report, as that level of precipitation exceeds all

[2] Climate Atlas Report (Essex). 2019. Prairie Climate Centre. Climate Atlas of Canada, version 2. https://climateatlas.ca

accepted Canadian design standards for stormwater management. However, although this event represents an unforeseeable event given current standards, it demonstrates that extreme events do pose a long term risk.

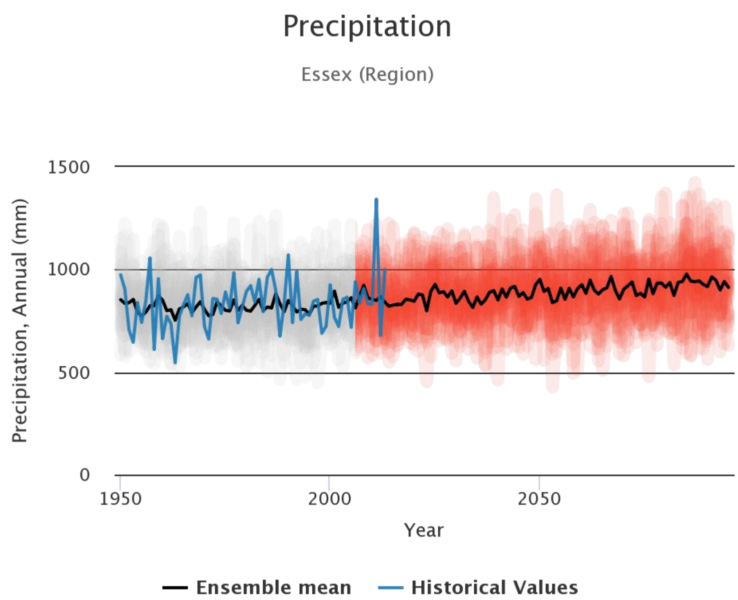


Figure 4. Graph depicting the expected increase in annual average precipitation from 1950 until 2095, based on an ensemble of 24 climate models.

Shifts in the occurrence of both short and long term weather and climate phenomena can impact how water must be managed. Changes in flood regimes can impact not only the likelihood of new flooding but also change how effective or resilient existing flood mitigations are at handling water. Given the historical precedent for flooding in the Point Pelee area, combined with the increased uncertainty due to climate change it is important to recognize the threat which is posed by flooding to the properties of Caldwell First Nation. As a result, it is important to include a flood risk assessment as part of the development planning for the properties.

Previous Work

In 2018, the River Institute was retained by Caldwell First Nation to perform a preliminary flood risk assessment and mapping exercise for two Caldwell First Nation properties deemed to be at an elevated risk. The properties located at 2020 Mersea Road 1 and 2128-2136 Mersea Road 2 were surveyed using aerial imagery collected by a remotely piloted aircraft system (RPAS). The imagery was collected from each property and then used to create a 3-dimensional model of the properties, including their elevations. These properties border Hillman Marsh, which is connected to Lake Erie, and as a result, is limited in its level only by the local level of Lake Erie. Given this proximity, the flood risk was assessed for each property on the basis of risk due to overland flooding. It was found that the property at 2020 Mersea Road 1 has an elevation below that of the contemporary Hillman Marsh/Lake Erie level, and is only protected by the south berm separating Hillman Marsh from the surrounding properties. Conversely, the property located at 2128-2136 Mersea Road 2 is at a lower risk of flooding given its relative elevation compared to the Hillman Marsh/Lake Erie level.

Given the insights derived from this original investigation, it was recommended that efforts be made to work with community partners to ensure that a long-term strategy is in place to maintain flood mitigation infrastructure. Furthermore, it was recommended that efforts be made to perform an assessment on the remaining Caldwell First Nation properties, such that flood risk can be incorporated into future development planning.

Project Goal

Based on the recommendations of the preliminary assessment, the goal of this report is to provide a frame of reference for the risk of flooding associated with each of the existing Caldwell First Nation properties. This includes an overview and understanding of the regional risk factors of flooding which face Caldwell First Nation. This will also provide an assessment of flood risk due to both overland flooding (such as in the event of a breach in a protective berm), as well as a risk of flooding due to flash flooding as a result of severe precipitation. From these analyses, areas of highest risk will be identified.

Methodology

Data Collection

Surveys were performed at a total of 30 of Caldwell First Nation's properties (Appendix A). These properties were subdivided into 72 parcels. Aerial imagery was collected from each parcel using a DJI Phantom 4 Pro RPAS. The RPAS was flown in a grid pattern at an altitude of 60 m, achieving a spatial resolution of 1.3 cm/pixel. Images were then archived for processing.

Data Processing

Once images were collected from each of the land parcels, adjacent parcels were identified and processed together as *Property Complexes.* These complexes represented continuous Caldwell First Nation properties, which would be comparably impacted by flooding. Images for each complex were stitched together using Drone2Map software, creating two primary data products: an orthomosaic map of the complex and a Digital Terrain Model (DTM) (Appendices B-M). The orthomosaic map provides a composite aerial photograph of the complex, which can be used to interpret physical features present in the image, such as buildings, roadways or vegetation. The DTM, similar to a Digital Surface Model (DSM) or Digital Elevation Model (DEM), provides a gradient-based image of the terrain elevation, relative to the RPAS system, removing the impacts of vegetation. Put simply the DTM provides a map of the bare earth elevation of the parcels being surveyed.

Supplementary Data

In addition to the imagery collected by the RPAS at each of the Caldwell First Nation land parcels, regional elevation data was incorporated as supplementary to provide regional context. A DTM of Essex and Kent counties exists with 1 m/pixel resolution. This imagery collected as part of the Natural Resources Canada CanElevation Series provides open-source high-resolution elevation data. This data has already been pre-processed and was used to provide supplemental information about the regional elevation, and information on adjacent properties.

Ground Control Points

At each of the property complexes, location and elevation information was recorded for ground control points. Ground control points provide a method of ground-truthing RPAS data and serve as a quality assurance check for the collected data. Latitude, longitude and elevation to within less than 1 cm were collected using a Real-time Kinematic (RTK) global positioning system (GPS). This system works by using the location of two GPS systems simultaneously to correct for error and provide highly accurate information on location and elevation of the RTK system. Where necessary, information derived from the RPAS system was corrected using the ground control points to improve accuracy.

Flood Mapping and Analysis of Risk

Flood mapping and analysis of the risk posed by flooding were broken down into two categories: risk due to overland flooding and risk due to flash flooding. In both instances, DTMs for each property complex were transferred to ArcGIS in order to perform flood analysis. Analysis of overland flooding was conducted by examining the relative elevation of the properties, relative to Lake Erie water levels under several realized and potential scenarios.

Overland Flooding

Analysis of overland flooding is a straightforward exercise, as it assumes that as floodwaters rise, they impact areas of the landscape at lowest elevations first. Caldwell First Nation properties are all currently protected by the berms which surround Point Pelee. As a result, for flooding of the Caldwell First Nation properties to occur, water from Lake Erie (or the Hillman Marsh) must be higher than the berms. If this instance were to occur, it would result in catastrophic flooding, as a significant portion of Point Pelee is at a lower elevation than the berms. Furthermore, as the berms are higher (though only marginally) than the observed maximum level for Lake Erie, a flooding event of this magnitude would be unprecedented[3]. As a result, to establish overland flood risk this report assumes that one or more of berms becomes compromised, allowing inundation of lake water based on the existing range of Lake Erie fluctuations. Under this scenario, if inundation were to occur, properties below the observed minimum Lake Erie level would always flood, those at a higher elevation than the observed long-term maximum would never flood. To capture this, four risk categories were established:

- **Low Risk** – Elevation >175.50 m; the maximum observed water level of Lake Erie
- **Moderate Risk** – Elevation 174.16 – 175.50 m; greater than the long-term average observed water level of Lake Erie, but less than the maximum observed water level of Lake Erie
- **High Risk** – Elevation 173.18 – 174.16 m; greater than the minimum observed water level of Lake Erie, but less than the long-term average observed water level of Lake Erie
- **Very High Risk** – Elevation <173.18 m; less than the minimum observed water level of Lake Erie

Flooding due to Precipitation

Analysis of flood risk due to flash flooding as a result of severe precipitation was conducted through a process known as *bluespot* analysis. Bluespot analysis assumes top-down flooding (e.g. the source of floodwaters is from the sky) and identifies areas within properties that are prone to holding standing water, as well as provides an estimate of the amount of precipitation required to cause flooding. With bluespot analysis, several assumptions must be made about the rate of infiltration into the soil, evaporation and drainage. To understand how water pools in a severe rainfall event, it is important to understand the primary drivers which are explained by the following water balance equation:

$$P = I + E + Ao + Au + Q$$

Where (P) is the precipitation equal to the interception caught by vegetation (I) plus evaporation (E) plus surface run-off (Ao) plus soil infiltration (Au) plus any remaining standing water (Q).

[3] Water levels have locally exceeded the average Lake Erie maximum during short-term weather events as a result of wave action or seiches. These events result in localized flooding, as the lake water is still partially impounded and managed by the existing water management infrastructure.

Hypothetically, imagine a large bathtub with the plug left in. With this formula there would be no losses from the system due to interception from vegetation (I), the bathtub is impervious, so there would be no losses through infiltration (Au) and with the plug in, there would be loss due to run-off (Ao). Furthermore, over a short period of time, the amount of water lost from evaporation (E), would be negligible. As a result, for this simplified example, the amount of water pooling in the bathtub would be equal to the amount which enters through the faucet (P) – the bluespot or flooded area would be the bathtub.

For a real-world scenario, predicting bluespots or flooded areas as a result of severe rainfall is a bit more challenging, however, some generalized assumptions can be made. In making these assumptions, it is important to err on the side of caution, utilizing a worst-case scenario. As a result, the following assumptions are made about the conditions facing Caldwell First Nation properties: In a severe rainfall event, interception, evaporation and soil infiltration can be assumed to be negligible. This is because the rainfall event occurs over such a small period of time that dry soils cannot facilitate rapid infiltration of precipitation, similarly, vegetation can have difficulty intercepting meaningful amounts of precipitation during severe rainfall events. Severe events are assumed to take place over a short duration (less than 12 hours), and during the event, the air is assumed to be near the point of saturation, evaporation can be assumed to be minimal. Finally, as a generalization, Caldwell First Nation properties and those surrounding them have minimal topographic relief and no direct stormwater management system. As a result, over short durations, runoff will also be limited. But for the purpose of this project, it will be assumed that water can be shed from the landscape at a rate of 10 mm/hour. Based on these assumptions, the bluespot analysis formula can be shorted to be:

$$P = 10 + Q$$

Or

$$Q = P - 10$$

Where the volume of water pooling is equal to the rate of precipitation less 10 mm/hour which is allowed to run-off.

To provide an assessment of vulnerability to the Caldwell First Nation properties, five risk categories were established:

- **Very Low Risk** – Standing water develops only after >90 mm/hour of rainfall
- **Low Risk** – Standing water develops only after 70 – 90 mm/hour of rainfall
- **Moderate Risk** – Standing water develops only after 50 – 70 mm/hour of rainfall
- **High Risk** – Standing water develops only after 30 – 50 mm/hour of rainfall
- **Very High Risk** – Standing water develops with <30 mm/hour of rainfall

In Ontario, Environment Canada issues a rainfall warning when more than 50 mm or more of rain is expected within one hour. As a result, the thresholds established in this report are intended to be reference points only. Areas deemed to be High or Very High risk are likely to flood or develop standing water routinely though the course of a given year. Moderate risk areas may flood occasionally. Low and Very Low-risk areas may flood or develop standing water only in extreme instances, though that is not to say they are entirely immune. Furthermore, areas identified are a specific product of the bluespot analysis described above. This analysis makes several assumptions about the landscape, which may not be fully realized in a given rainfall or flood event.

Overall Vulnerability to Flooding

Understanding of the direct risk of flooding to Caldwell First Nation properties, whether it be overland flooding or flash flooding due to precipitation, is important on an individual basis, as it can help inform the flood mitigation strategies necessary to deal with specific events. However, from property development and utilization perspective, what is of greater importance is to identify areas that are vulnerable to flooding regardless of the pathway. In all likelihood, instances of flooding are more likely the combined result of overland and severe, or continued precipitation, rather than specifically one or the other. To account for this, a secondary assessment of Caldwell First Nation properties was performed to establish overall vulnerability. Using the matrix outlined in Table 1, instances where properties, or portions of properties have both high risk of both overland and flash flooding, would be considered most vulnerable. Conversely, properties with low risk for both flood categories would be rated as least vulnerable, with the remaining situations rated as intermediate as appropriate.

Table 1. Conceptual figure establishing the relative vulnerability due to flood properties face based on a combination of overland flood risk and flash flooding as a risk of intense precipitation.

		Elevation (Risk of Overland Flooding)				
		>175.5 m	175.5 – 174.16 m	173.18 – 174.16 m	<173.18m	
	<30 mm	Very High	Very High	Very High	Very High	Very High
	30 –50 mm	High	High	High	Very High	
Rainfall Flooding Amount (Risk of Flash Flooding)	50 – 70 mm	Moderate	Moderate	High	Very High	Vulnerability
	70 – 90 mm	Low	Moderate	High	Very High	
	>90 mm	Low	Moderate	High	Very High	Very Low
		Low	Vulnerability		Very High	

Assessment of Flood Risk

Historically much of the point was a wetland environment, with much of the land area frequently underwater. Point Pelee formed through the deposition of sediment, which created a ridge, promoting further deposition, which when combined with long-term fluctuations in lake level and the establishment of vegetation, resulted in the permanent landform which exists today. As Point Pelee is at such a low elevation, it remains a dynamic landform, exposed to continued cycles of erosion and deposition. Given the low relative elevation, Point Pelee is at high risk due to flooding due to high amounts of precipitation and overland inundation. Figure 5, illustrates the elevation of Point Pelee and the surrounding area, as well as the observed minimum, mean and maximum heights of Lake Erie[4].

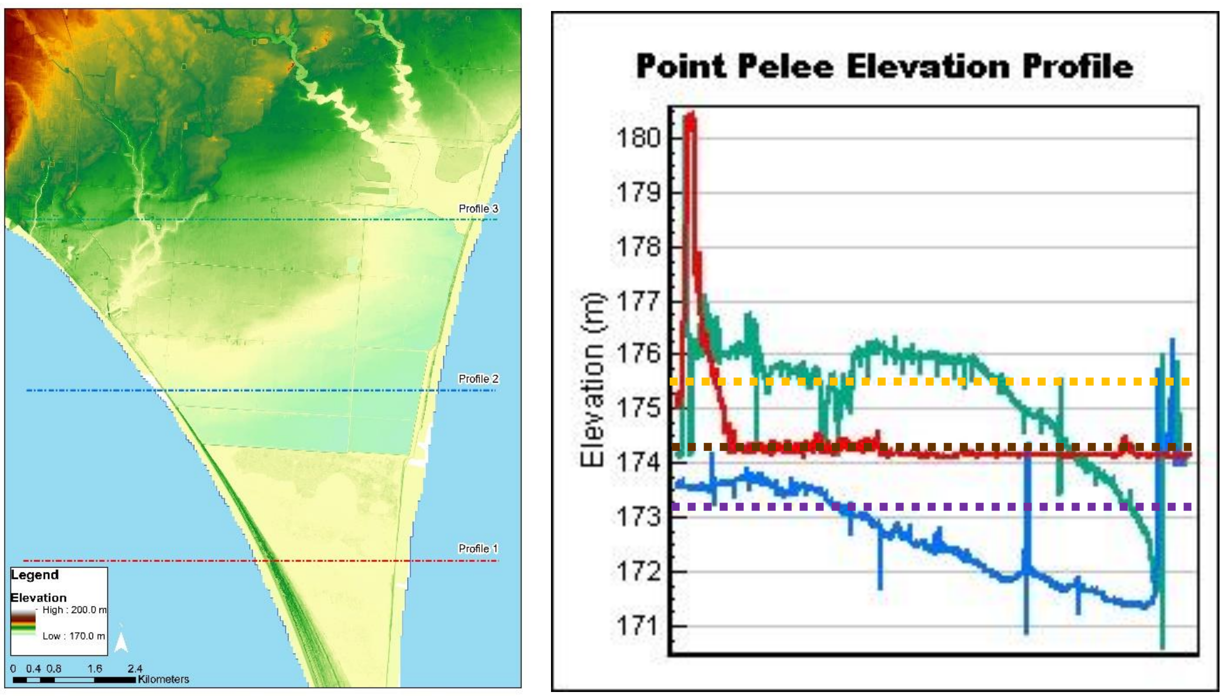


Figure 5. Topographical Map (left) and profile of Point Pelee. Central sections of the Point (north of Point Pelee National Park) have the lowest profile. In each instance, elevated protective berms surround the lower interior. Minimum (purple), Average (brown) and Maximum (yellow) Lake Erie water levels are plotted over top of the land topography profiles.

A significant portion of Point Pelee resides below even the minimum water levels (173.18 m) observed in 1935, with nearly half of the Point Pelee area below the long-term average. The portion of the point which is occupied by Point Pelee National Park is at an elevation approximately equal to the long-term water level average and is comprised of a large wetland comparable to what may be expected of the landscape if it were naturalized. Directly adjacent to the north of the Park area is an area of significant agricultural activity. This area is at the lowest elevation and is separated from the park wetlands and Lake Erie by a retaining berm. The elevation of this area is as low as 8 m below the long-term Lake Erie minimum observation. The elevation increases moving north and west from this depression area.

[4] National Oceanic and Atmospheric Administration/Environment and Climate Change Canada 1918-Present Lake Erie Water Levels. Water levels are averaged across gauging stations at Port Stanley ON, Port Colborne ON, Toledo OH and Fairport OH.

Vulnerability due to Overland Flooding

Overland flooding is a major source of risk for the Caldwell First Nation properties, as many of them lie near or below the long-term average Lake Erie water level. Properties located below Lake Erie water level are at sustained risk of flooding, in the event that one or more of the protective berms are breached, or otherwise compromised. In absence of the protective berm, water from Lake Erie would be able to flow unencumbered through much of the low-lying eastern portion of the point, significantly flooding much of the 2018-2038, 2009-2017-2020, 1611-1615, 1833-1905 and 13 property complexes (Table 2), all of which have an average elevation below the Lake Erie long-term average (174.16 m).

It is important, however, to note that although these properties are at continued risk of flooding, due to their low elevation, the flood defences – some of which date back to the 1850s when the region was first drained – remain in place. As a result, it would require a catastrophic failure of infrastructure (in some cases a series of failures, as there are redundant berms and protective barriers), in order for a wide-scale flood event to occur. However, as witnessed in previous flooding events, record-high Lake Erie water level can increase the likelihood of water to breach existing flood infrastructure. The result of these breaches is localized flooding, with low-lying areas and those closest to the breach at greatest risk. Many factors influence where and when a breach of the flood infrastructure will occur, which is beyond the scope of this report, however this assessment of overland flood vulnerability establishes a baseline flood scenario for the Caldwell First Nation properties.

Table 2. Land area for each property complex vulnerable to overland flooding, based on elevation.

Parcel Complex	Area	Mean Elevation	Overland Flood Vulnerability			
			Low (>175.5 m)	Moderate (175.5 - 174.16 m)	High (174.16 – 173.18 m)	Very High (<173.18 m)
Marina Complex	7.7 ha	175.11 m	0.9 ha	6.7 ha	0.1 ha	0.0 ha
1611-1615 Complex	4.0 ha	172.01 m	0.0 ha	0.0 ha	<0.1 ha	4.0 ha
1833-1905 Complex	12.5 ha	171.23 m	0.0 ha	0.0 ha	<0.1 ha	12.5 ha
13 Complex	2.9 ha	171.87 m	0.0 ha	0.0 ha	<0.1 ha	2.9 ha
2018-2038 Complex	16.9 ha	172.98 m	0.0 ha	0.0 ha	3.1 ha	16.5 ha
2009-2017-2020 Complex	58.8 ha	173.45 m	0.0 ha	0.1 ha	54.4 ha	4.3 ha
1900 Complex	45.2 ha	174.01 m	<0.1 ha	18.4 ha	23.3 ha	3.4 ha
1837 Complex	21.9 ha	175.32 m	4.9 ha	17.0 ha	<0.1 ha	0.0 ha
215-230 Complex	54.7 ha	176.46 m	49.0 ha	5.6 ha	<0.1 ha	0.0 ha
2130 Complex	5.5 ha	174.91 m	0.1 ha	5.3 ha	0.0 ha	0.0 ha
920 Complex	81.4 ha	176.78m	81.9 ha	2.2 ha	0.0 ha	0.0 ha
882 Complex	18.0 ha	181.27 m	17.9 ha	0.0 ha	0.0 ha	0.0 ha

Vulnerability due to Precipitation (Flash) Flooding

Flooding due to precipitation (typically severe rainfall) is a result of water being added to the landscape faster than it can be shed through surface runoff or infiltration. The result is the formation of standing water across the landscape. Relative to overland flooding, flooding due to precipitation does not pose as widespread of a risk. For standing water to form, the surface of a property must be concave, in which water will drain into, but not out (i.e., pooling). Furthermore, depending on the size of the landscape depression, it will require more (or less) water before the depression is filled. As a result, interpretation of precipitation flooding needs to be done with some caution. For example, areas within a property with Very High vulnerability, requiring less than 30 mm of rainfall per hour, require relatively little precipitation before creating a pool of standing water (flooding), however, an area with Very Low vulnerability, requiring more than 90 mm of rainfall per hour, are able to hold a much greater amount of volume. As a result, while Very High vulnerability areas are likely to flood quickly, Very Low vulnerability areas, if they are able to receive sufficient precipitation, will be more substantial.

Generally, within the Caldwell First Nation properties, the total amount of vulnerable area is proportionate to the property size, with most of the vulnerable areas determined to be either Very High or Very Low (Table 3). The Caldwell First Nation properties comprise largely of agricultural fields and other undeveloped lands. Agricultural fields ideally have minimal relief, or slight gradation to encourage drainage. This results in minimal areas where water will pool, or where it does pool, it is greatly limited in volume, resulting in the rapid development of standing water in the Very High vulnerability areas. The areas classified as Very Low vulnerability comprise areas where it will require more than 90 mm of precipitation per hour to fill or more. These areas are not expected to result in flooding under normal circumstances. Instances where Very Low vulnerability areas flood, would result in a much broader flooding event beyond what can be anticipated through this report.

