Sea Level Rise and Casco Bay's Wetlands:

A Look at Potential Impacts

BRUNSWICK EDITION

Casco Bay Estuary PARTNERSHIP

Muskie School of Public Service · University of Southern Maine · www.cascobayestuary.org
PO Box 9300 · Portland, ME 04104-9300 · 207.780.4820 (phone) · 207.228.8460 (fax)

Sea Level Rise and Casco Bay's Wetlands:

A Look at Potential Impacts

• Curtis Bohlen • Marla Stelk • Matthew Craig • Caitlin Gerber

This report is one of a series of ten reports focusing on the following Casco Bay municipalities:

Brunswick	Phippsburg
Cape Elizabeth	Portland
Falmouth	South Portland
Freeport	West Bath
Harpswell	Yarmouth

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Casco Bay Estuary Partnership 2013

Overview

The Intergovernmental Panel on Climate Change (IPCC) released a report in 2007 documenting a rise in average global temperatures, ocean temperatures and sea level rise. The sea level off Maine's 3,478 miles of coastline, as measured by the Portland, Maine tide gauge, has been rising at a rate of 1.8 ± 0.1mm/yr since 1912. This is markedly similar to the global average sea level rise determined by the IPCC. The most likely impacts of sea level rise in Maine will be inland migration of beaches, dunes and salt marshes over the next century.

Tidal wetlands are economically, environmentally and socially significant resources. They provide flood storage, flood protection, storm surge buffers, erosion control, water quality improvements, and wildlife habitat. Commercial fishing, shellfishing and outdoor recreation also contribute millions of dollars to Maine's economy and are dependent on healthy wetlands. Coastal communities and those along critical watershed areas will have to plan a comprehensive response to the changes in topography suggested by the projected impacts of sea level rise.

The unique geological make-up of Maine's coastline is characterized by very different coastal estuarine environments which are a direct result of prehistoric glacial activity. This led geologists such as Joseph T. Kelley, to subdivide Maine's coastline into four distinct sub-regions approximately corresponding to Casco Bay, Saco Bay, Penobscot Bay, and the northeast region around Cobscook Bay. Consequently, Maine's tidal wetlands are diverse, and the impacts to, and responses of, those wetlands to sea level rise are likely to be markedly different in each of those four regions.

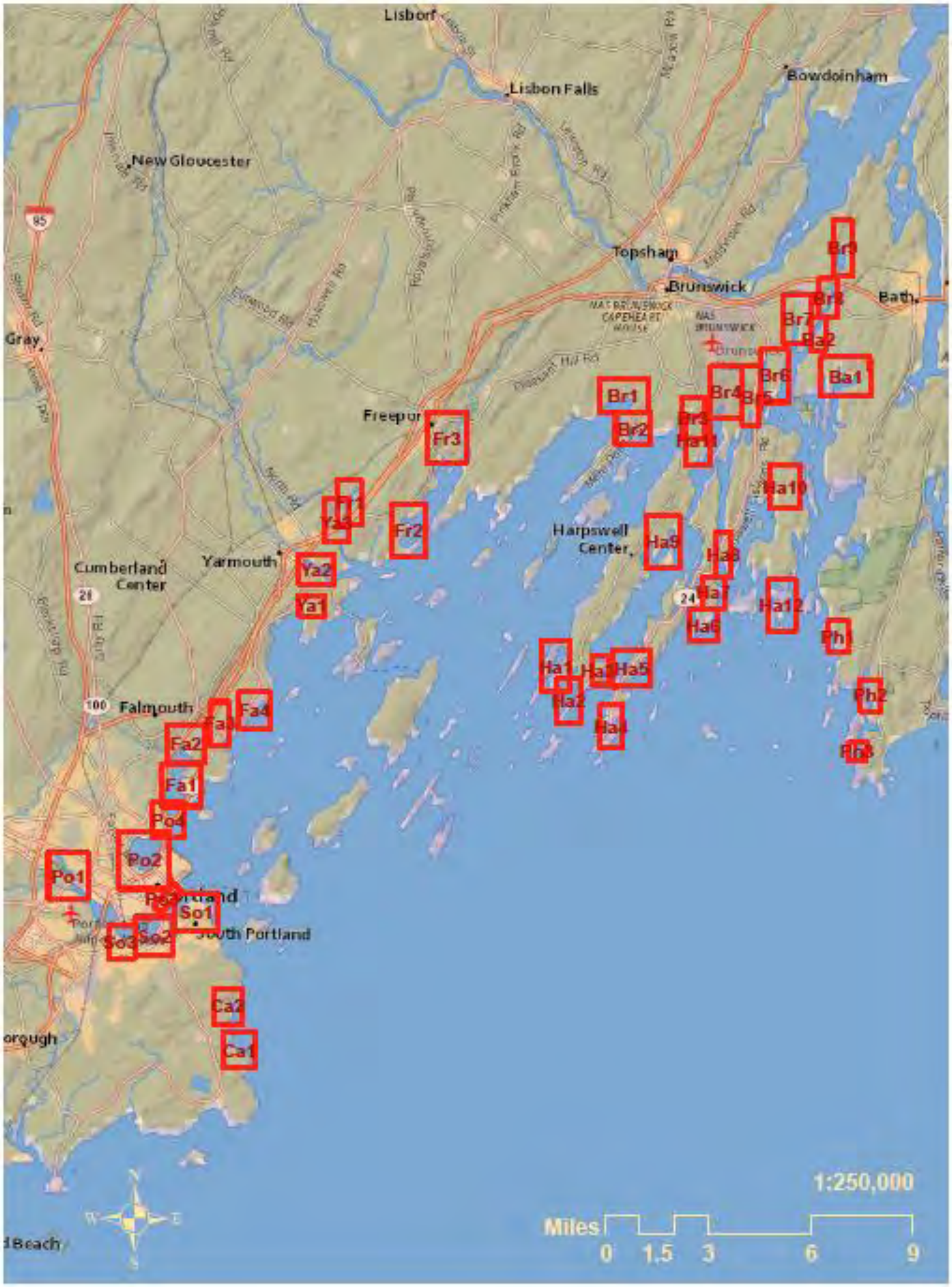
The Casco Bay Watershed comprises 986 square miles of land, and stretches from the mountains near Bethel to the coastal waters between Small Point in Phippsburg and Dyer Point in Cape Elizabeth. Home to nearly 20 percent of Maine's population, the watershed contains 44 municipalities, including some of the state's largest and fastest growing towns. The Casco Bay Estuary Partnership (CBEP), one of 28 National Estuary Programs nationwide, is a collaborative effort of people and organizations interested in protecting and restoring the Bay. Our partnership includes local, state and federal government organizations, non-profits, local businesses, citizens, universities and more.

The Study

CBEP looked at the ten of the fourteen municipalities that line Casco Bay to identify potential areas of marsh migration and possible impacts to existing developed areas due to tidal inundation from sea level rise. Figure 1 shows focus areas across the study area.

FIGURE 1

Casco Bay Focus Areas



Brunswick, Maine

This report is designed to help municipal staff and decision makers understand risk levels and potential impacts associated with sea level rise, and to provide science-based projections to inform future policy-making responses. The U.S. Environmental Protection Agency (EPA) produced a publication titled *Synthesis of Adaptation Options for Coastal Areas* in January, 2009 which identifies several planning and management options for coastal communities.