Table 3. Land area for each property complex vulnerable to flooding due to severe precipitation, based on the occurrence of landscape depressions.

Parcel Complex	Area	Mean Elevation	Precipitation Flood Vulnerability				
			Very Low (>90 mm)	Low (70 – 90 mm)	Moderate (50 – 70 mm)	High (30 - 50 mm)	Very High (<30 mm)
Marina Complex	7.7 ha	175.11 m	6.8 ha	0.0 ha	0.4 ha	<0.1 ha	0.5 ha
1611-1615 Complex	4.0 ha	172.01 m	3.9 ha	0.0 ha	0.0 ha	0.0 ha	0.2 ha
1833-1905 Complex	12.5 ha	171.23 m	11.7 ha	0.0 ha	0.0 ha	0.0 ha	0.8 ha
13 Complex	2.9 ha	171.87 m	2.5 ha	0.0 ha	0.0 ha	0.0 ha	0.4 ha
2018-2038 Complex	16.9 ha	172.98 m	19.4 ha	0.02 ha	0.0 ha	<0.1 ha	0.7 ha
2009-2017-2020 Complex	58.8 ha	173.45 m	53.8 ha	0.0 ha	0.0 ha	<0.1 ha	5.0 ha
1900 Complex	45.2 ha	174.01 m	40.0 ha	0.0 ha	<0.1 ha	0.4 ha	4.8 ha
1837 Complex	21.9 ha	175.32 m	20.8 ha	0.0 ha	0.1 ha	0.1 ha	1.0 ha

Parcel Complex	Area	Mean Elevation	Precipitation Flood Vulnerability				
			Very Low (>90 mm)	Low (70 – 90 mm)	Moderate (50 – 70 mm)	High (30 - 50 mm)	Very High (<30 mm)
215-230 Complex	54.7 ha	176.46 m	52.5 ha	0.1 ha	<0.1 ha	0.2 ha	1.8 ha
2130 Complex	5.5 ha	174.91 m	4.7 ha	0.1 ha	<0.1 ha	0.0 ha	0.7 ha
920 Complex	81.4 ha	176.78m	72.3 ha	<0.1 ha	2.5 ha	1.1 ha	5.5 ha
882 Complex	18.0 ha	181.27 m	15.8 ha	<0.1 ha	0.0 ha	<0.1 ha	2.2 ha

Combined Flood Vulnerability

The assessment of total flood vulnerability combines the risk imposed by overland flooding with the risk of flooding due to severe precipitation. As a result, the combined flooding vulnerability is greatly influenced by the low regional elevation of the Caldwell First Nation properties. Specifically, properties with an elevation entirely below the long-term minimum Lake Erie water level (173.18 m), are assessed as entirely Very High vulnerability. Comparatively, properties at higher elevations (e.g., 920 Complex or 882 Complex), have low combined flood vulnerability.

Table 4. The land area of combined flood vulnerability for each property complex. Combined flood vulnerability is assessed based on the categorization of overland flooding and flooding due to precipitation.

Parcel Complex	Area	Mean Elevation	Combined Flood Vulnerability			
			Low	Moderate	High	Very High
Marina Complex	7.7 ha	175.11 m	0.9 ha	6.3 ha	0.1 ha	0.5 ha
1611-1615 Complex	4.0 ha	172.01 m	0.0 ha	0.0 ha	0.0 ha	4.0 ha
1833-1905 Complex	12.5 ha	171.23 m	0.0 ha	0.0 ha	0.0 ha	12.5 ha
13 Complex	2.9 ha	171.87 m	0.0 ha	0.0 ha	0.0 ha	2.9 ha
2018-2038 Complex	16.9 ha	172.98 m	0.0 ha	0.0 ha	0.3 ha	16.6 ha
2009-2017-2020 Complex	58.8 ha	173.45 m	0.0 ha	0.1 ha	49.5 ha	9.2 ha
1900 Complex	45.2 ha	174.01 m	0.0 ha	16.2 ha	20.8 ha	8.2 ha
1837 Complex	21.9 ha	175.32 m	4.5 ha	16.2 ha	0.2 ha	1.0 ha
215-230 Complex	54.7 ha	176.46 m	47.4 ha	5.3 ha	0.1 ha	1.9 ha
2130 Complex	5.5 ha	174.91 m	0.1 ha	4.4 ha	0.3 ha	0.7 ha
920 Complex	81.4 ha	176.78m	70.7 ha	4.1 ha	1.1 ha	5.5 ha
882 Complex	18.0 ha	181.27 m	15.8 ha	0.0 ha	0.0 ha	2.2 ha

Uncertainty of Climate Change

Generally speaking, there is great uncertainty about the specific effects that will impact the Point Pelee area. However, climate models can be used to make predictions, which can then be used to extrapolate how the changing environment will manifest in the future.

Potential Scenarios

The risk assessment performed in this report focuses on flooding within the context of what has already been observed. Flooding observed as a result of the inundation of water from Lake Erie has long occurred in the region and is a part of life. This inundation is driven typically by one of two environmental drivers, taking place over either short or long time scales. First, inundation over a short time scale can be driven by tilting of the lake's surface, (e.g. seiches or wave action), which can result in increases in lake level by as much as 3.5 m over the course of a week. The shape of the lake, combined with its relatively shallow depth, especially in the western basin, can allow water to be pushed from east to west, increasing water levels in the western basin while lowering them in the eastern. This short term action can result in lake water to breach the berms surrounding Point Pelee resulting in localized flooding. The second form of inundation, which occurs over the course of a season, or several seasons, is an increase in total water levels for the entire lake. This can be a result of changes in the relationship between inputs (e.g., inflow, precipitation and runoff) and outputs (e.g., outflow and evaporation), increasing the amount of water volume present.

The effects of flooding on shoreline regions are often greatest when both the overall lake level is high, while a short term event results in a tilting of the Lake Erie surface, pushing water towards the western basin. In 2017 and 2019, the combination of high water levels, as a result of increased seasonal precipitation, with short term weather events, such as high easterly winds, resulted in multiple localized flooding events. These events impacted properties directly adjacent to Lake Erie the greatest, however during the 2019 flooding, Lake Erie breached the outer Marentette waterbreak, exposing the internal berms to wave action. This event is significant as the intern berm structure is not designed to guard against high energy wave action of Lake Erie, as exposure may lead to rapid erosion. Continued breaching of the external breakwater and berm system, poses a significant risk to the long term sustainability of Point Pelee's flood defences. Conditions observed during the 2017 and 2019 high water events may be considered outliers over the long term record (1918-present), however, they are not without precedent, with conditions in 1973 (174.98 m), 1986 (175.04 m), and 1997 (175.01 m), all demonstrating similarly high water levels and often resulting in the establishment of additional flood defences (e.g. the Marentette waterbreak was built as an emergency response to the 1973 inundation).

Moving forward and with an eye towards a changing and uncertain climate, it is important for Caldwell to expect increased instances of both localized and wider spread flooding through many of the Caldwell properties.

Recommendations and Conclusion

The Caldwell First Nation properties and the surrounding Point Pelee area are located in a precarious and vulnerable area as a result of their low elevation. This region was historically a large wetland complex, and as a result, without active flood prevention measures (e.g. the berm and drainage networks), the area would revert back to a landscape dominated by water. These existing flood defence measures are vital to protect against flooding in the Point Pelee area. In order to maintain the integrity of the Caldwell First Nation properties, it is imperative that existing flood mitigation infrastructure is maintained. A significant proportion of the existing Caldwell First Nations properties, especially those in the southeast portion of Point Pelee (e.g., Properties 1611, 1615 1833, 1905 and 13) are located at or below the long-term average Lake Erie water level. These properties are continually reliant on the long-term maintenance of the protective berms and drainage network. Further to this point, as witnessed in 2017 and 2019, even with the existing flood prevention measures, flooding as a result of inundation in shoreline areas, or in properties surrounding the Hillman Marsh are vulnerable. The record high water levels of Lake Erie are likely going to persist at least through the short-to-medium terms as upstream Lake Huron/Michigan and Lake Superior are at, or near, record levels. Based on both historical (e.g., 1973) and contemporary (e.g., 2019) flooding of the Point Pelee region, it can be expected that flooding of the area will continue so long as the Lake Erie water level remains above the long term average.

Sustained high water conditions are a challenge to the existing water management infrastructure, as berms (especially the unprotected interior berms) are vulnerable to erosion if exposed to wave action or moving water. Similar is the case with un-hardened shorelines, which may experience increased wave action during high water levels. It is important to balance regional priorities, as shoreline hardening (e.g. the addition of rip-rap or waterbreaks to the shoreline) can reduce erosion, it comes at the cost of reduced habitat which need naturalized shorelines to move between the land and water. To continue to prevent significant flooding and impacts to the Caldwell First Nation Properties, it is imperative that water management infrastructure, including but not limited to the East Beach berm, Hillman Marsh berm, as well as the interior berms, be monitored and maintained.

Risks associated with precipitation were also examined for each of the Caldwell First Nation properties. In many instances, areas of High or Very High risk of flooding, or the development of standing water were identified. Generally, this is common among agricultural lands with minimal gradation, as they rely on infiltration into the soil for their drainage. It is expected that as a result of development, the property may experience re-grading, which will change the validity of this data set. However, by understanding where precipitation collects across the landscape, efforts can be made to move planned activities or improve site conditions prior to development. This report outlines the worst scenario case for flash flooding due to severe precipitation in which the soil has very limited capacity to uptake the falling precipitation. This scenario is limited to soil which is already saturated, such as the case in the spring, or is experiencing drought. Examining the worst-case scenarios for soil drainage provides added caution when planning. It is recommended that as properties are developed, stormwater management infrastructure such as low impact development (e.g. green roofs, bioswales, retention wetlands), which promote water diversion from infrastructure, yet encourage natural drainage and uptake be considered.

This report outlines our assessment of the risk that faces Caldwell First Nation with respect to localized flooding. This document is intended to serve only as a guidance document and may not be fully inclusive of all factors which contribute to flood risk. However, given the unique spatial context of the Caldwell First Nations properties, located in close proximity to Lake Erie and at such a relatively low elevation, the risk of flooding will perpetually be elevated compared to other areas where these factors do not play a significant role. As a result, it is recommended that Caldwell First Nation continue to work with local and regional partners responsible for water resources to maintain flood management infrastructure and take steps to mitigate the risks that flooding presents to potential future development on the Caldwell First Nation properties.

Limitations

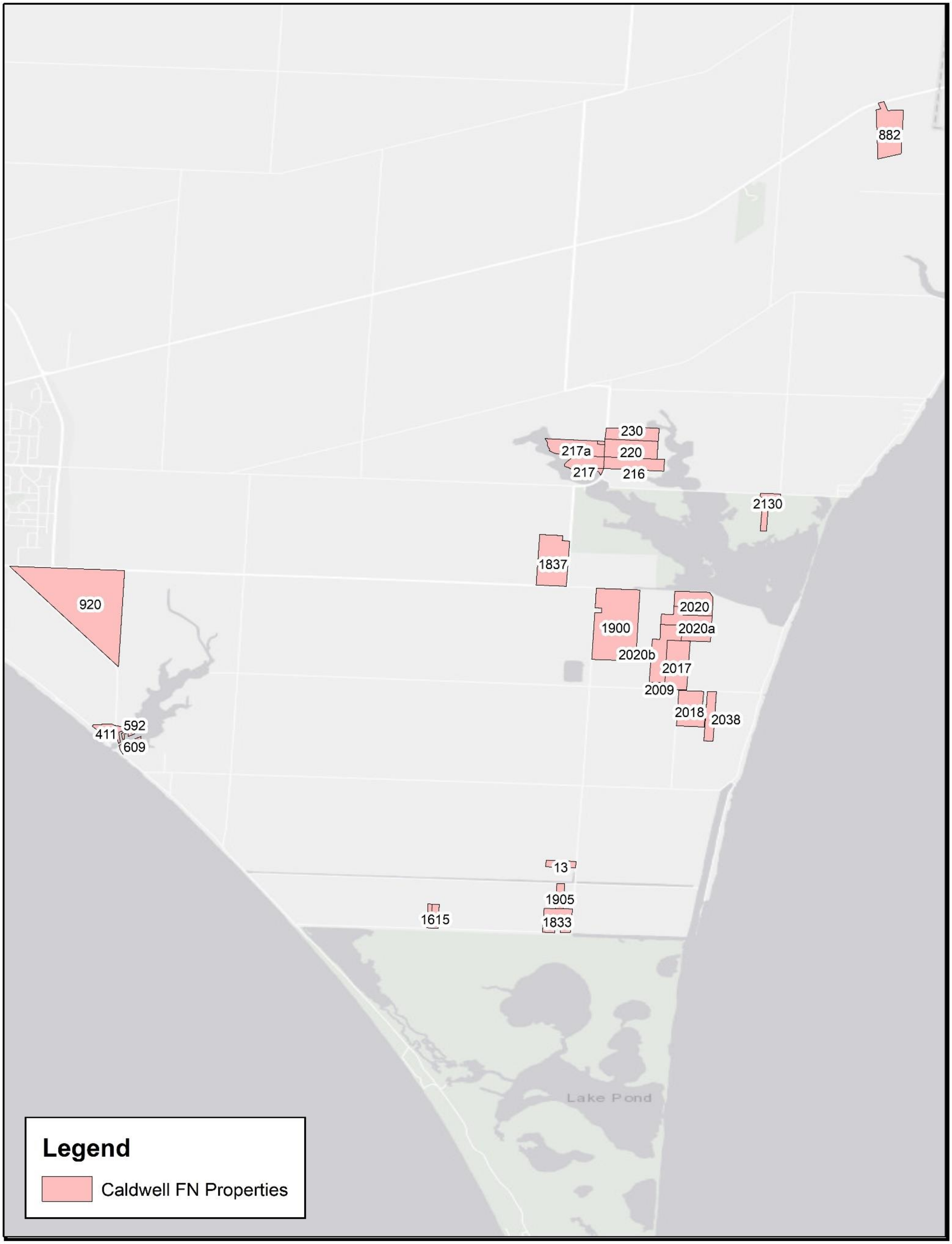
This report has been prepared by the St. Lawrence River Institute of Environmental Sciences (RiverLabs) for the exclusive use and benefit of Caldwell First Nation. This report is intended to serve strictly as a reference and guidance document to aid in future development planning. Although an effort was made to ensure that the collection and analysis of information represented in this report are accurate, the St. Lawrence River Institute of Environmental Sciences or its subsidiaries denies any liability to parties who access and use this report. Furthermore, it should be acknowledged that this report does not replace or supersede any existing or future official flood maps.

Finally, this report does not conform with flood plain mapping technical standards as established by the Ontario Ministry of Natural Resources and Forestry. As a result, this report should serve for informational purposes only.

Appendix A - List of Land Parcels

Table 5. List of each property complex, including each individual property, approximate street address, location and estimate land area.

Parcel Complex	Parcel (Property)	Street Address	Latitude	Longitude	Land Area
Marina Complex	411	411 Robinson Road	42.01242	-82.57397	7.7 ha
	609	609 County Road 33	42.01080	-82.57108	
	592	592 County Road 33	42.01222	-82.57171	
1611-1615 Complex	1611	1611 Mersea Road E	41.98768	-82.53319	4.0 ha
	1615	1615 Mersea Road E	41.98767	-82.53226	
1833-1905 Complex	1833	1833 Mersea Road E	41.98785	-82.51706	12.5 ha
	1905	1905 Mersea Road D	41.99154	-82.51680	
13 Complex	13	13 Mersea Road 19	41.99572	-82.51694	2.9 ha
2018-2038 Complex	2018	2018 Mersea Road B	42.01530	-82.50061	19.6 ha
	2038	2030 Mersea Road B	42.01463	-82.49779	
2009-2017-2020 Complex	2009	2009 Mersea Road B	42.01980	-82.50445	59.3 ha
	2017	2017 Mersea Road B	42.01929	-82.50233	
	2020	2020 Mersea Road 1	42.02778	-82.50010	
	2020a	2020 Mersea Road 1	42.02612	-82.50067	
	2020b	2020 Mersea Road 1	42.02120	-82.50391	
1900 Complex	1900	1900 Mersea Road 1	42.02745	-82.50933	45.1 ha
1837 Complex	1837	1837 Mersea Road 1	42.03263	-82.51777	21.9 ha
215-230 Complex	215	215 Mersea Road 19	42.04487	-82.51275	54.6 ha
	216	216 Mersea Road 19	42.04510	-82.51017	
	217	217 Mersea Road 19	42.04715	-82.51217	
	217a	217 Mersea Road 19	42.04763	-82.51209	
	217b	217 Mersea Road 19	42.04895	-82.51128	
	220	220 Mersea Road 19	42.04826	-82.50891	
	230	230 Mersea Road 19	42.05019	-82.50783	
2130 Complex	2130	2130 Mersea Road 2	42.04188	-82.49062	5.4 ha
920 Complex	920	920 Bevel Line	42.02962	-82.57822	84.1 ha
882 Complex	882	822 County Road 34	42.09037	-82.47568	17.9 ha



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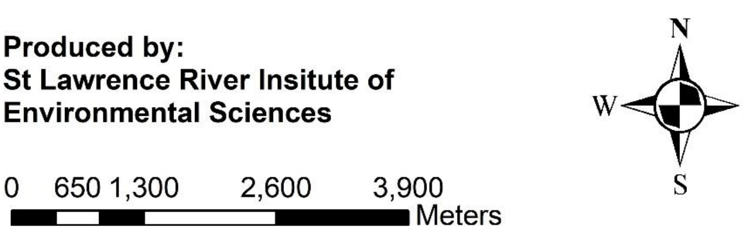

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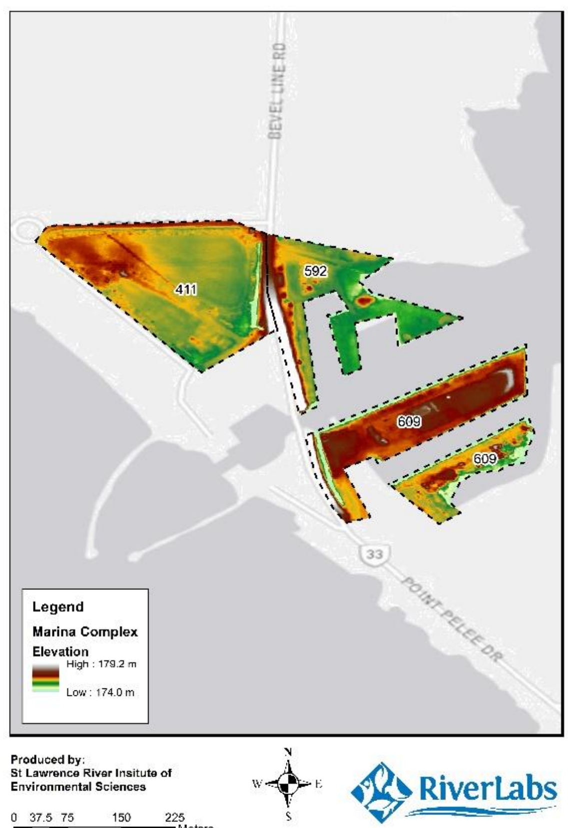
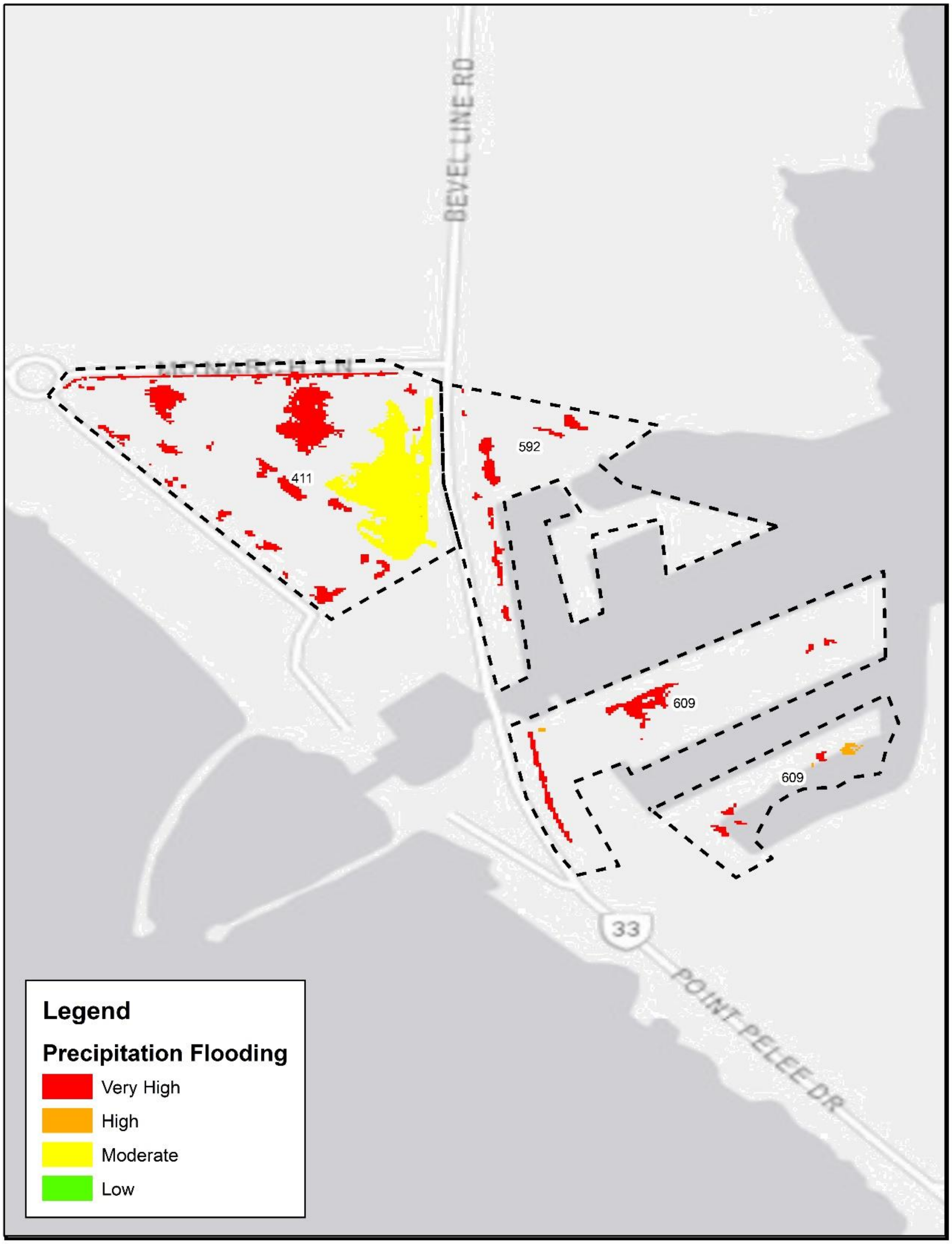
Appendix B – Marina Complex