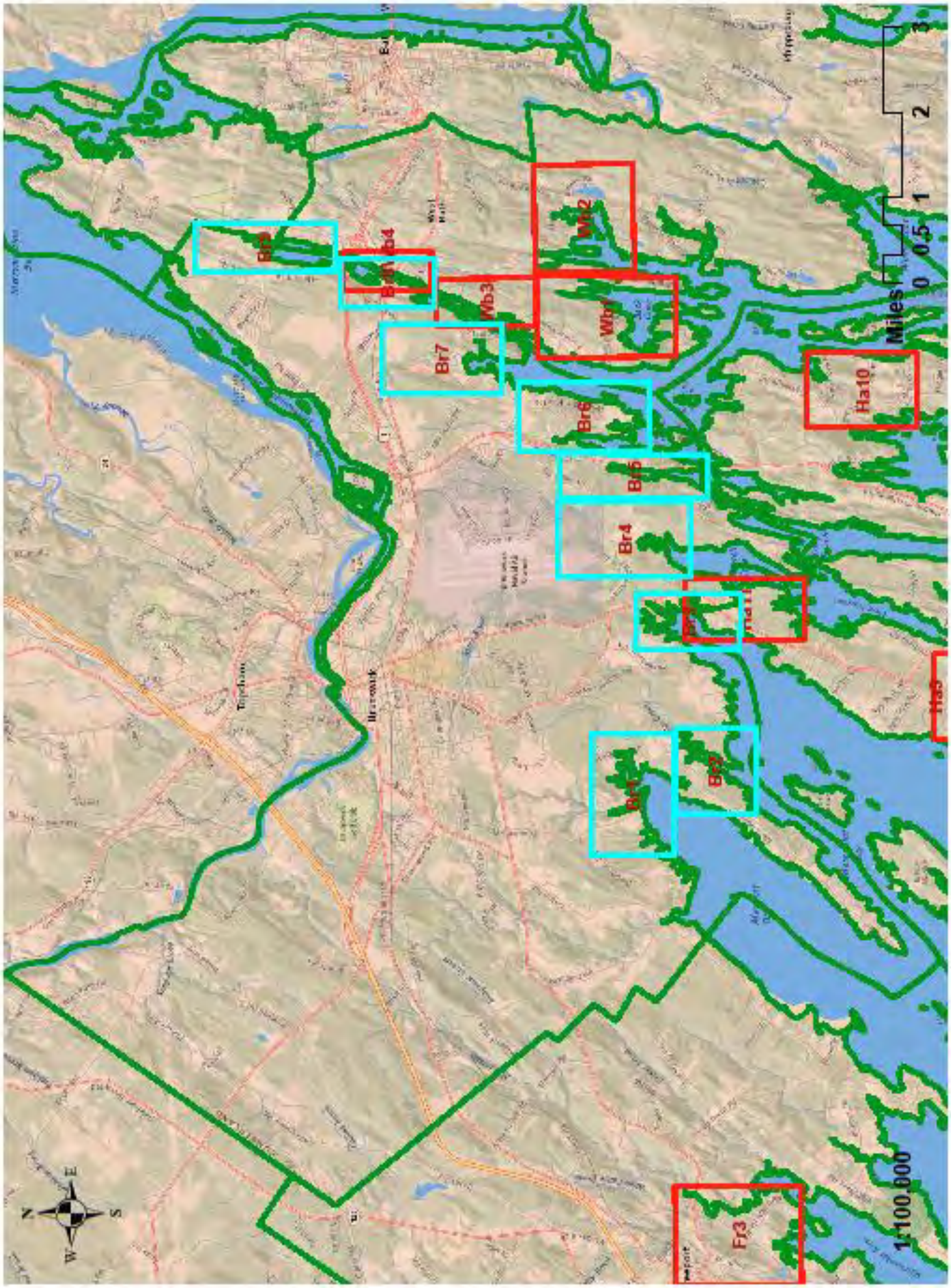
The maps display places where roads, railroads, trails, dams, and other structures cross tidal wetlands. In most cases, these structures alter the way that water is passed from one side of the wetland to the other. When tidal exchange is restricted, even if it is restricted only during astronomical spring tides, long-term impacts to wetlands can develop that reduce ecosystem resiliency to respond to impacts such as sea level rise. Tidal restrictions also increase velocities in the creek channels, creating scour that may undermine structural integrity over time. Under the sea level rise scenarios illustrated in these maps, the impacts of roads and other crossings on wetland resiliency will only increase. At the same time, creek channel dimensions can be expected to grow significantly. As a result, one of the most effective adaptations steps that towns can take to protect existing infrastructure and allow for marsh migration is to increase the size of culverts beneath existing roads. Such sites are attractive opportunities to the habitat restoration funding community, and removal of existing tidal restrictions is a high priority for the Casco Bay Estuary Partnership. If your town is interested in exploring culvert replacement or removal projects and would like technical or grant writing assistance, contact CBEP staff for information on structural options, federal and state contacts, and funding opportunities.

In Brunswick, we have identified nine primary areas as either being at risk of conflict between rising seas and existing developed areas, and/or including areas where we see potential tidal wetlandmigration (Figure 2).

These areas are identified as:

1. Maquoit Bay
2. Mere Point Bay
3. Middle Bay
4. Harpswell Cove
5. Buttermilk Cove
6. Woodward Cove
7. Thomas Bay
8. Lower New Meadows ‘Lake’
9. Upper New Meadows ‘Lake’

FIGURE 2



Brunswick Focus Areas

Two maps were produced for each of the areas above. The maps show existing infrastructure such as roads and dams, as well as existing wetlands (blue), then show how these resources are likely to be impacted by a 1' and then a 3' rise in sea level. Projected impacts are displayed as lost wetlands (yellow), and conflicts between existing infrastructure and sea level rise are shown in pink. Projected new wetlands are shown in orange.

As mentioned previously, caution must be taken when interpreting these maps because some of the areas may or may not pose any serious future risk for tidal inundation. Local knowledge of these areas will be necessary to more accurately gauge whether or not they are areas of concern for Brunswick according to current or future development plans, comprehensive plans, or conservation plans. Some areas may pose concern with regard to existing or future infrastructure, and other areas may see more significant changes with regard to wetland type and, subsequently, habitat.

Br1: Maquoit Bay

Figures 3 and 4 show projected sea level rise impacts in Maquoit Bay. Maquoit Bay could see significant loss of existing wetlands under both the 1' and the 3' sea level rise scenarios, but at 3', there is also potential for new tidal wetlands to develop without conflict in developed areas. Future marsh migration is complicated by the presence of several structures, including Rossmore Road, Maquoit Road, and Woodside Road, as well as a dam upstream of Rossmore Road. These structures are currently affecting tidal exchange, particularly during spring tides, and the effects of these constrictions are likely to increase with rising seas, creating impacts to habitat and infrastructure. The maps show conflicts with existing development at these sites and at Wharton Point. Road crossings of tidal creeks should be maintained and replaced with the expectation that creek channel dimensions are likely to expand over time.

Br2: Mere Point Bay

Figures 5 and 6 show projected sea level rise impacts in Mere Point Bay. Mere Point Bay may lose more wetland adjacent to coastal waters due to sea level rise than it gains through marsh migration inland at the head of existing wetlands. An unknown structure at 43.86037, -69.978734, which appears to be a bridge with a berm across the marsh, could be impacted by rising seas. This structure may also block the flow of water across the high marsh surface during spring tide events. While the current impacts to upstream wetland habitat are likely minimal, these impacts could increase with rising seas.

Br3: Middle Bay

Figures 7 and 8 show projected sea level rise impacts in Middle Bay. The maps project a major loss of tidal wetlands at the head of the Bay, with considerably less opportunity for marshes to migrate inland. Our analysis shows that conflicts with existing infrastructure are likely to occur at the Town's border with Harpswell along Harpswell Road/Route 123, at 43.855249,-69.946492, from both Middle Bay to the west and Skolfield Cove to the east. Further north on Harpswell Road, an undersized, perched culvert at 43.867065,-69.945065 currently restricts tidal exchange under the road during astronomical spring tides, and likely blocks movement of smelt known to frequent the stream.

Br4: Harpswell Cove

Figures 9 and 10 show projected sea level rise impacts in the Harpswell Cove area. The maps illustrate that while some existing wetlands may be lost along the shoreline of Harpswell Cove, there are low lying areas upstream which are suitable for expansion of tidal wetlands, particularly with a 3' increase in sea level. An existing cart path at the Mere Creek Golf Course (43.87319,-69.932543) currently restricts tidal exchange into upstream wetlands, and this path is likely to be impacted by sea level rise. As a whole, Harpswell Cove may wind up with a net increase in tidal wetlands as sea level rises.

Br5: Buttermilk Cove

Figures 11 and 12 show projected sea level rise impacts in the Buttermilk Cove area. Although some small amount of wetland could be lost at the head of the Cove, low lying areas upstream are suitable for migration of wetlands inland, particularly with a 3' rise in sea level. Few impacts are projected around Buttermilk Cove with a 1' increase in sea level, but low lying areas adjacent to the Coombs Road crossing, and at the Princes Point Road boat launch, are likely to be impacted by a 3' increase in sea level.

Br6: Woodward Cove

Figures 13 and 14 show projected sea level rise impacts in the Woodward Cove area. No conflicts with existing development are evident within the Cove at either the 1' or the 3' sea level rise scenario. A small amount of wetland may be lost at the head of Woodward Cove, but low lying areas at the head of the wetland are suitable for marsh migration, particularly if sea level rises by 3'. A small dam/road on Woodward Point (43.874958,-69.903879) could be impacted by rising seas and will likely impede the migration of wetlands. It appears that there may be some conflicts on the north end of Upper Coombs Island. However, the Kimberly Circle area as well as the residential and Route 24 areas at the tip of the marsh may also see future impacts due to marsh migration close to homes and roads.

Br7: Thomas Bay

Figures 15 and 16 show projected sea level rise impacts around Thomas Bay. With a 1' rise in sea level, some wetland loss at the head of Thomas Bay is likely, and these losses would be substantially increased under a 3' rise in sea level. Low lying areas along the western shoreline of Thomas Bay Marsh are suitable for inland marsh migration, but these potential gains would not offset the losses along the Bay itself. The analysis suggests that three areas around Thomas Bay and the Thomas Bay Marsh are likely to be impacted by a 3' rise in sea level: 1) the Adams Road causeway, 2) low lying areas along Varney Lane, and 3) Thomas Beach Road, where apparent past wetland fill appears to have severed tidal exchange into a small wetland at 43.895442,-69.893337.