Property Complex Name:	Marina Complex	
Property(ies) Street Address:	411 Robinson Road 609 County Road 33 592 County Road 33	
Total Complex Area:	7.7 ha	
Minimum Elevation:	174.04 m	
Maximum Elevation:	179.20 m	
Mean Elevation:	175.11 m	
Total Flood Risk	***Very High***	0.5 ha
	High	0.1 ha
	Moderate	6.3 ha
	Low	0.9 ha





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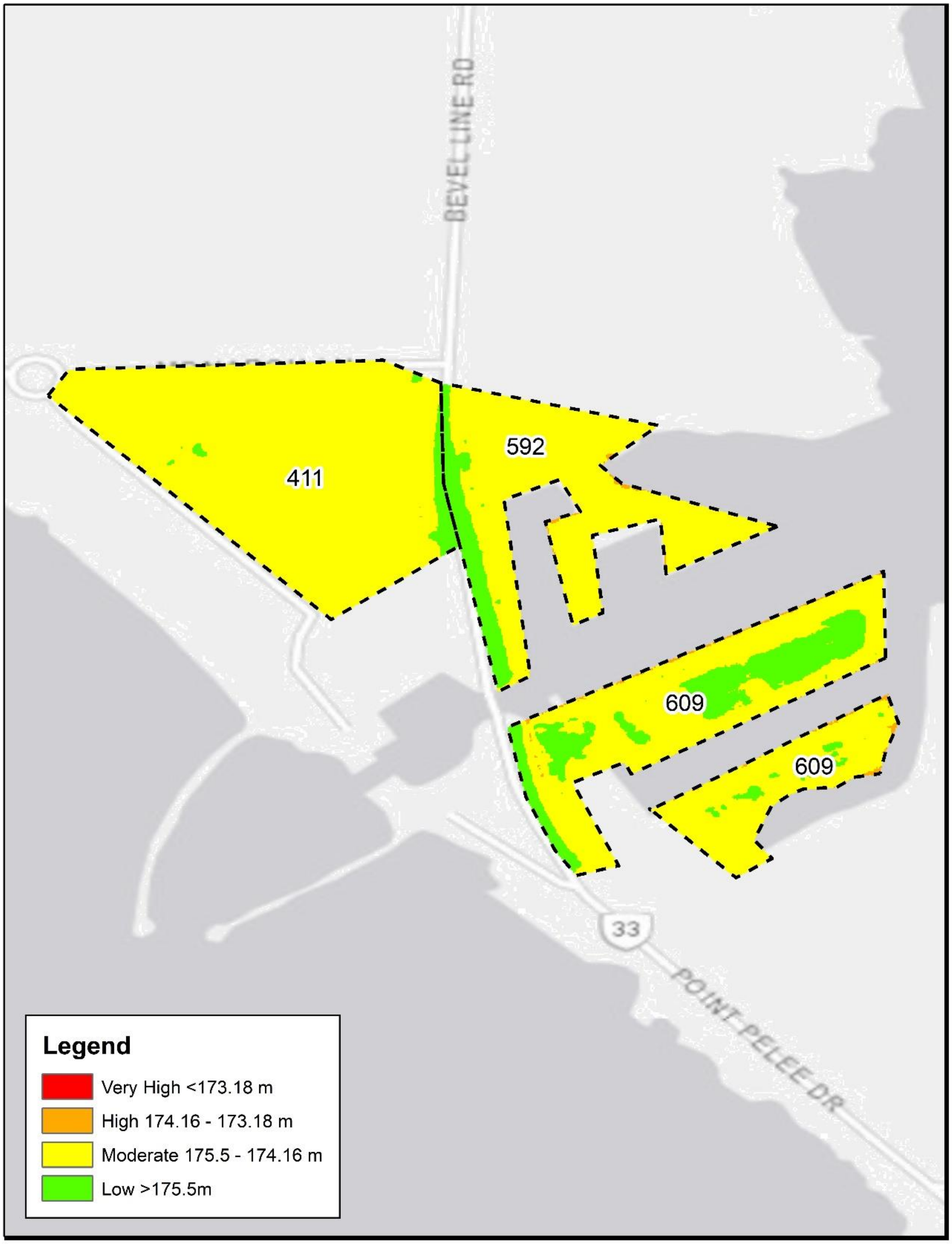

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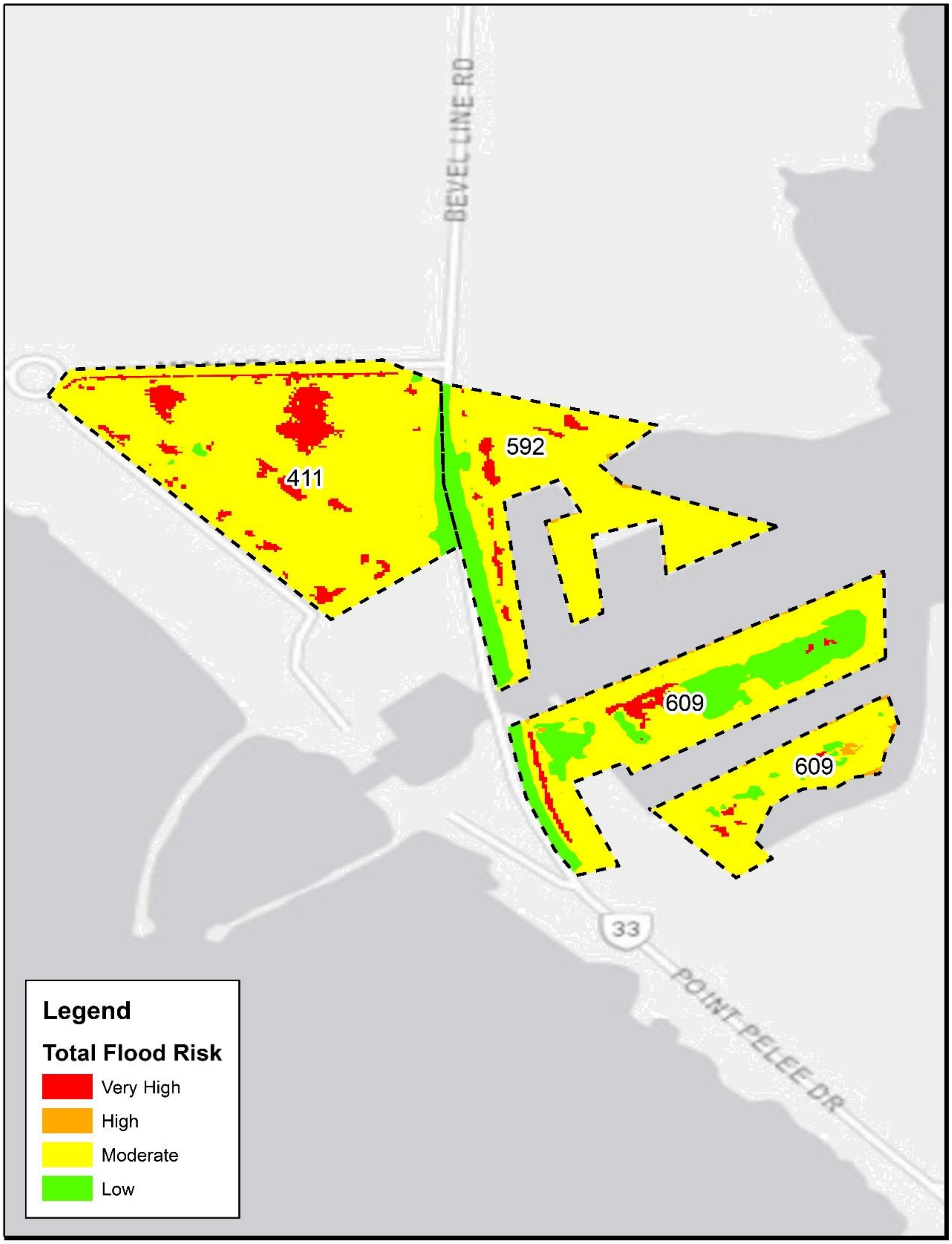

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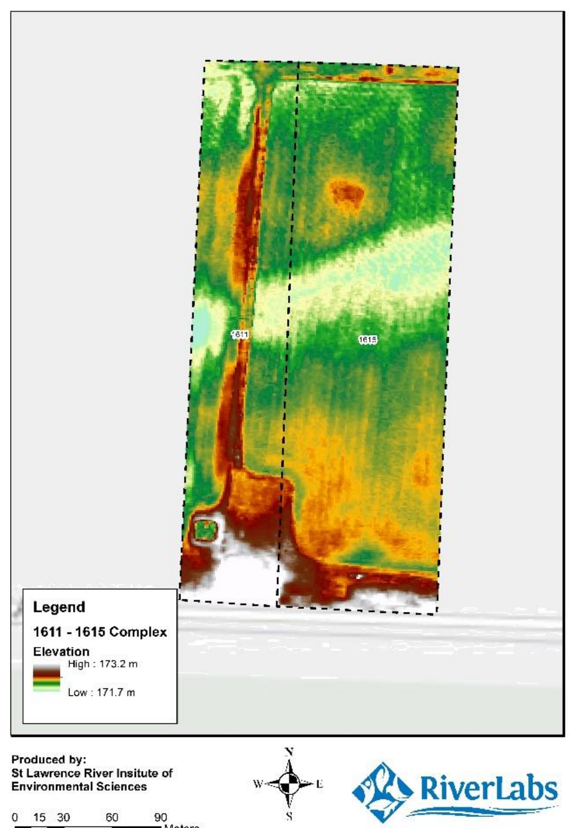
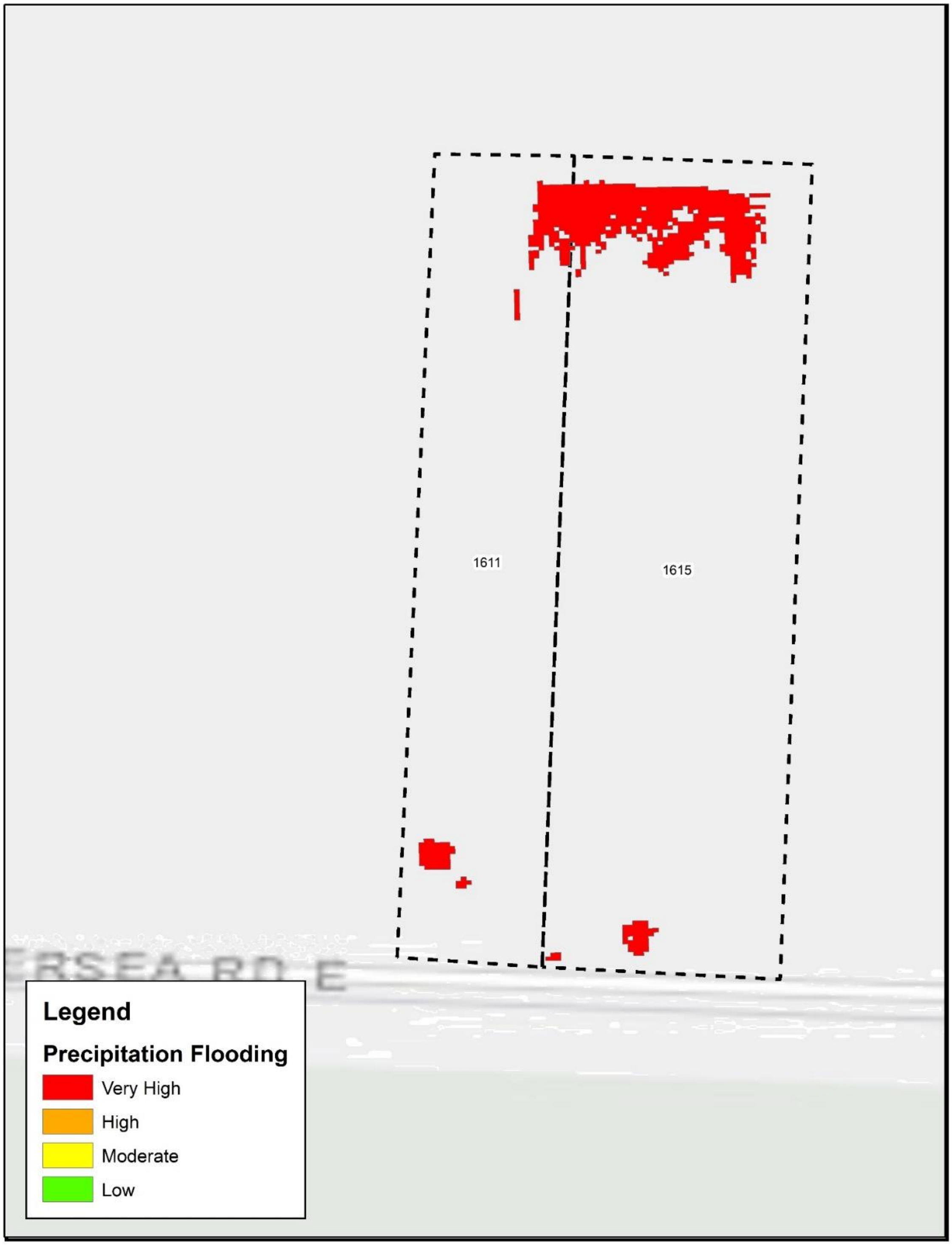
Appendix C – 1611-1615 Complex

Property Complex Name:	1611 - 1615 Complex	
Property(ies) Street Address:	1611 Mersea Road E 1615 Mersea Road E	
Total Complex Area:	4.0 ha	
Minimum Elevation:	171.75 m	
Maximum Elevation:	173.23 m	
Mean Elevation:	172.01 m	
Total Flood Risk	***Very High***	4.0 ha
	High	0.0 ha
	Moderate	0.0 ha
	Low	0.0 ha





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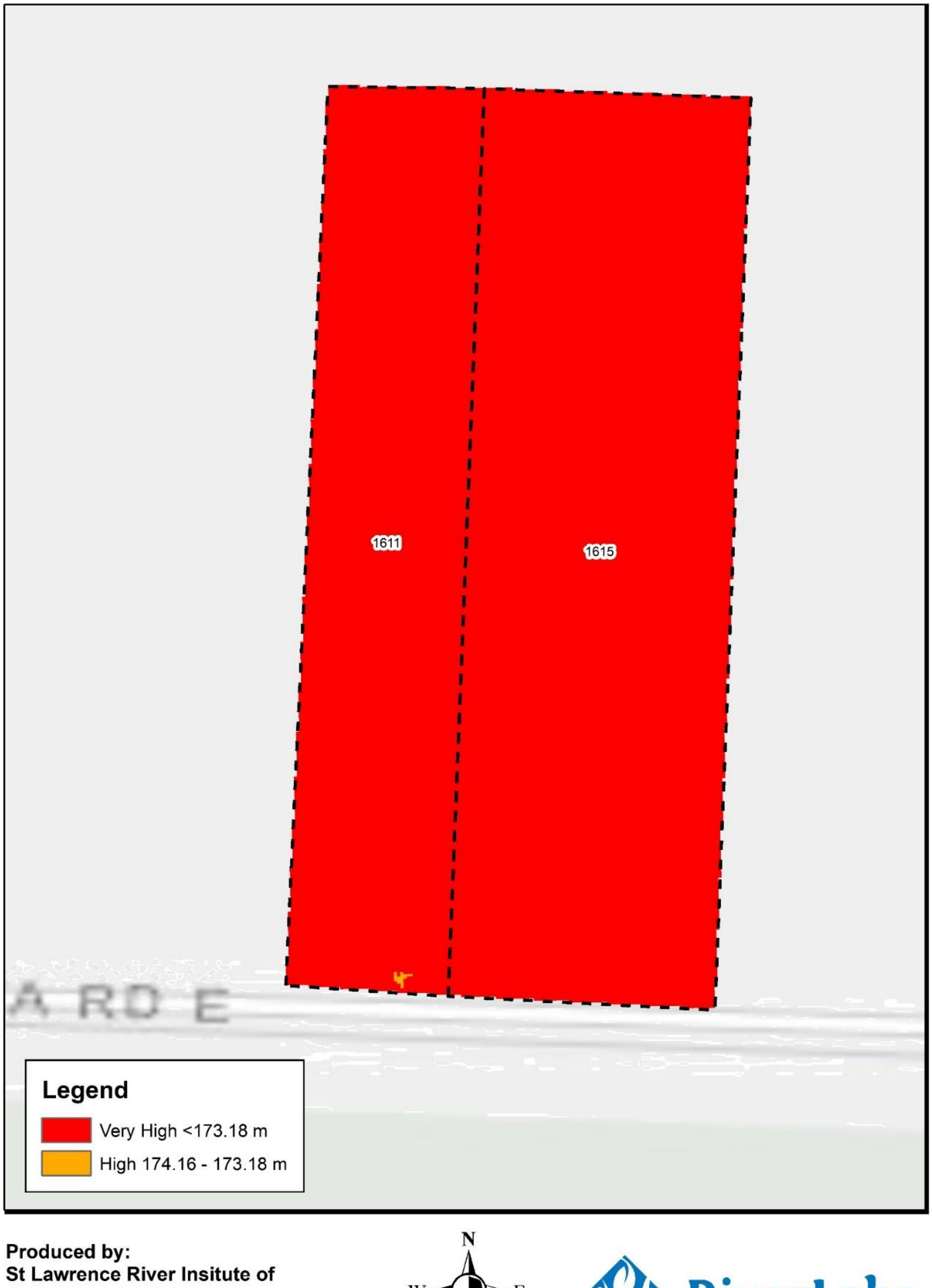

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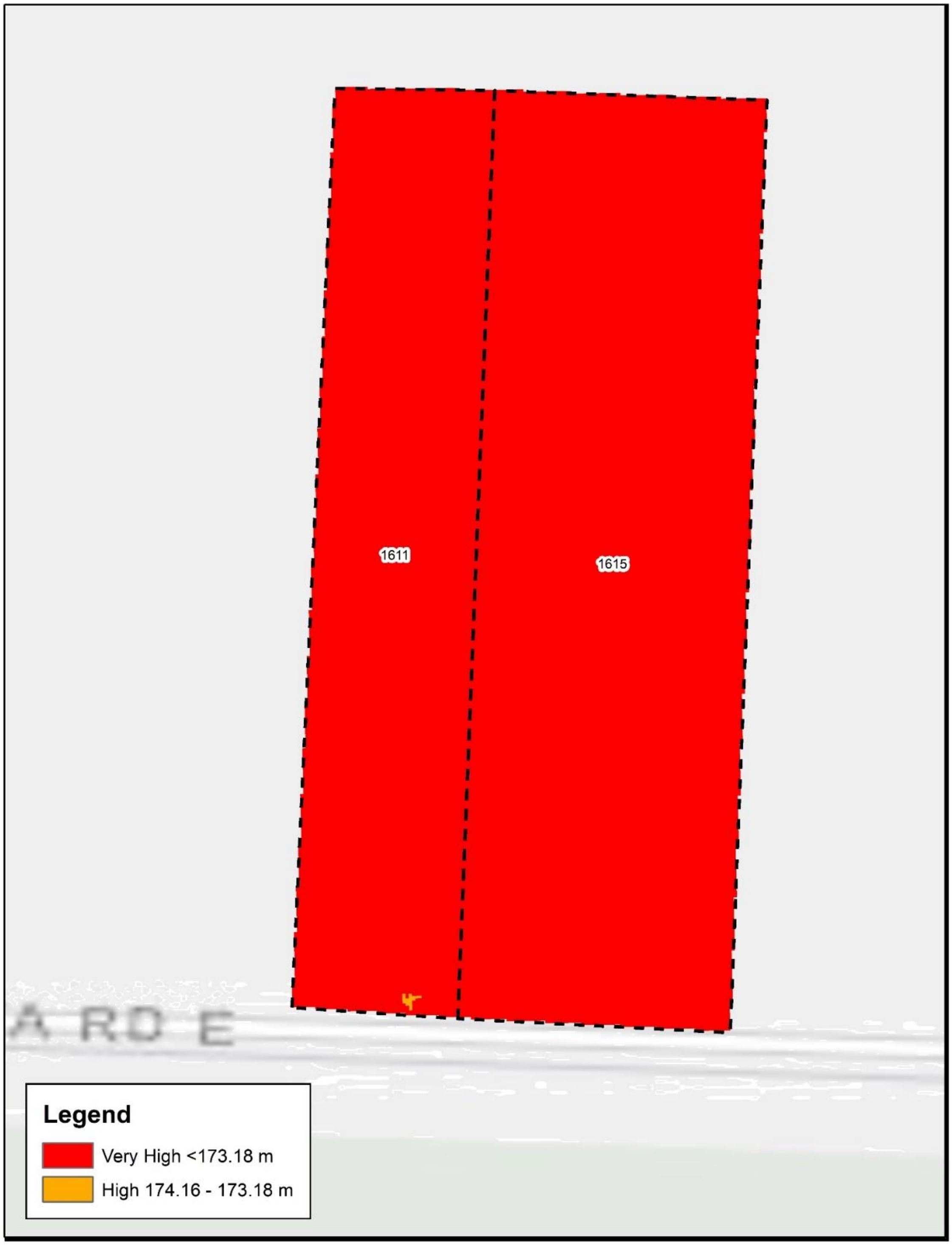

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Appendix D – 1833-1905 Complex

Property Complex Name:	1833 - 1905 Complex	
Property(ies) Street Address:	1833 Mersea Road E 1905 Mersea Road D	
Total Complex Area:	12.5 ha	
Minimum Elevation:	170.47 m	
Maximum Elevation:	173.95 m	
Mean Elevation:	171.23 m	
Total Flood Risk	***Very High***	12.5 ha
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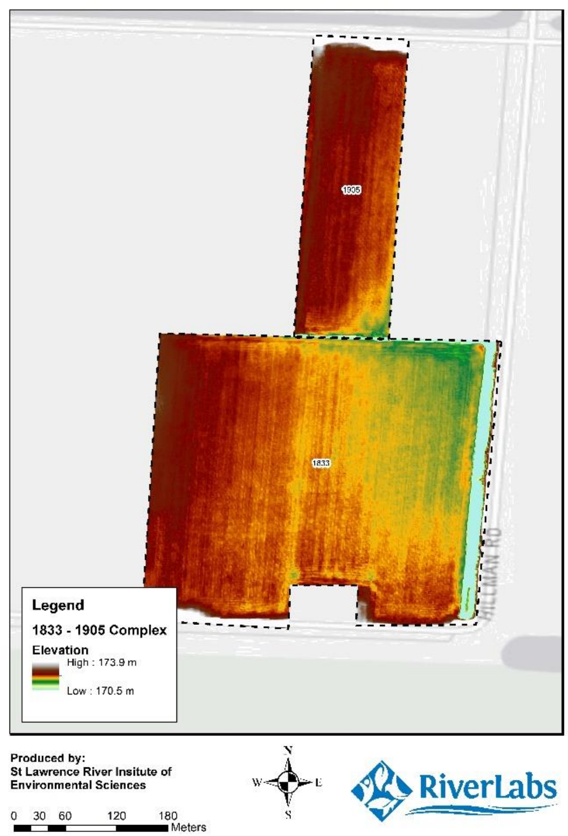
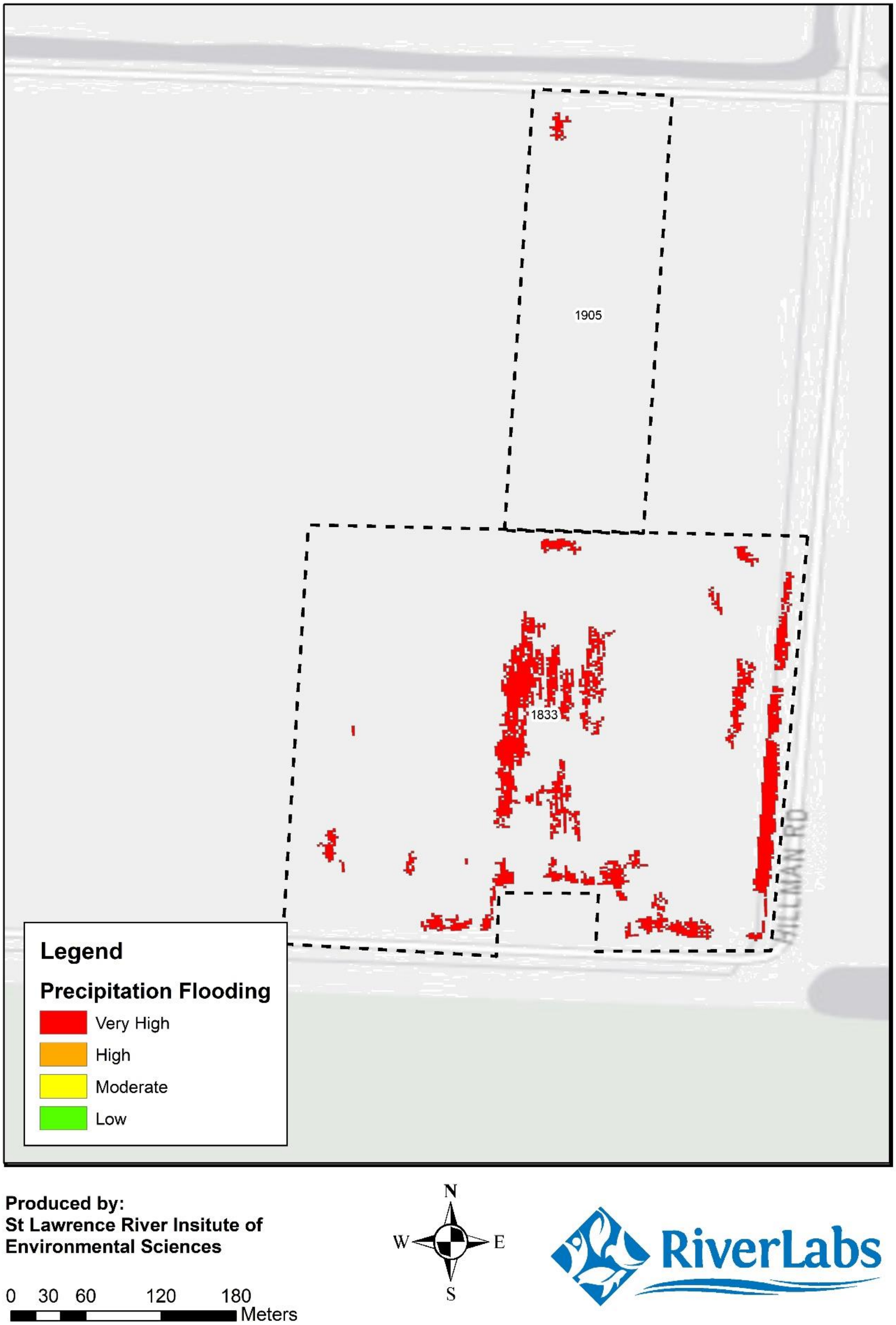
	Moderate	0.0 ha
	Low	0.0 ha

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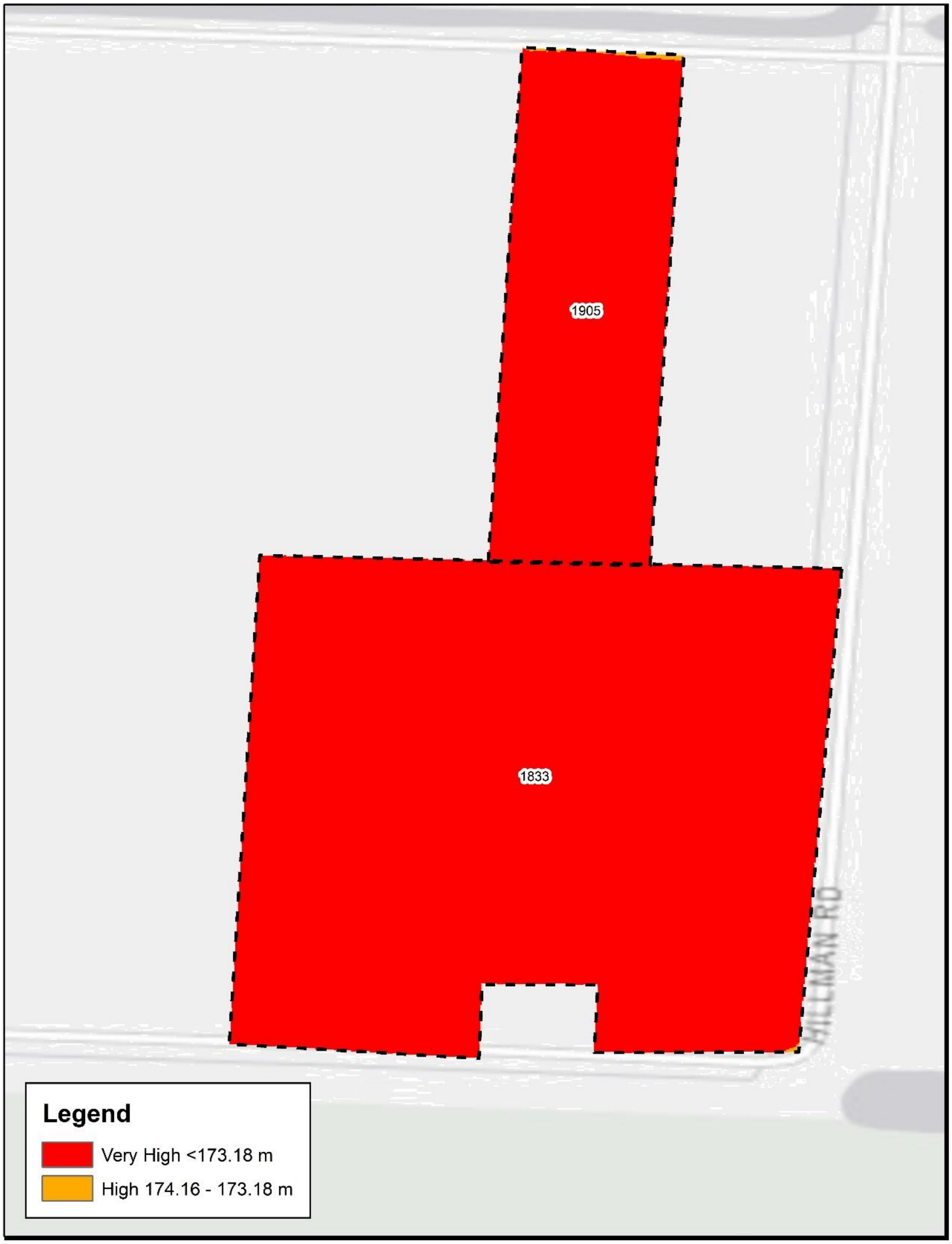

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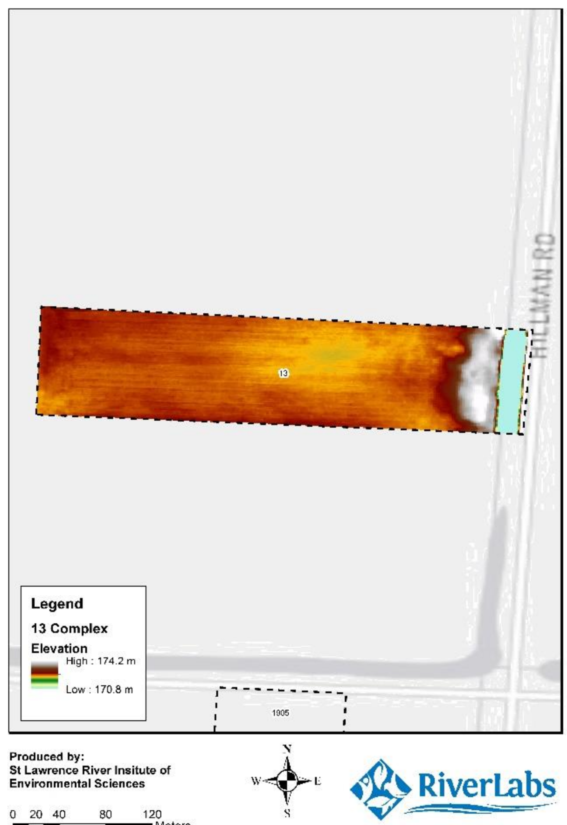
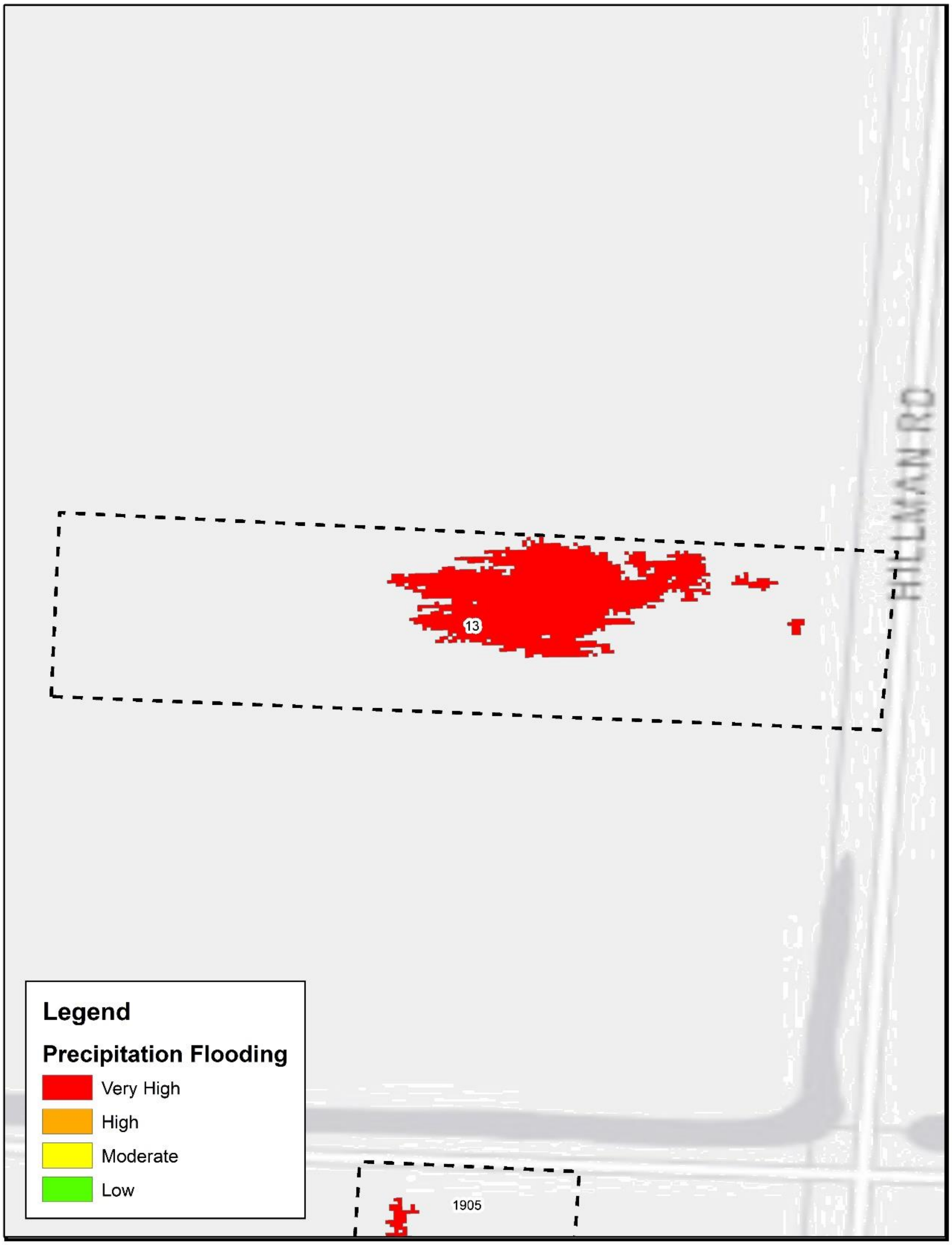
Appendix E – 13 Complex

Property Complex Name:	13 Complex	
Property(ies) Street Address:	13 Mersea Road 19	
Total Complex Area:	2.9 ha	
Minimum Elevation:	170.80 m	
Maximum Elevation:	174.20 m	
Mean Elevation:	171.87 m	
Total Flood Risk	***Very High***	2.9 ha
	High	0.0 ha
	Moderate	0.0 ha
	Low	0.0 ha





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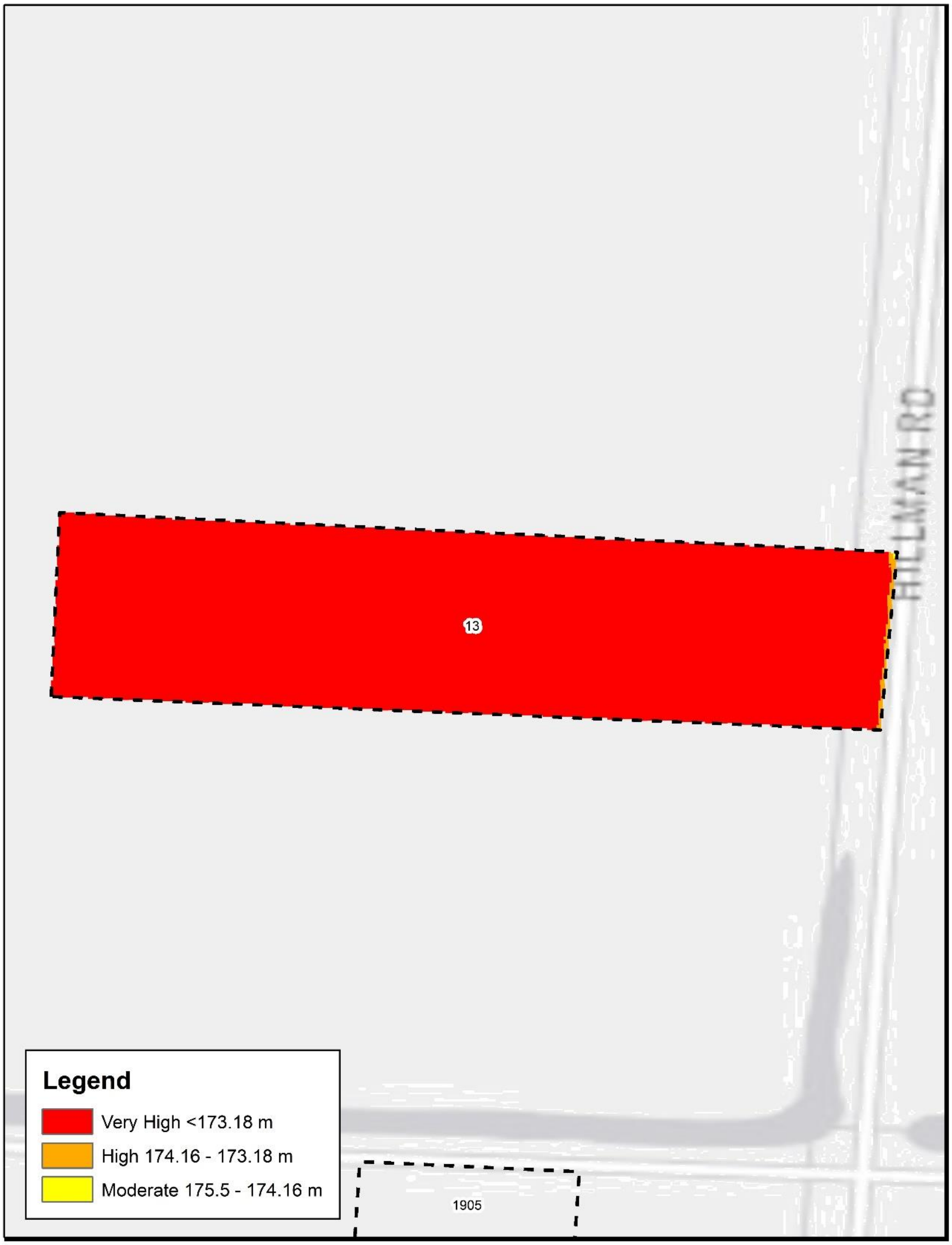

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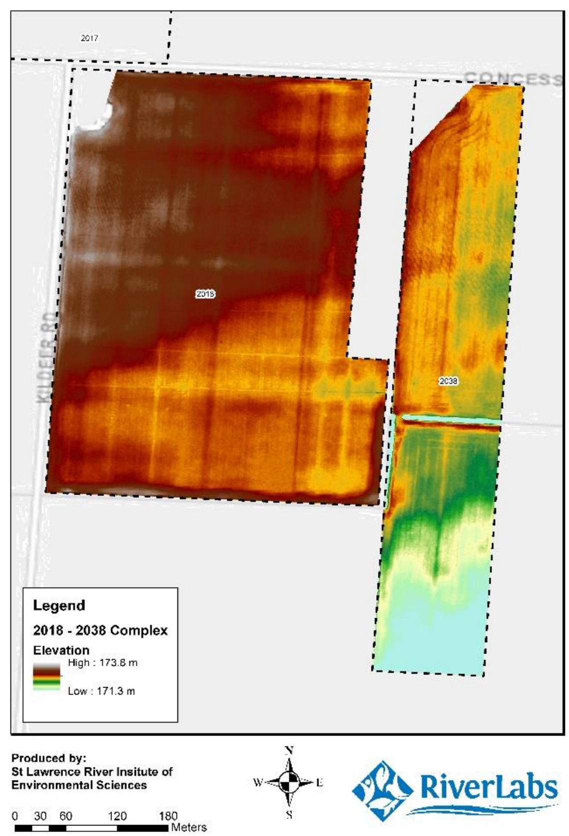
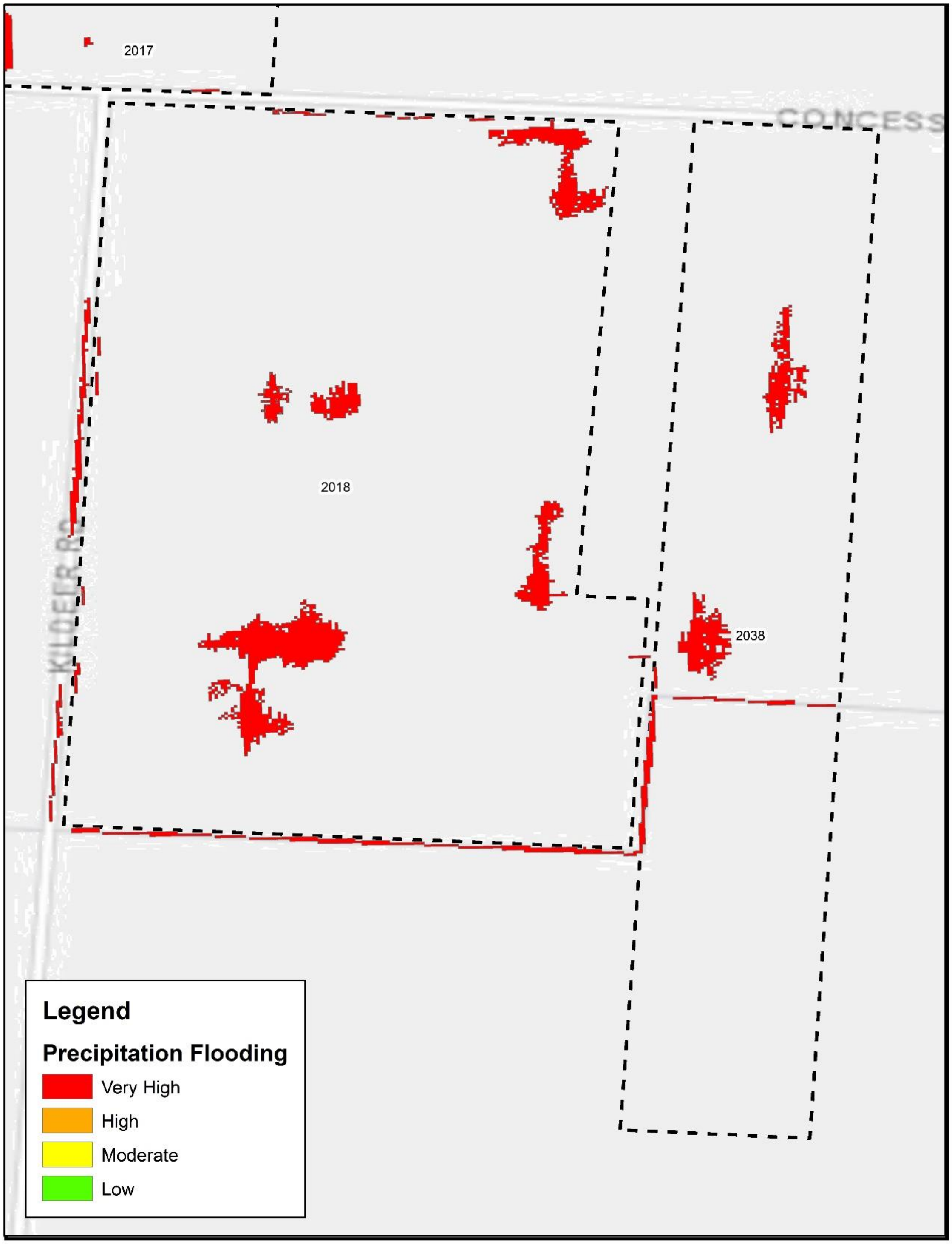
Appendix F – 2018-2038 Complex