Around Howard's Point, along the western shore of the New Meadows River, low lying areas appear to be suitable for marsh migration and a significant gain in wetland. A tidal restriction/dam in this Area (43.897732,-69.881239) may be currently altering tidal exchange in this area.

Br8: Lower New Meadows 'Lake'

Figures 17 and 18 show projected sea level rise impacts around the lower New Meadows 'Lake'. Tidal exchange in this area is heavily impacted by Bath Road and U.S. Route 1, and apparent past wetland filling associated with these roads and a railroad. The maps show that under both a 1' and a 3' rise in sea level, elevation is suitable for marsh migration to occur between the railroad and Bath Road, however, the ability of water to reach this area is unknown. This low lying area provides the best potential for future marsh migration in the lower 'Lake'. The analysis shows that there could be conflicts between rising sea level and existing infrastructure along Bath Road, particularly if sea level rises 3'. A 3-foot sea level rise may impact the New Meadows Marina as well as other commercial and residential property and roads in that area and in the area between Bath Road and the Railroad tracks. The banks along Bath Road and U.S. Route 1 would be impacted if seas rise 3', and Route 1 appears to have some low-lying areas between eastbound and westbound lanes that could be flooded at high tides.

Br9: Upper New Meadows 'Lake'

Figures 18 and 20 show projected sea level rise impacts around the upper New Meadows 'Lake'. Elevations along the western shore, particularly to the north of Old Bath Road, are suitable for formation of new tidal wetlands as marshes migrate inland in response to a 3' increase in sea level. If sea level rises by 3', the hydrology of this system would likely change in part due to the historical canal connecting the New Meadows to the Kennebec River. Impacts to Old Bath Road due to tidal inundation are likely if sea level rises by 3'.