Property Complex Name:	2018 - 2038 Complex	
Property(ies) Street Address:	2018 Mersea Road B 2030 Mersea Road B	
Total Complex Area:	16.9 ha	
Minimum Elevation:	171.26 m	
Maximum Elevation:	173.82 m	
Mean Elevation:	172.98 m	
Total Flood Risk	***Very High***	16.6 ha
	High	0.3 ha
	Moderate	0.0 ha
	Low	0.0 ha





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Total Flood Risk
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Environmental Sciences
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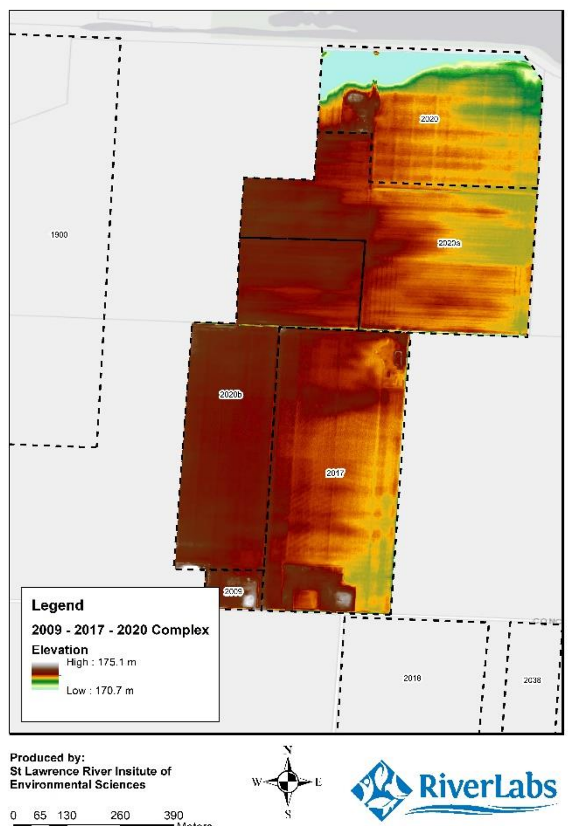
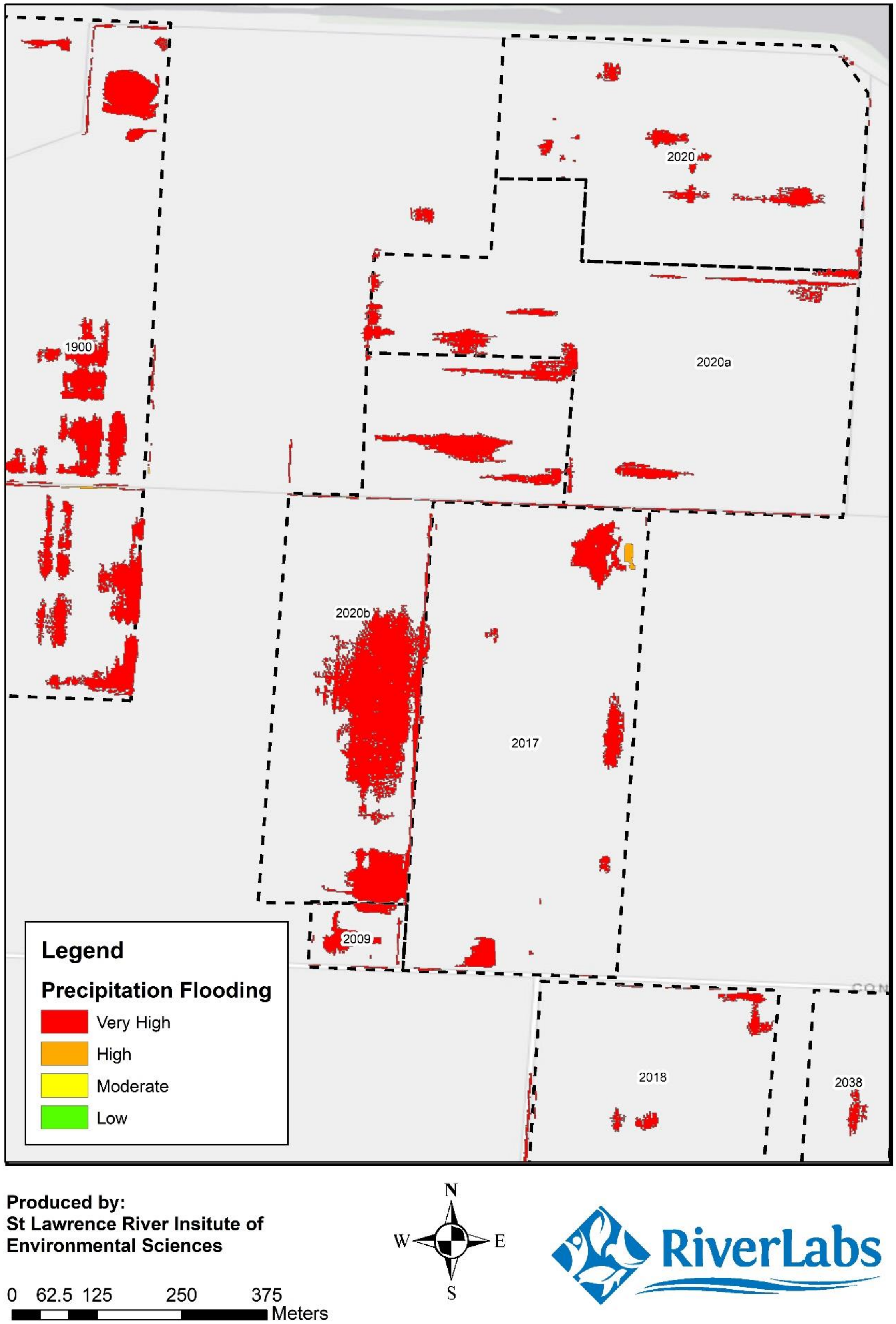
Appendix G – 2009-2017-2020 Complex

Property Complex Name:	2009 – 2017 – 2020 Complex	
Property(ies) Street Address:	2009 Mersea Road B 2017 Mersea Road B 2020 Mersea Road 1	
Total Complex Area:	58.8 ha	
Minimum Elevation:	170.73 m	
Maximum Elevation:	175.09 m	
Mean Elevation:	173.45 m	
Total Flood Risk	***Very High***	9.2 ha
	High	49.5 ha
	Moderate	0.1 ha
	Low	0.0 ha





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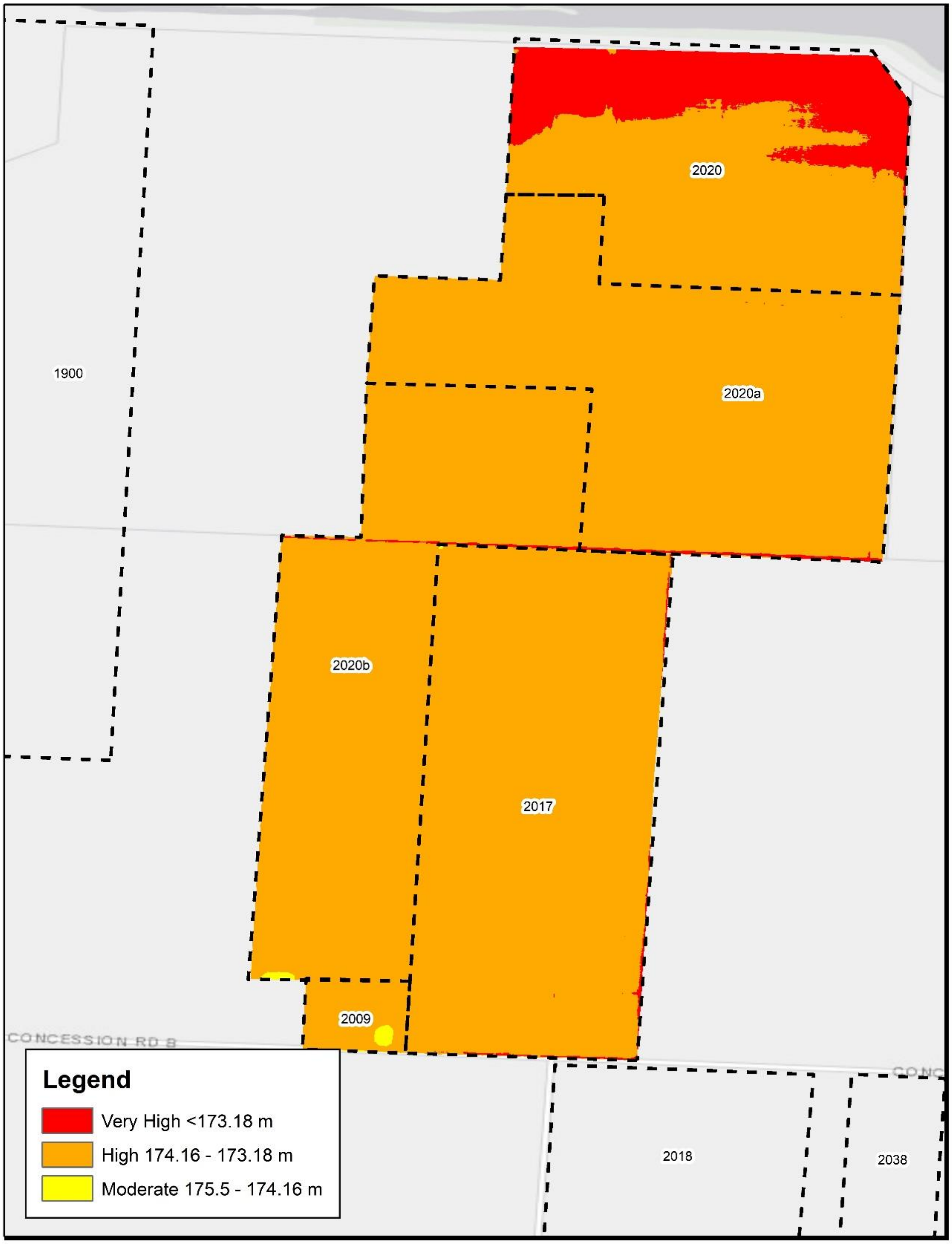

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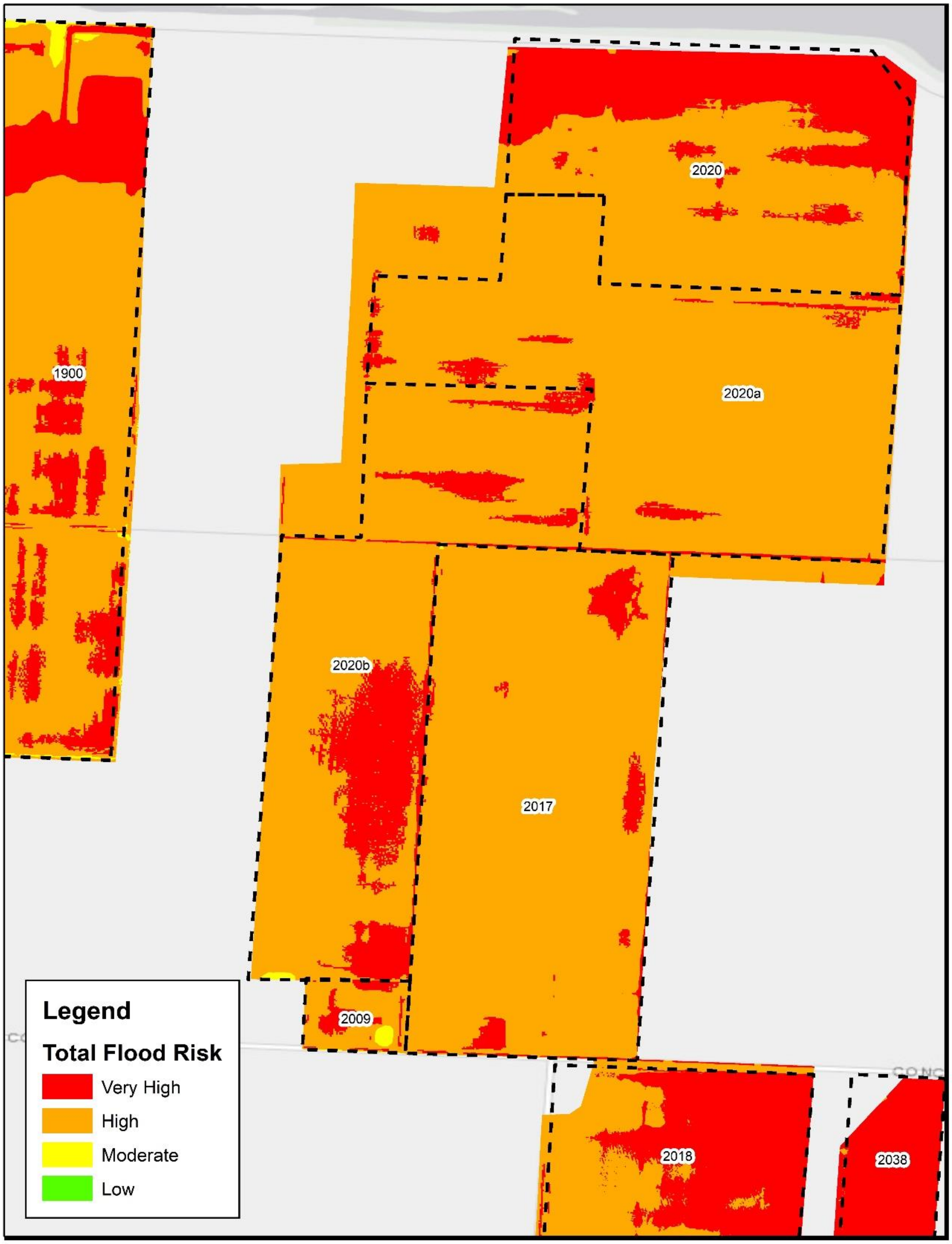

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St Lawrence River Insitute of Environmental Sciences

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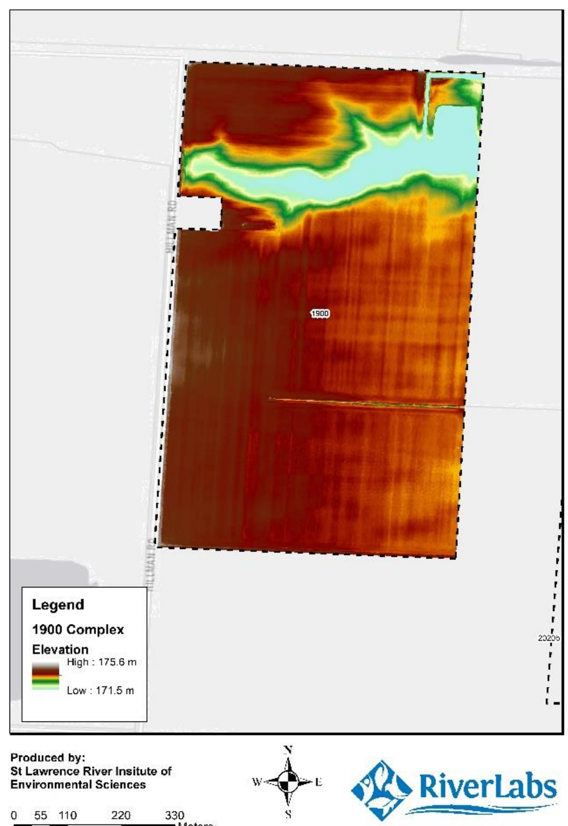
RiverLabs

0 62.5 125 250 375
Meters

Appendix H – 1900 Complex

Property Complex Name:	1900 Complex	
Property(ies) Street Address:	1900 Mersea Road 1	
Total Complex Area:	45.3 ha	
Minimum Elevation:	171.53 m	
Maximum Elevation:	175.64 m	
Mean Elevation:	174.01 m	
Total Flood Risk	***Very High***	8.2 ha
	High	20.8 ha
	Moderate	16.2 ha
	Low	0.0 ha



Produced by:
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0 50 100 200 300 Meters

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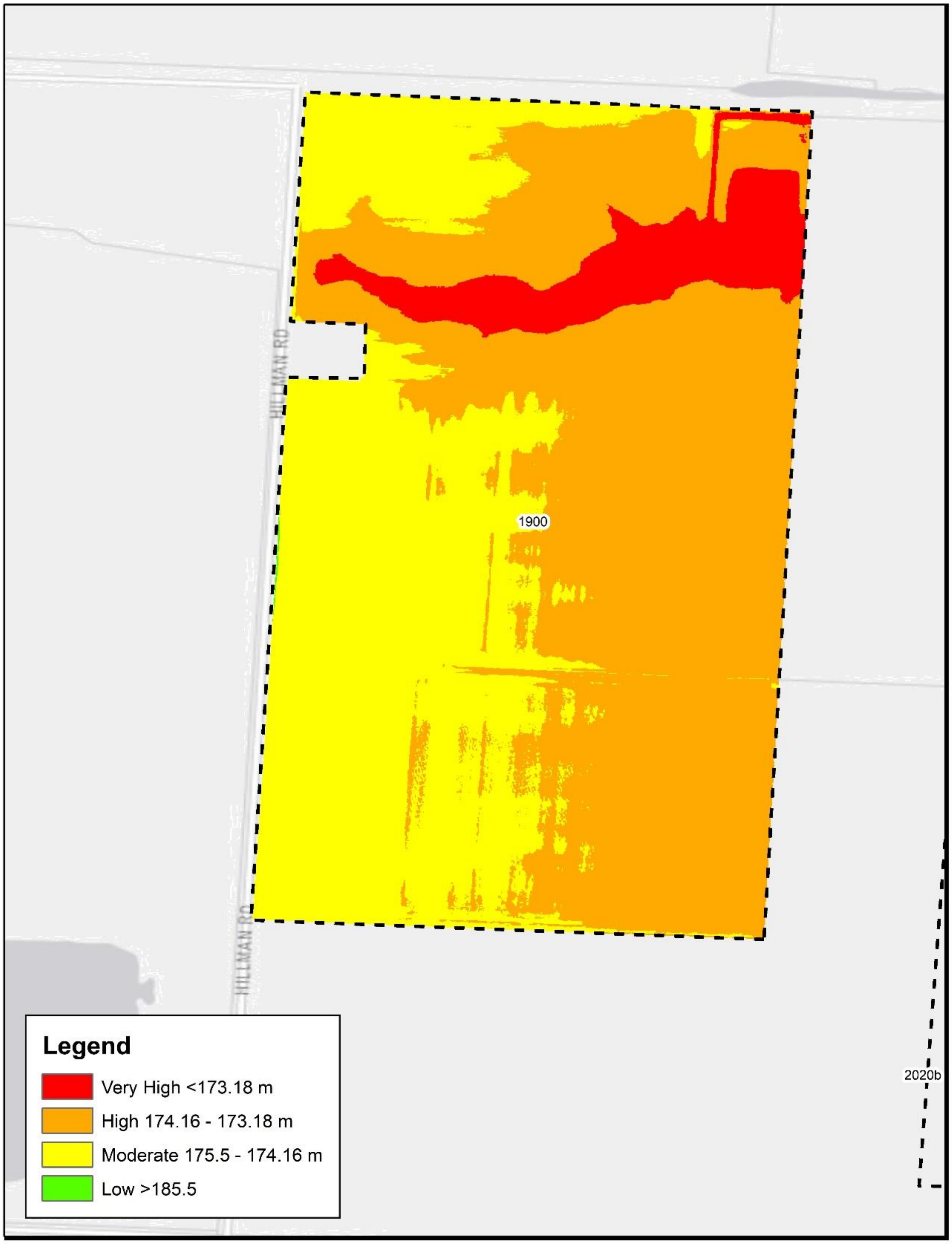
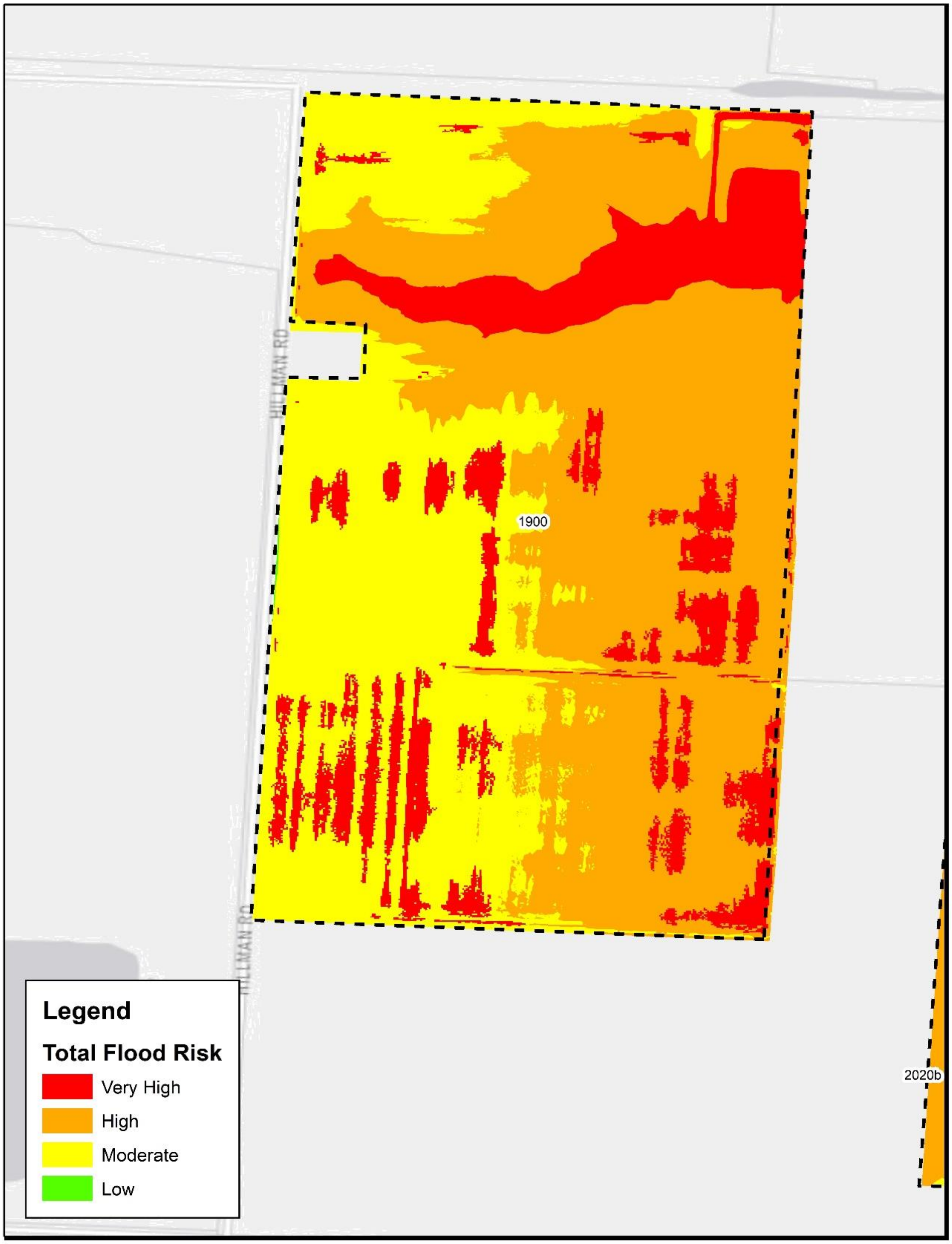