FIGURE 3: Br1

Maquoit Bay: 1 ft. Sea Level Rise

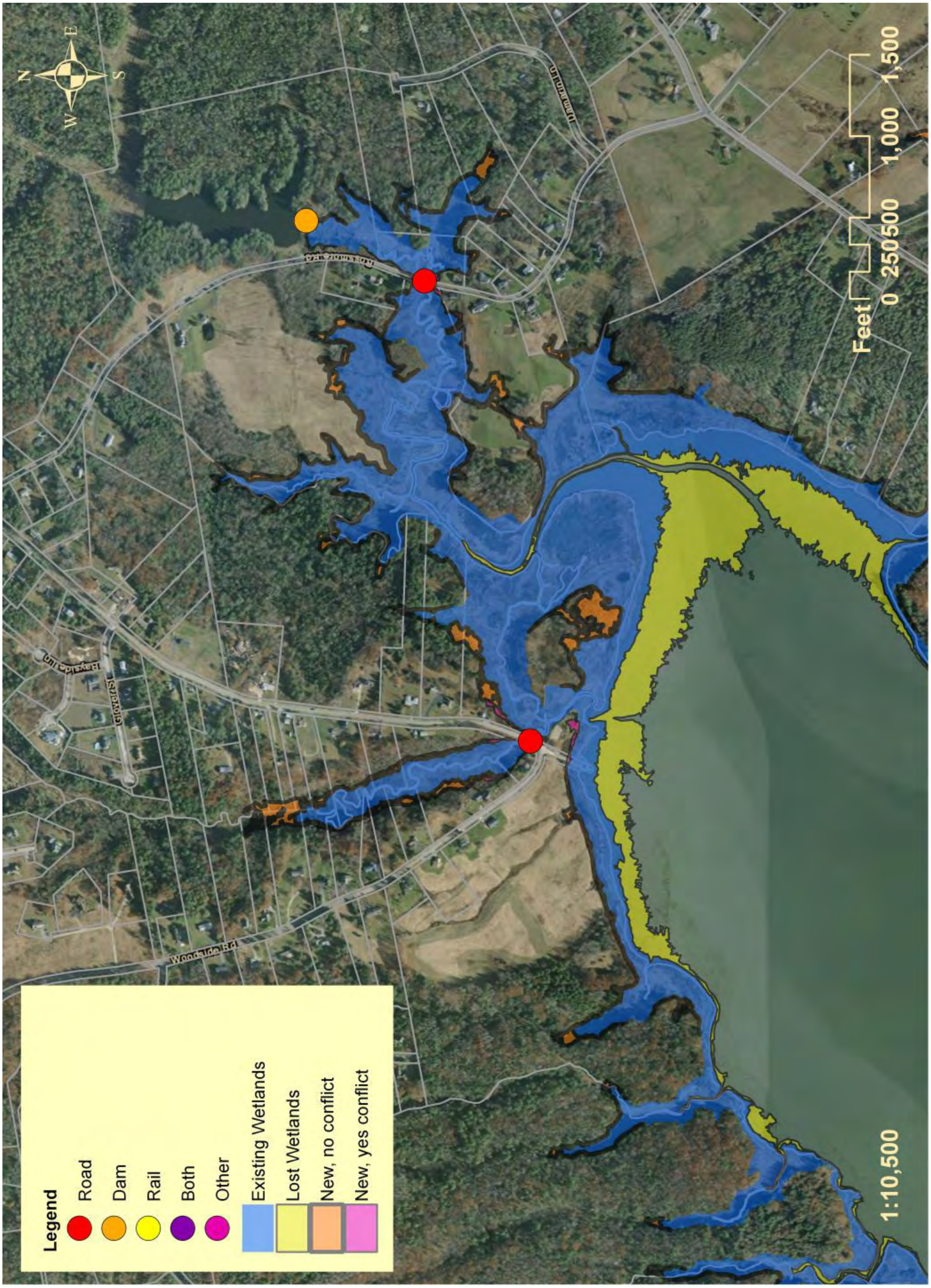


FIGURE 4: Br1

Maquoit Bay: 3 ft. Sea Level Rise