Produced by:
St Lawrence River Insitute of Environmental Sciences

0 55 110 220 330 Meters

N W E S

RiverLabs



Produced by:
St Lawrence River Insitute of Environmental Sciences

0 55 110 220 330 Meters

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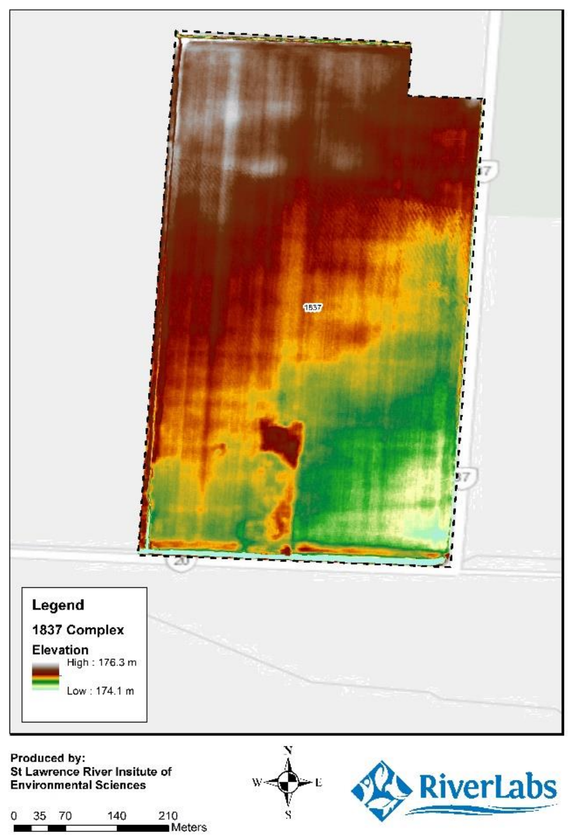
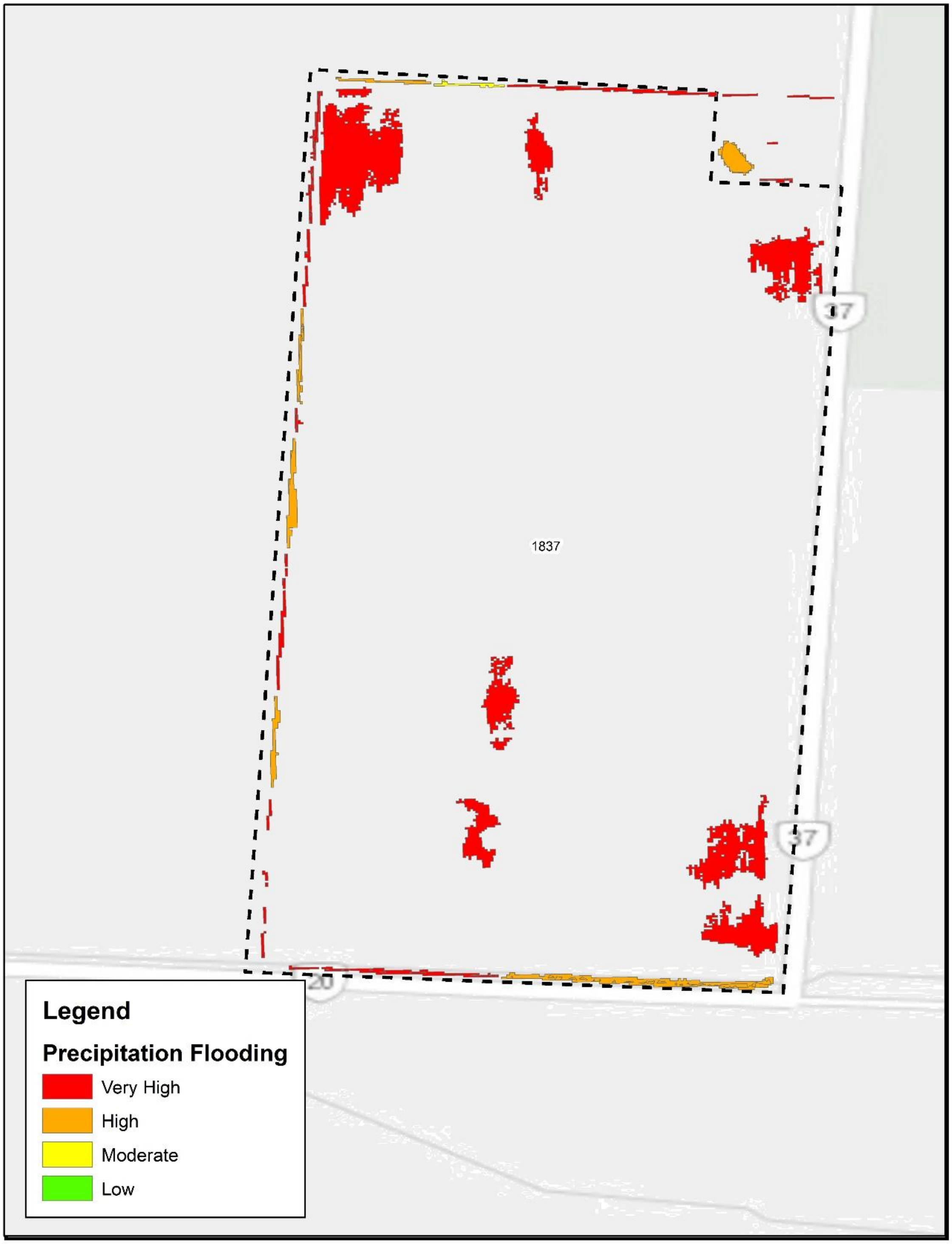
Appendix I – 1837 Complex

Property Complex Name:	1837 Complex	
Property(ies) Street Address:	1837 Mersea Road 1	
Total Complex Area:	21.9 ha	
Minimum Elevation:	174.14 m	
Maximum Elevation:	176.30 m	
Mean Elevation:	175.32 m	
Total Flood Risk	***Very High***	1.0 ha
	High	0.2 ha
	Moderate	16.2 ha
	Low	0.0 ha





Produced by:
St Lawrence River Insitute of Environmental Sciences

0 35 70 140 210
Meters

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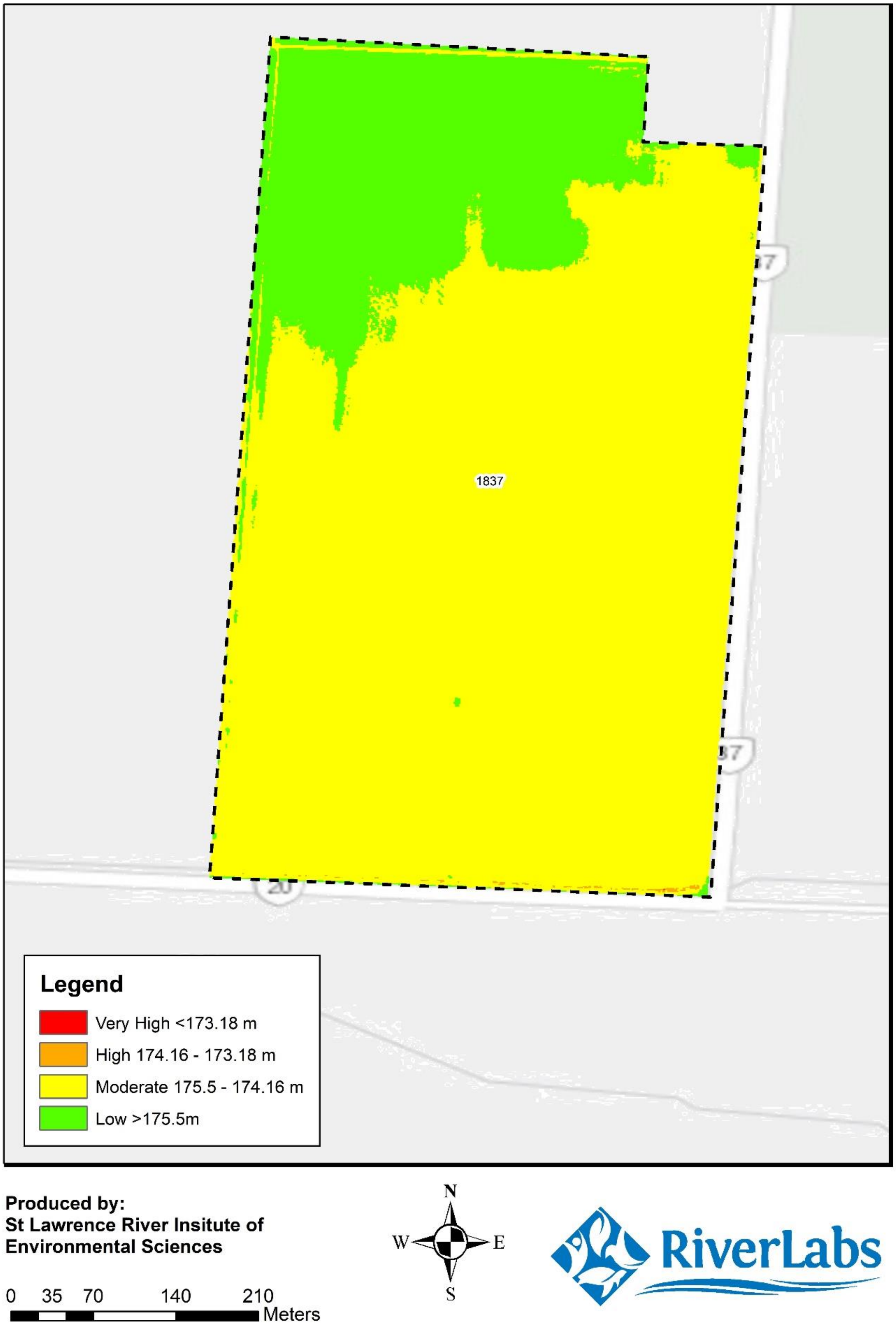
RiverLabs


1837
17
37
20
Legend
Very High <173.18 m
High 174.16 - 173.18 m
Moderate 175.5 - 174.16 m
Low >175.5m
Produced by:
St Lawrence River Insitute of
Environmental Sciences
0 35 70 140 210
Meters
N
W
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RiverLabs

Produced by:
St Lawrence River Insitute of Environmental Sciences

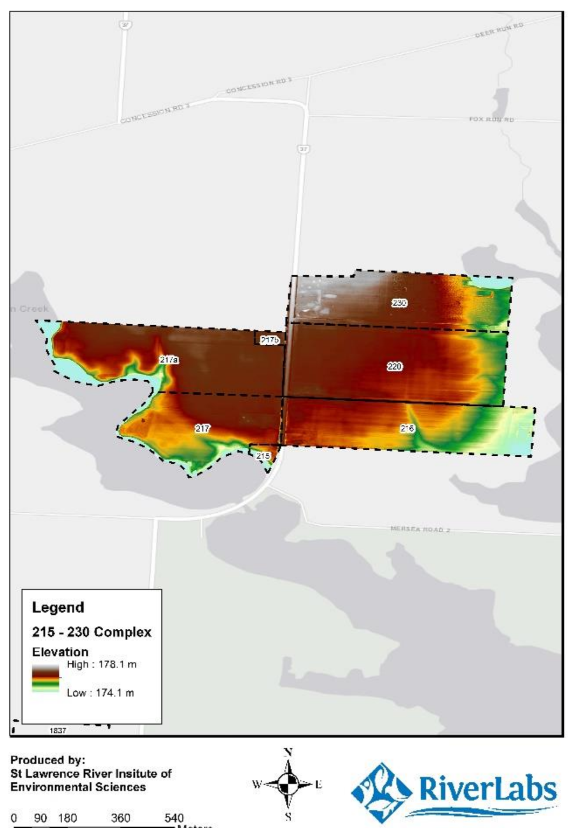
0 35 70 140 210 Meters

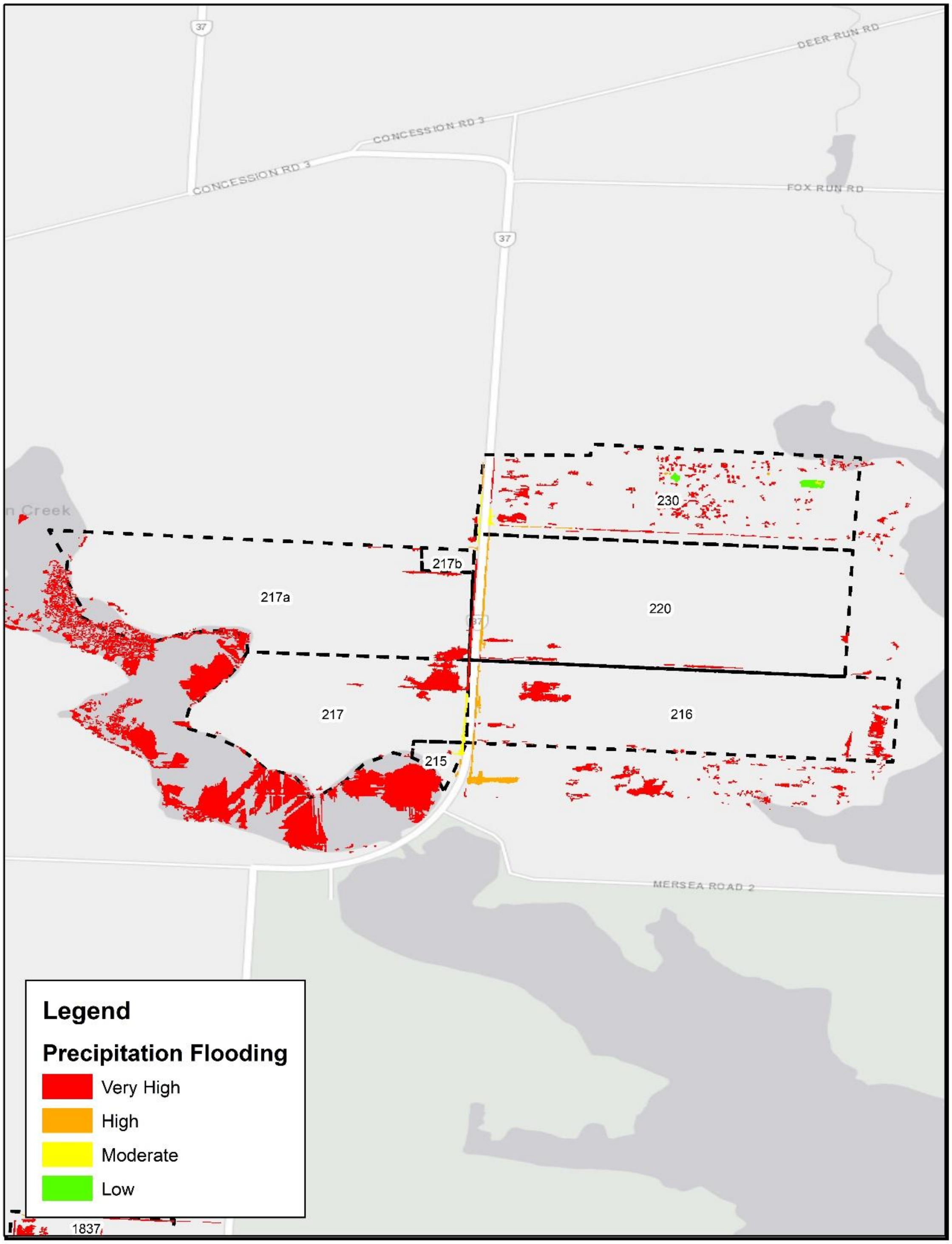
N W E S

RiverLabs

Appendix J – 215-230 Complex

Property Complex Name:	215 – 230 Complex	
Property(ies) Street Address:	215 Mersea Road 19 216 Mersea Road 19 217 Mersea Road 19 217a Mersea Road 19 217b Mersea Road 19 220 Mersea Road 19 230 Mersea Road 19	
Total Complex Area:	54.7 ha	
Minimum Elevation:	174.11 m	
Maximum Elevation:	178.12 m	
Mean Elevation:	176.47 m	
Total Flood Risk	***Very High***	1.9 ha
	High	0.1 ha
	Moderate	5.3 ha
	Low	47.4 ha