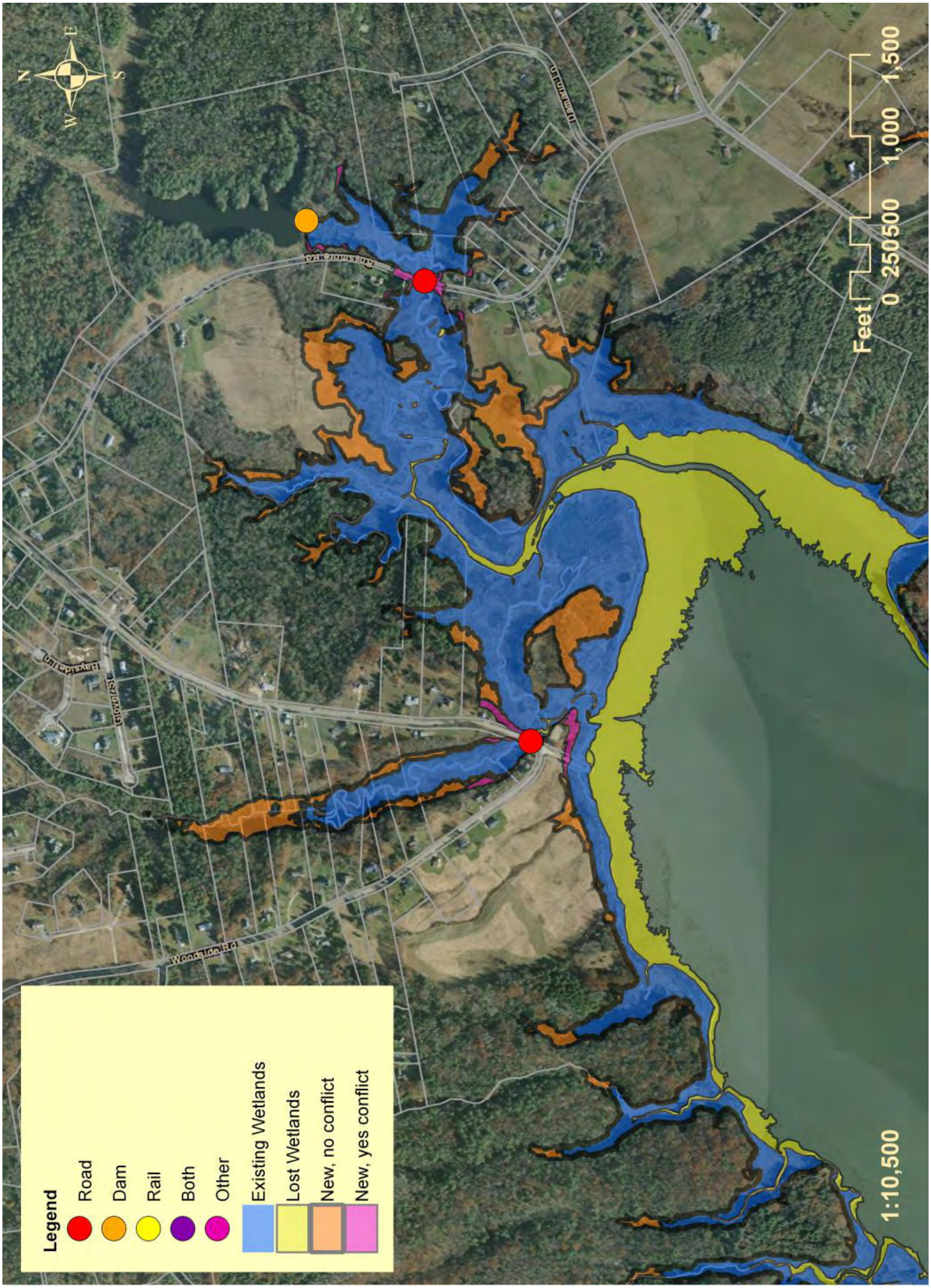


FIGURE 5: Br2

Merepoint Bay: 1 ft. Sea Level Rise

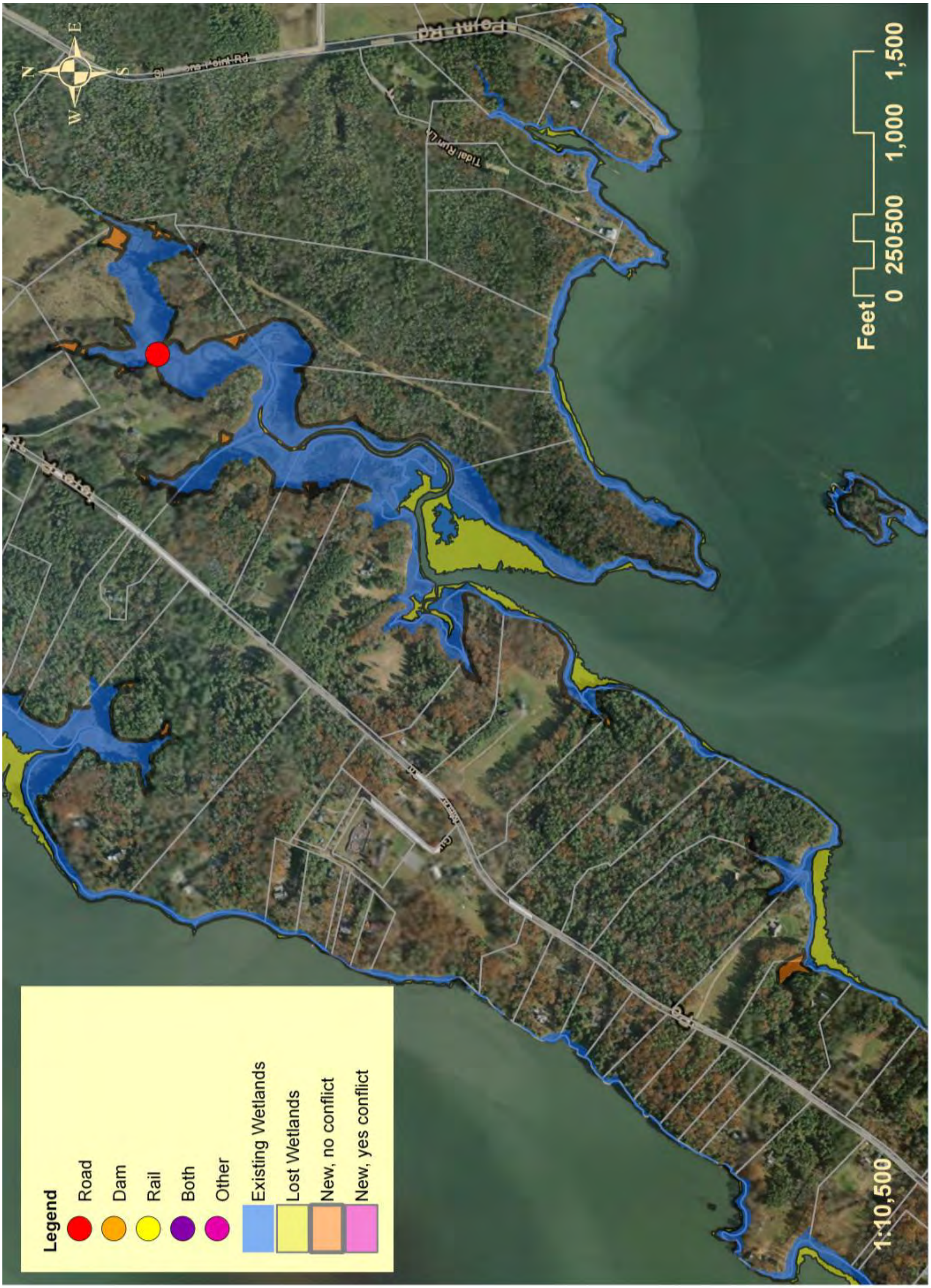