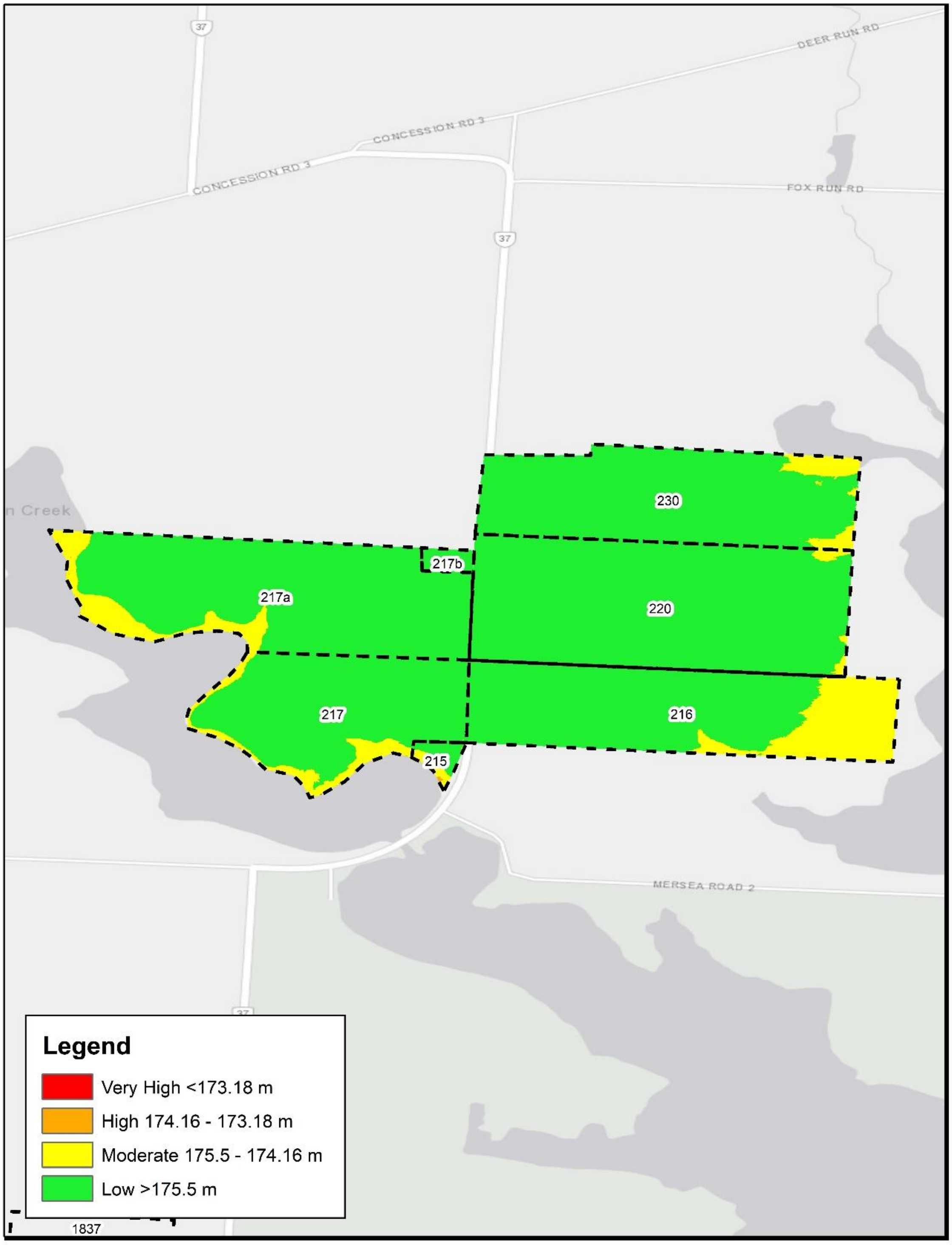


Produced by:
St Lawrence River Insitute of Environmental Sciences

0 90 180 360 540 Meters

N W E S

RiverLabs

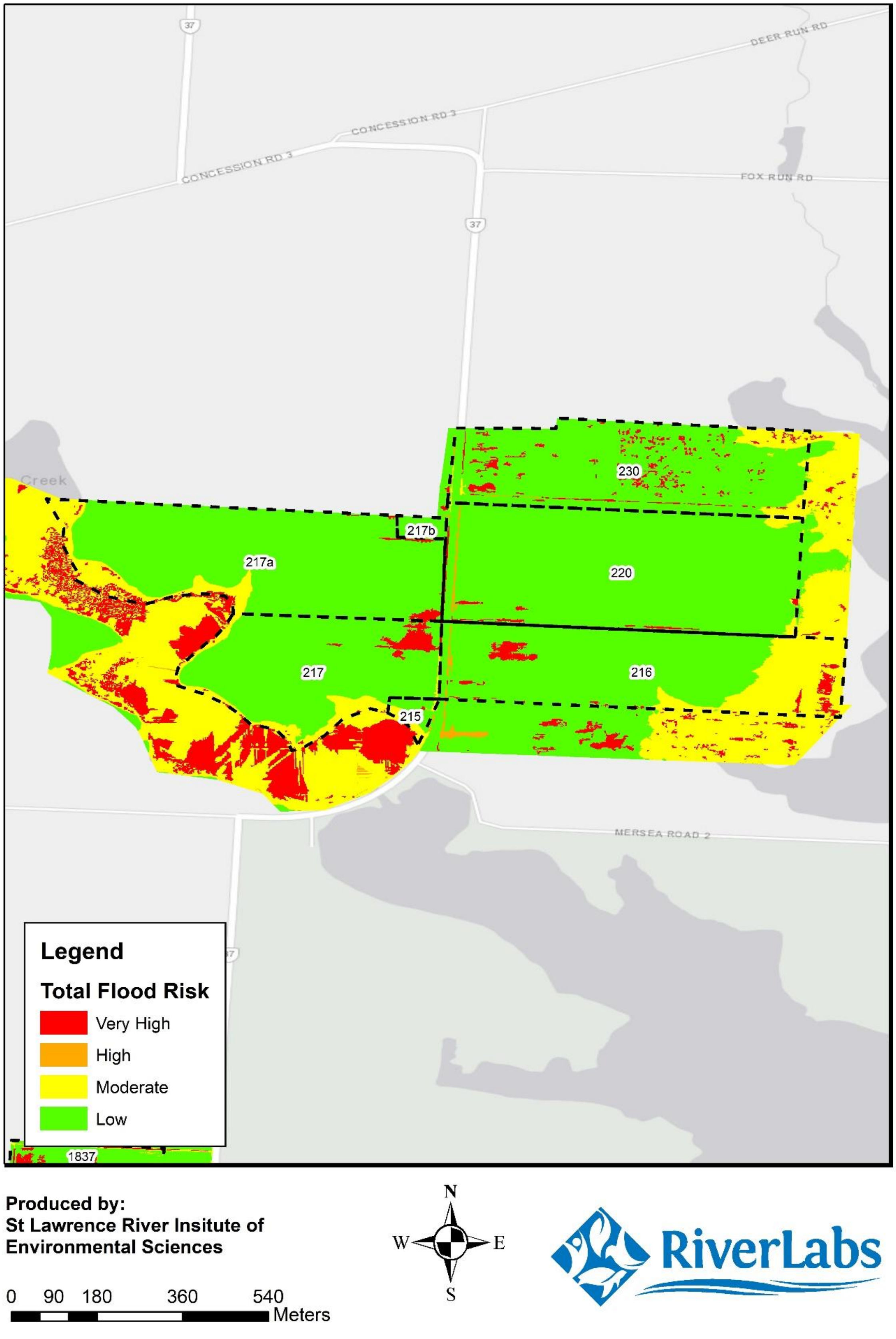


Produced by:
St Lawrence River Insitute of
Environmental Sciences

0 90 180 360 540
Meters

N
W E
S

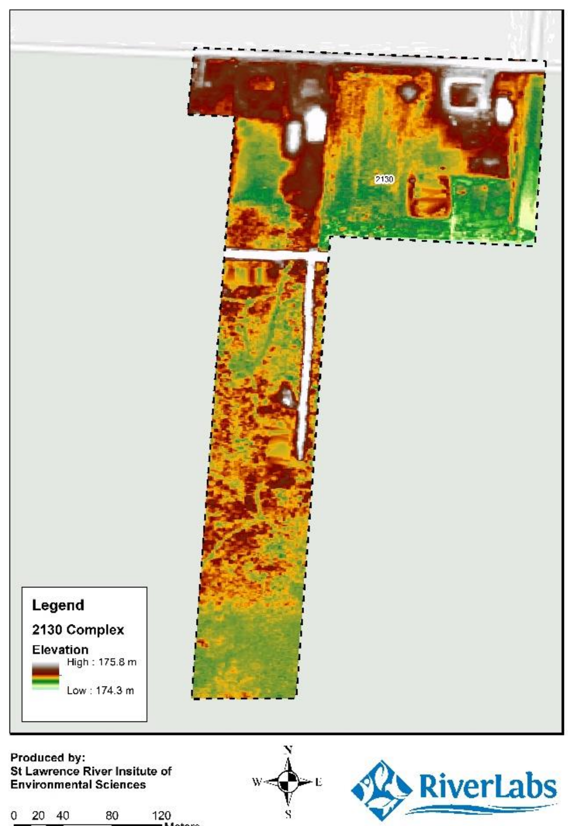
RiverLabs

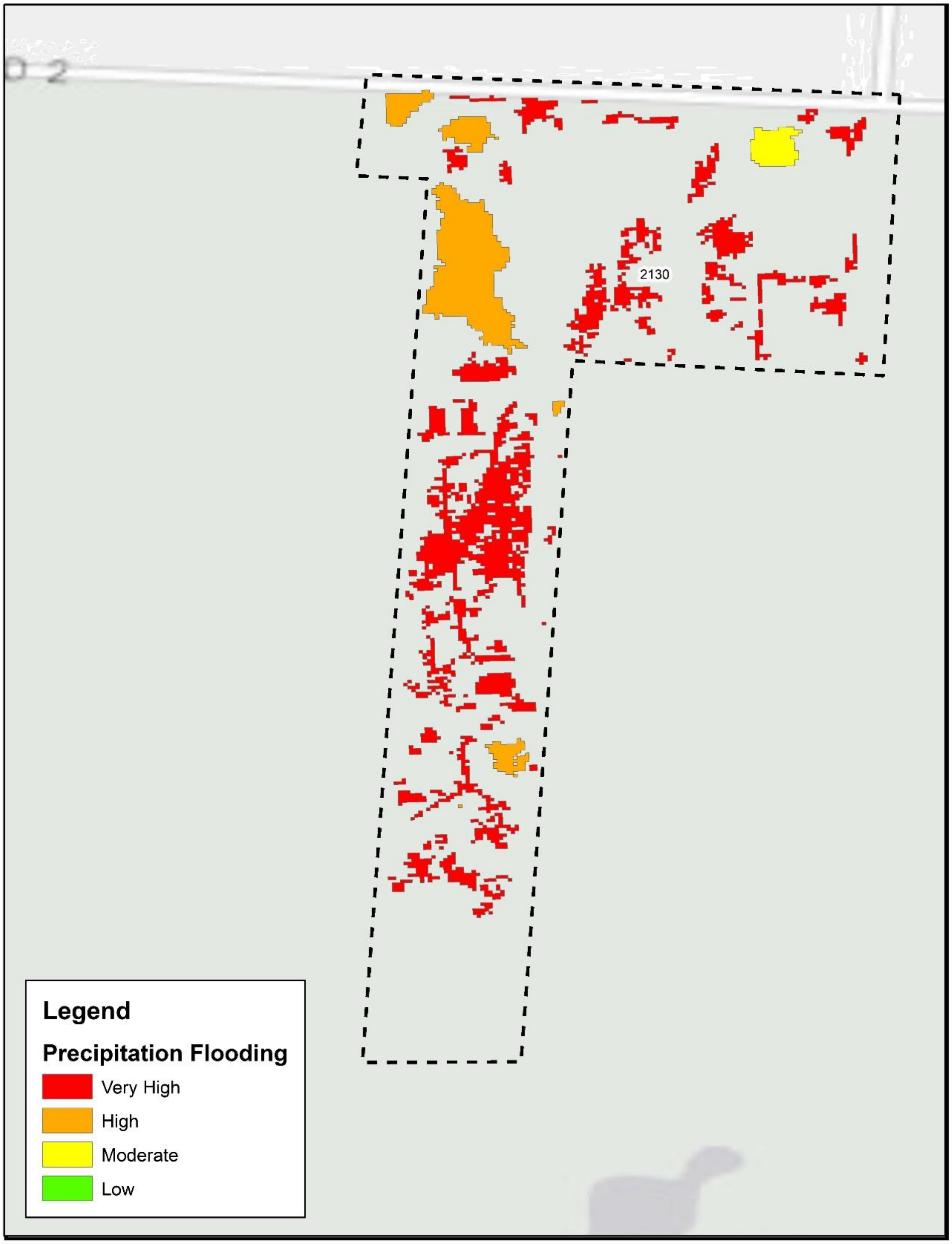


37
DEER RUN RD
CONCESSION RD 3
CONCESSION RD 3
FOX RUN RD
37
Creek
230
217b
217a
220
217
216
215
MERSEA ROAD 2
Legend
Total Flood Risk
Very High
High
Moderate
Low
1837
Produced by:
St Lawrence River Insitute of Environmental Sciences
0 90 180 360 540
Meters
N
W
E
S
RiverLabs

Appendix K – 2130 Complex

Property Complex Name:	2130 Complex	
Property(ies) Street Address:	2130 217 Mersea Road 2	
Total Complex Area:	5.5 ha	
Minimum Elevation:	174.26 m	
Maximum Elevation:	174.91 m	
Mean Elevation:	175.76 m	
Total Flood Risk	***Very High***	0.7 ha
	High	0.3 ha
	Moderate	4.4 ha
	Low	0.1 ha



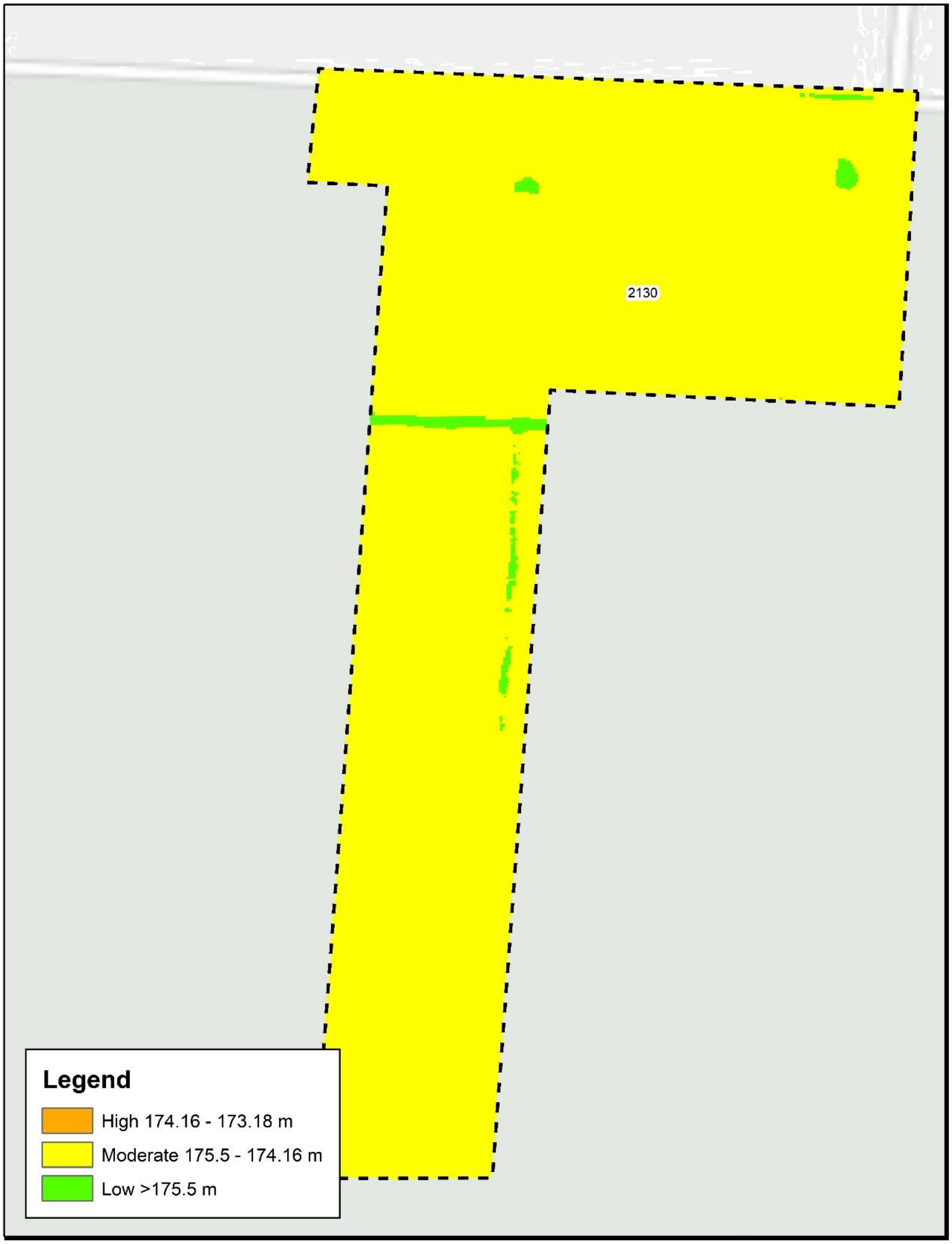


Produced by:
St Lawrence River Insitute of Environmental Sciences

0 20 40 80 120
Meters

N
W E
S

RiverLabs

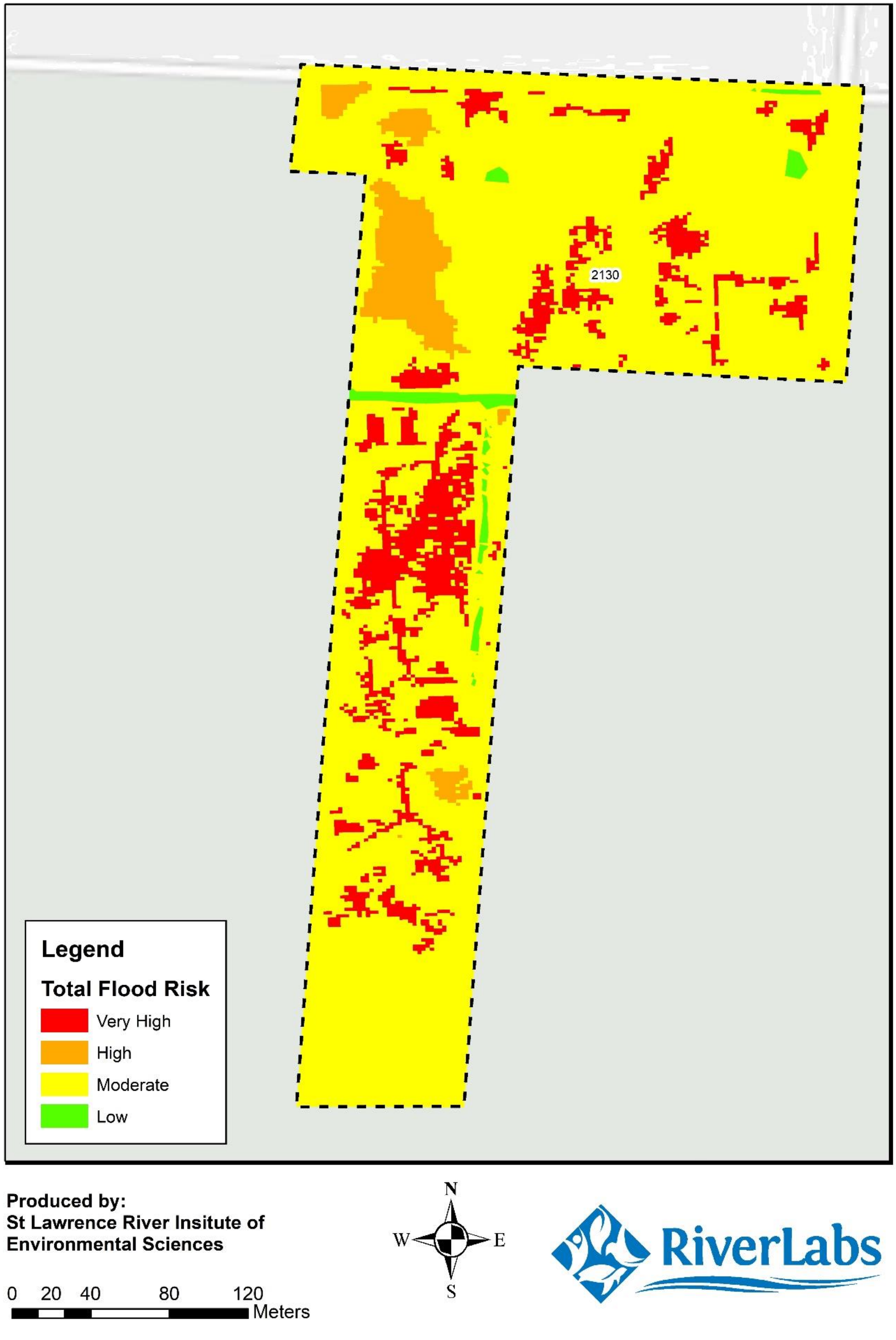


Produced by:
St Lawrence River Insitute of Environmental Sciences

0 20 40 80 120 Meters

N W E S

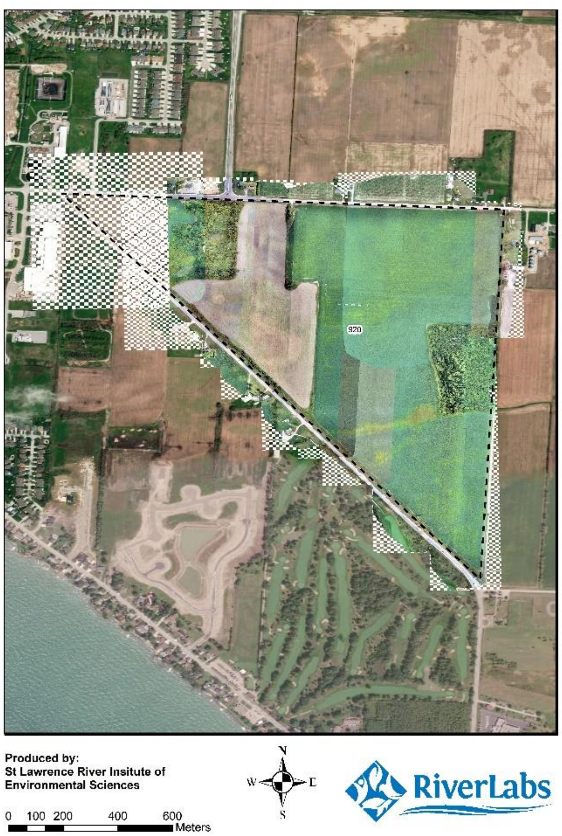
RiverLabs

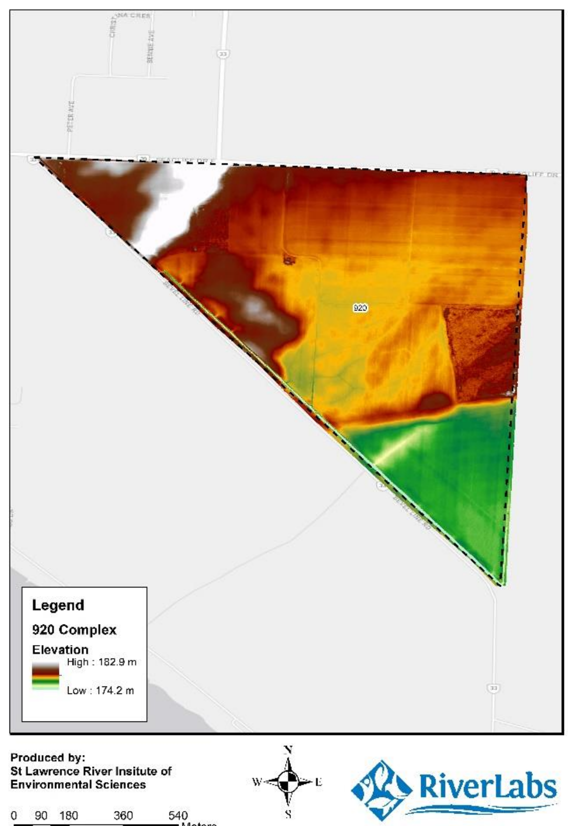


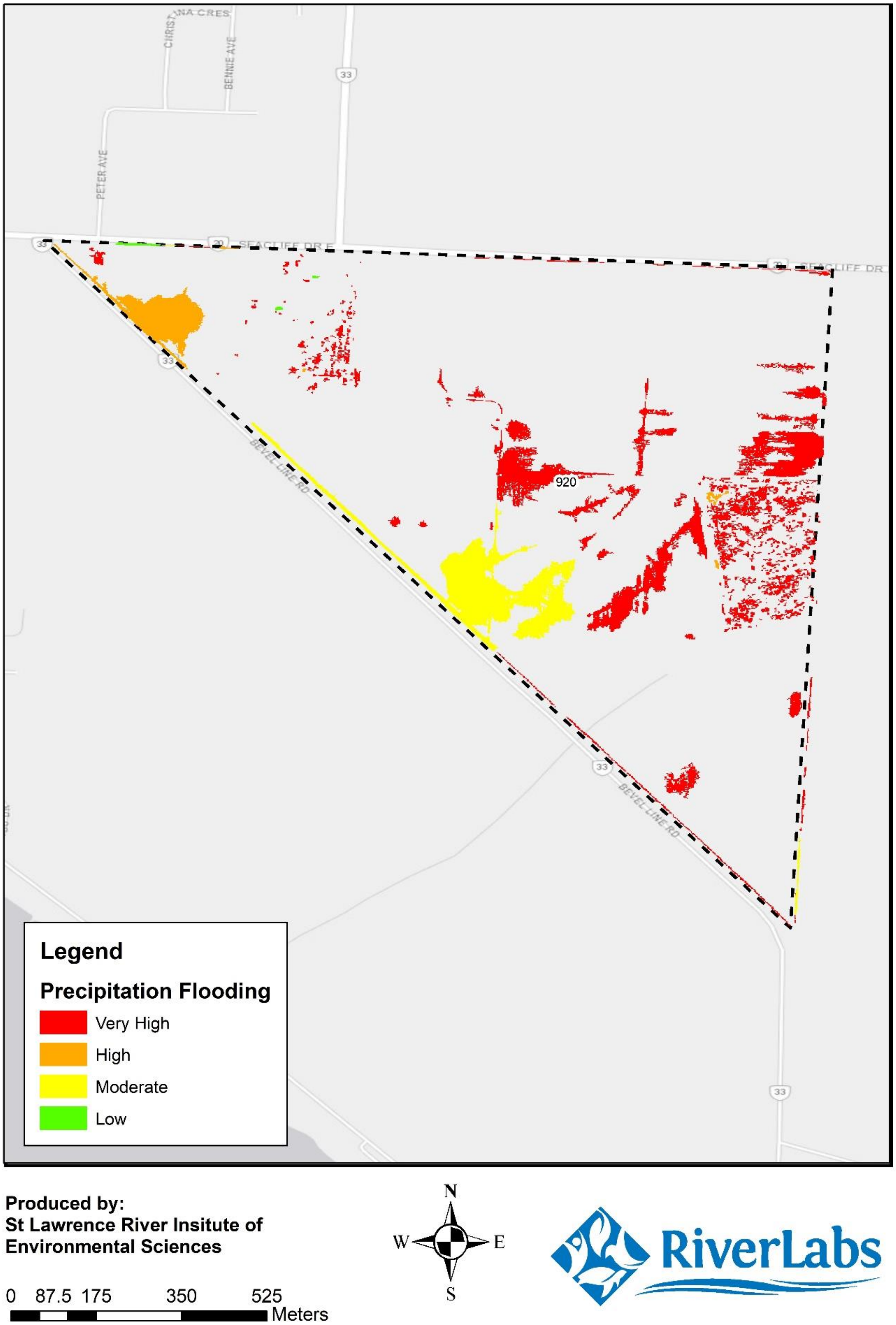
2130
Legend
Total Flood Risk
Very High
High
Moderate
Low
Produced by:
St Lawrence River Insitute of
Environmental Sciences
0 20 40 80 120
Meters
N
W
E
S
RiverLabs

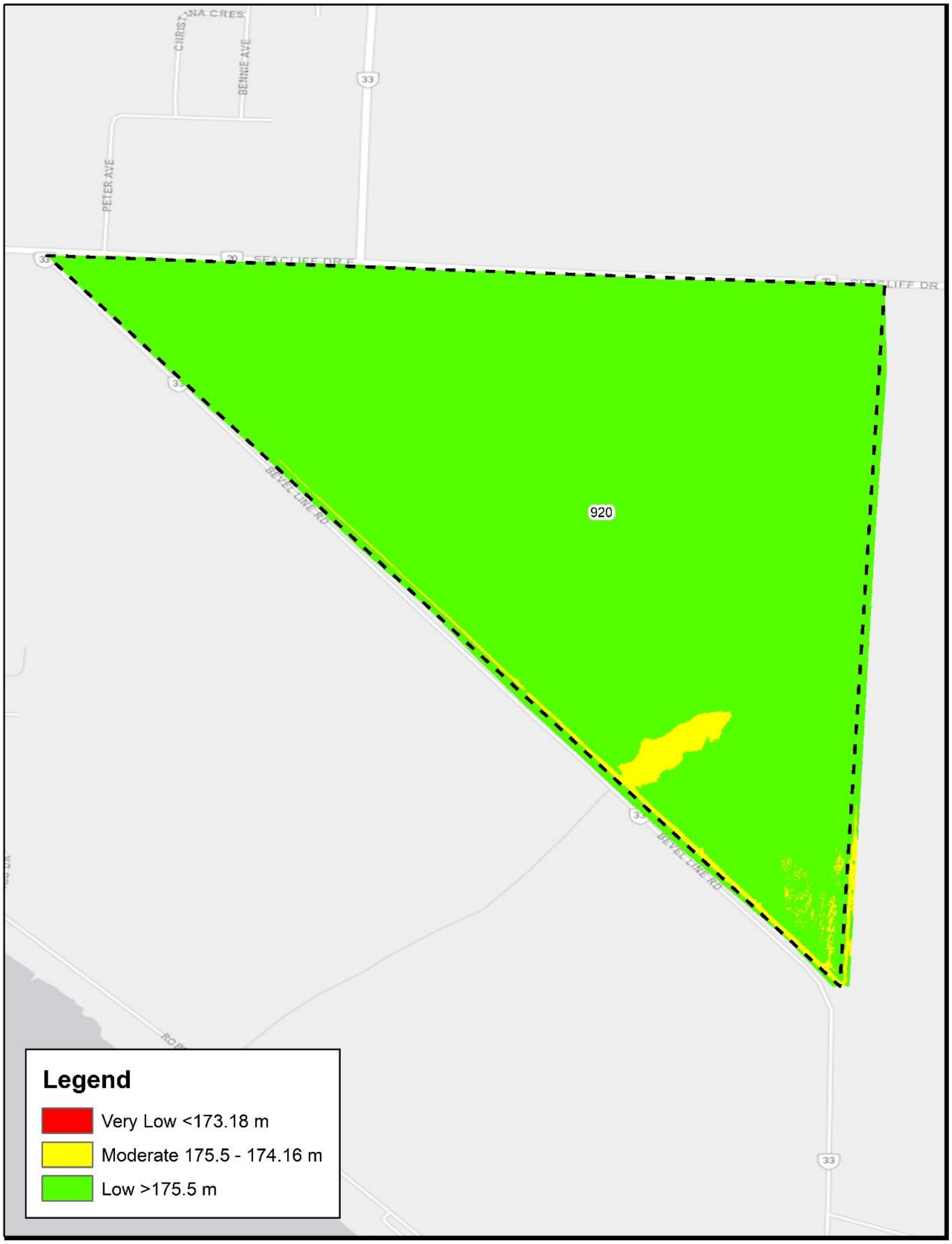
Appendix L – 920 Complex

Property Complex Name:	920 Complex	
Property(ies) Street Address:	920 Bevel Line	
Total Complex Area:	81.4 ha	
Minimum Elevation:	174.19 m	
Maximum Elevation:	182.95 m	
Mean Elevation:	176.77 m	
Total Flood Risk	***Very High***	5.5 ha
	High	1.1 ha
	Moderate	4.1 ha
	Low	70.7 ha






CHRISTINA CRES
BENNIE AVE
PETER AVE
33
20
SEACLIFF DR E
SEACLIFF DR
BEVEL LINE RD
920
Legend
Precipitation Flooding
Very High
High
Moderate
Low
Produced by:
St Lawrence River Insitute of
Environmental Sciences
0 87.5 175 350 525
Meters
N
W
E
S
RiverLabs

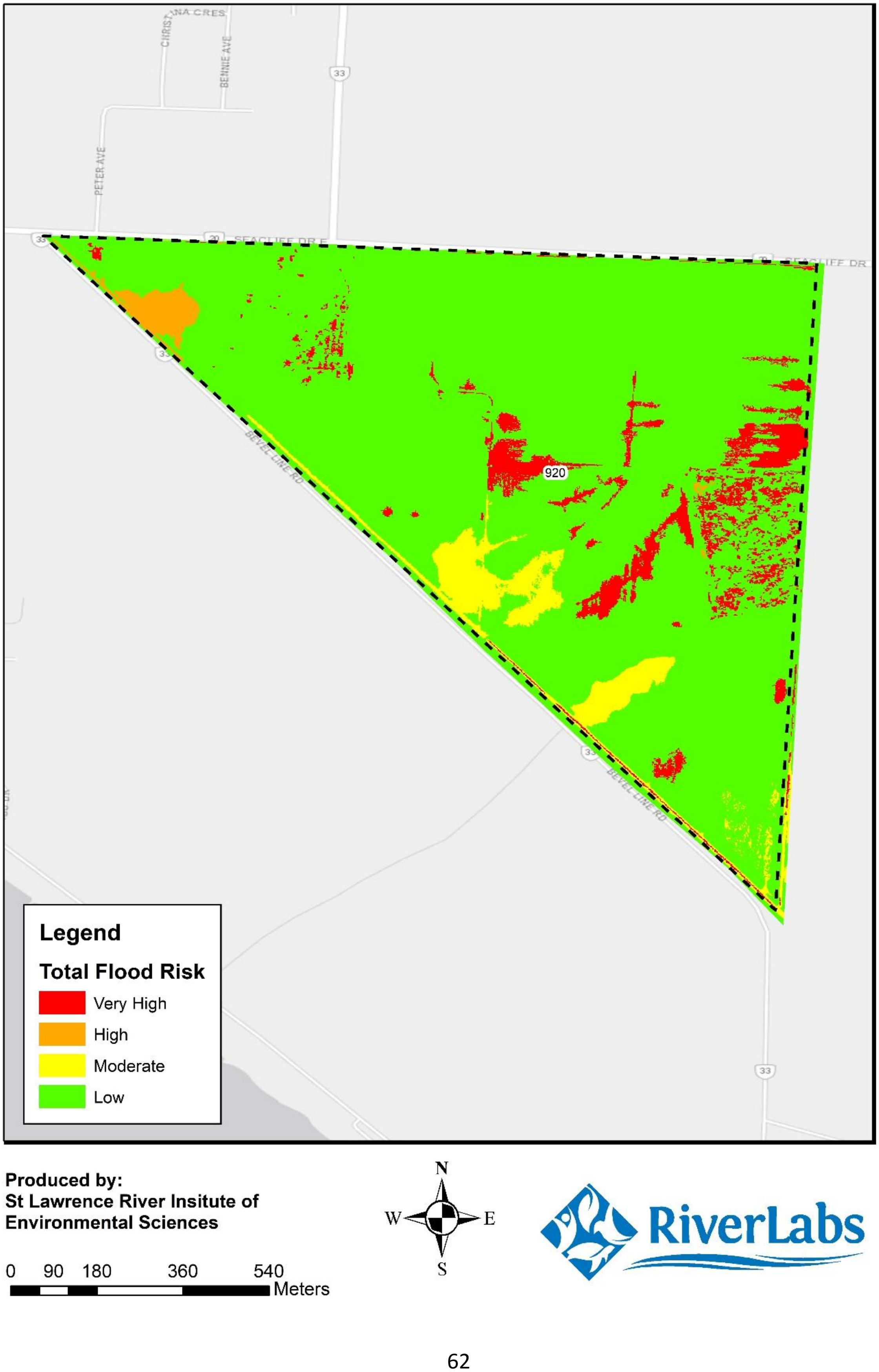


Produced by:
St Lawrence River Insitute of Environmental Sciences

0 90 180 360 540 Meters

N W E S

RiverLabs



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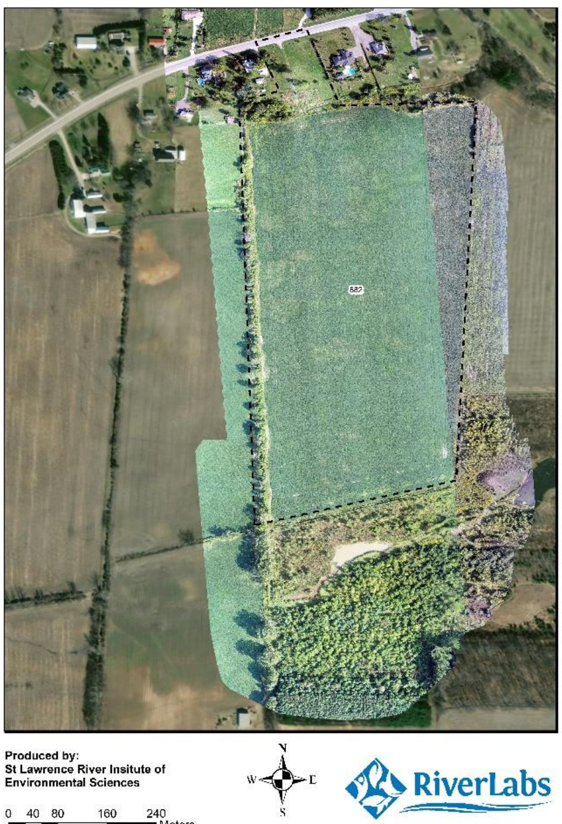
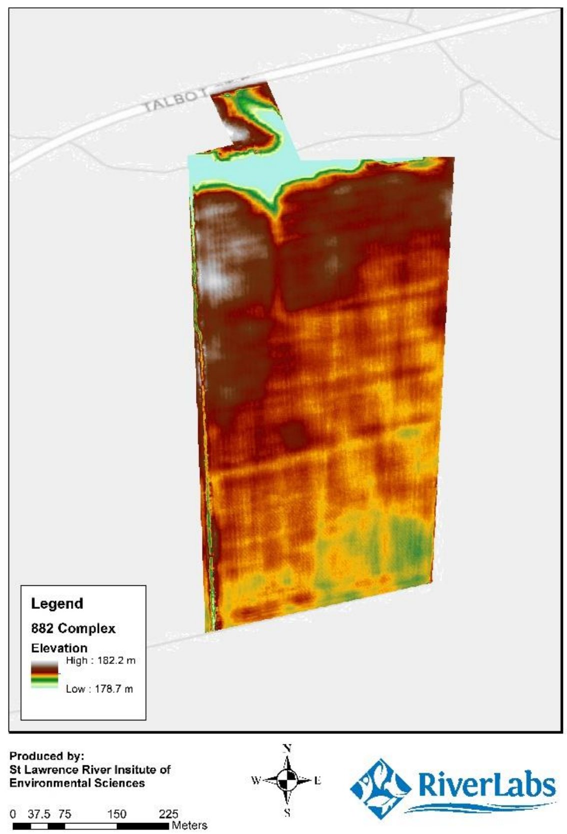
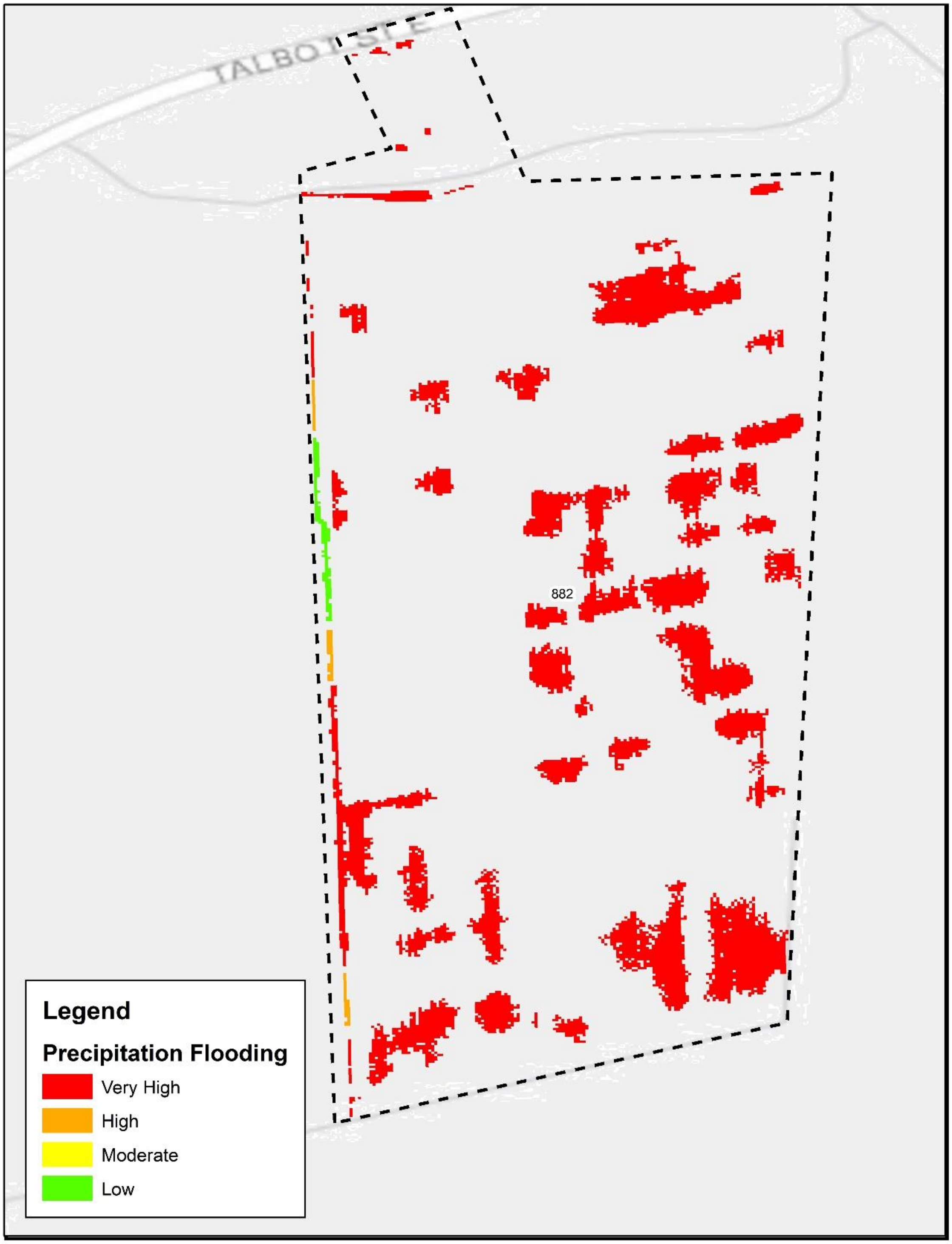
Appendix M – 882 Complex

Property Complex Name:	882 Complex	
Property(ies) Street Address:	882 Essex County Road 34	
Total Complex Area:	18.0 ha	
Minimum Elevation:	178.66 m	
Maximum Elevation:	182.26 m	
Mean Elevation:	181.27 m	
Total Flood Risk	***Very High***	2.2 ha
	High	0.0 ha
	Moderate	0.0 ha
	Low	15.8 ha







Produced by:
St Lawrence River Insitute of Environmental Sciences

0 30 60 120 180 Meters

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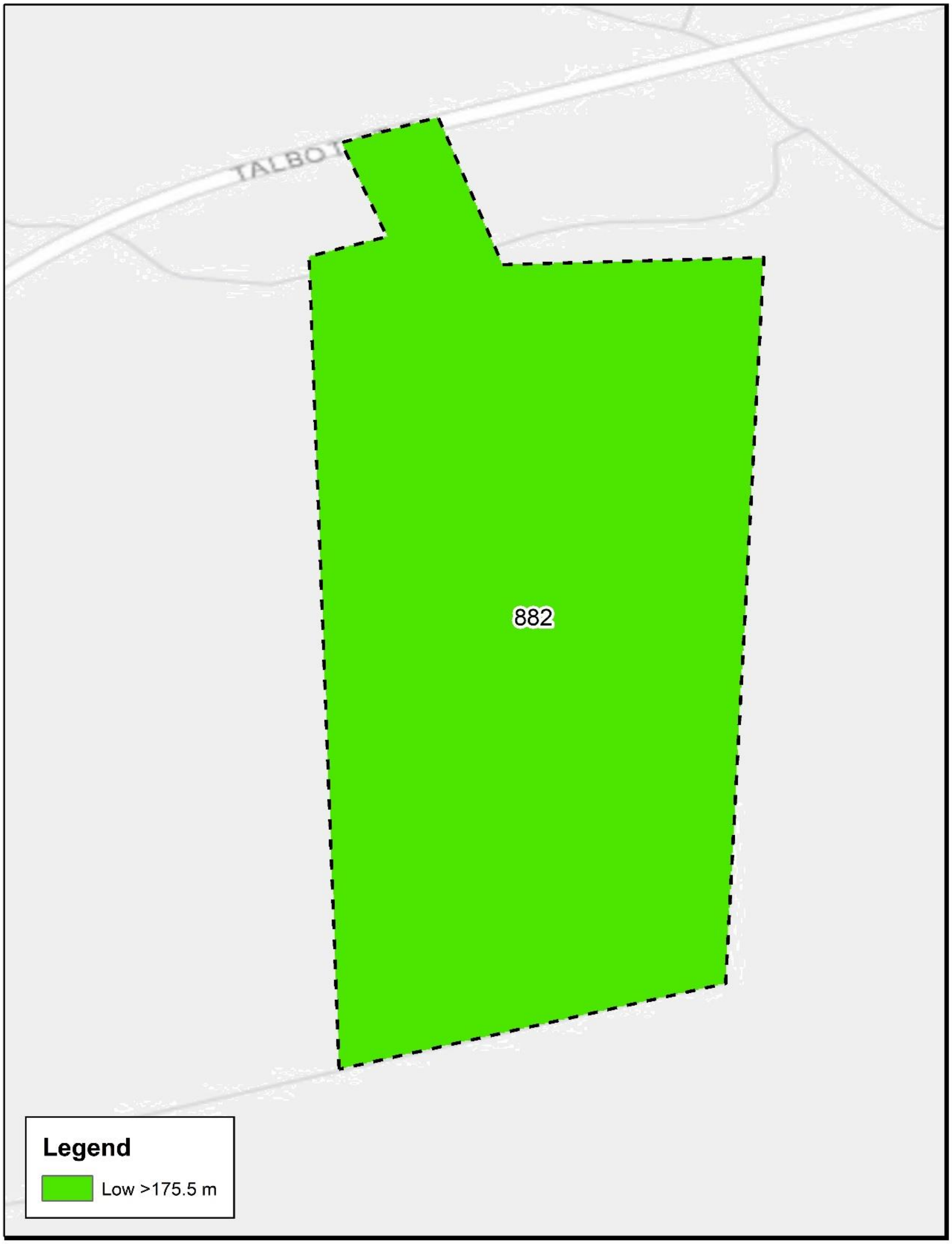
RiverLabs



Produced by:
St Lawrence River Insitute of Environmental Sciences

0 37.5 75 150 225 Meters

N W E S

RiverLabs


TALBOT
882
Legend
Total Flood Risk
Very High
High
Moderate
Low
Produced by:
St Lawrence River Insitute of
Environmental Sciences
0 37.5 75 150 225
Meters
N
W
E
S
RiverLabs