FIGURE 6: Br2

Merepoint Bay: 3 ft. Sea Level Rise

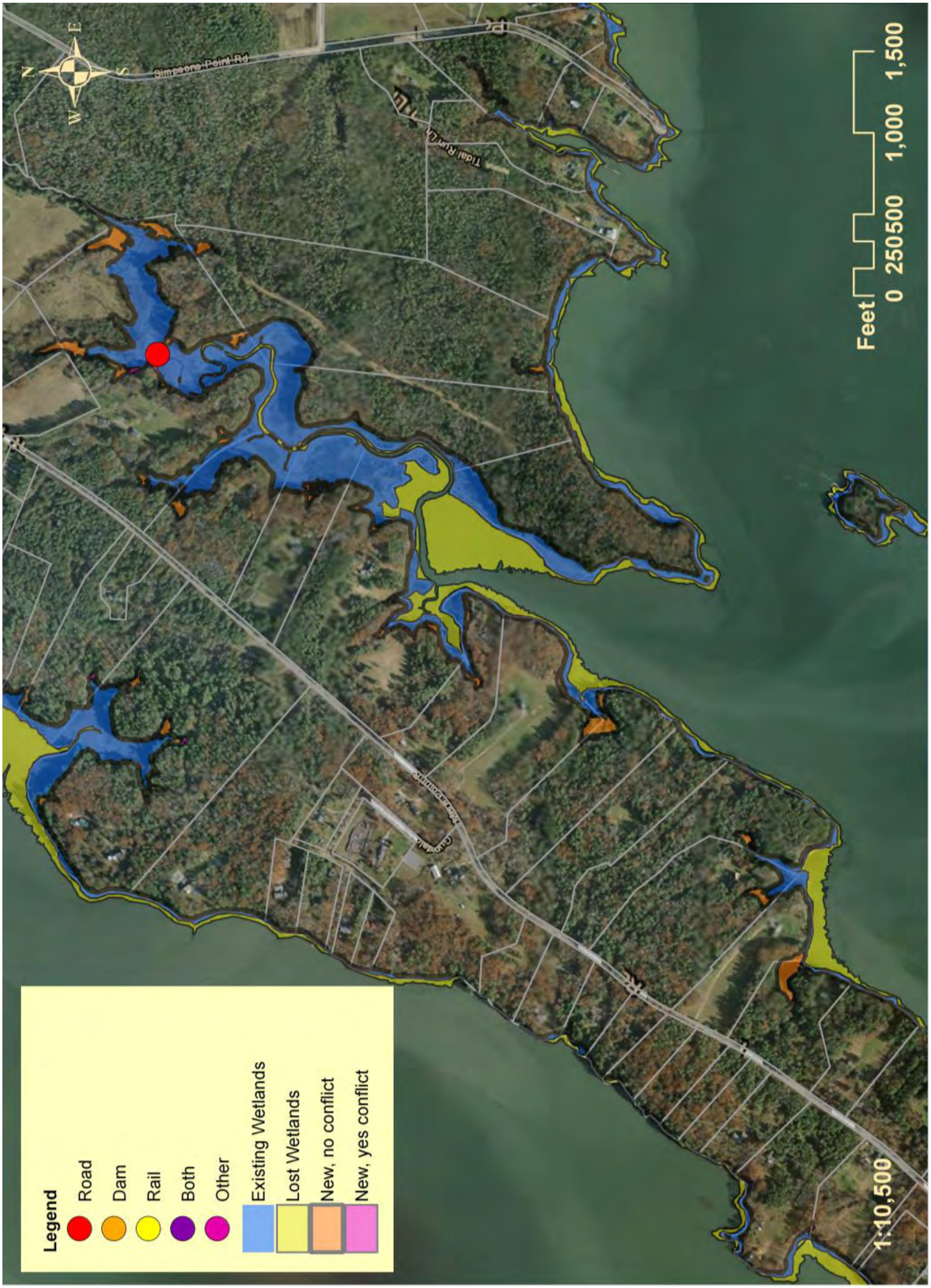


FIGURE 7: Br3

Middle Bay: 1 ft. Sea Level Rise

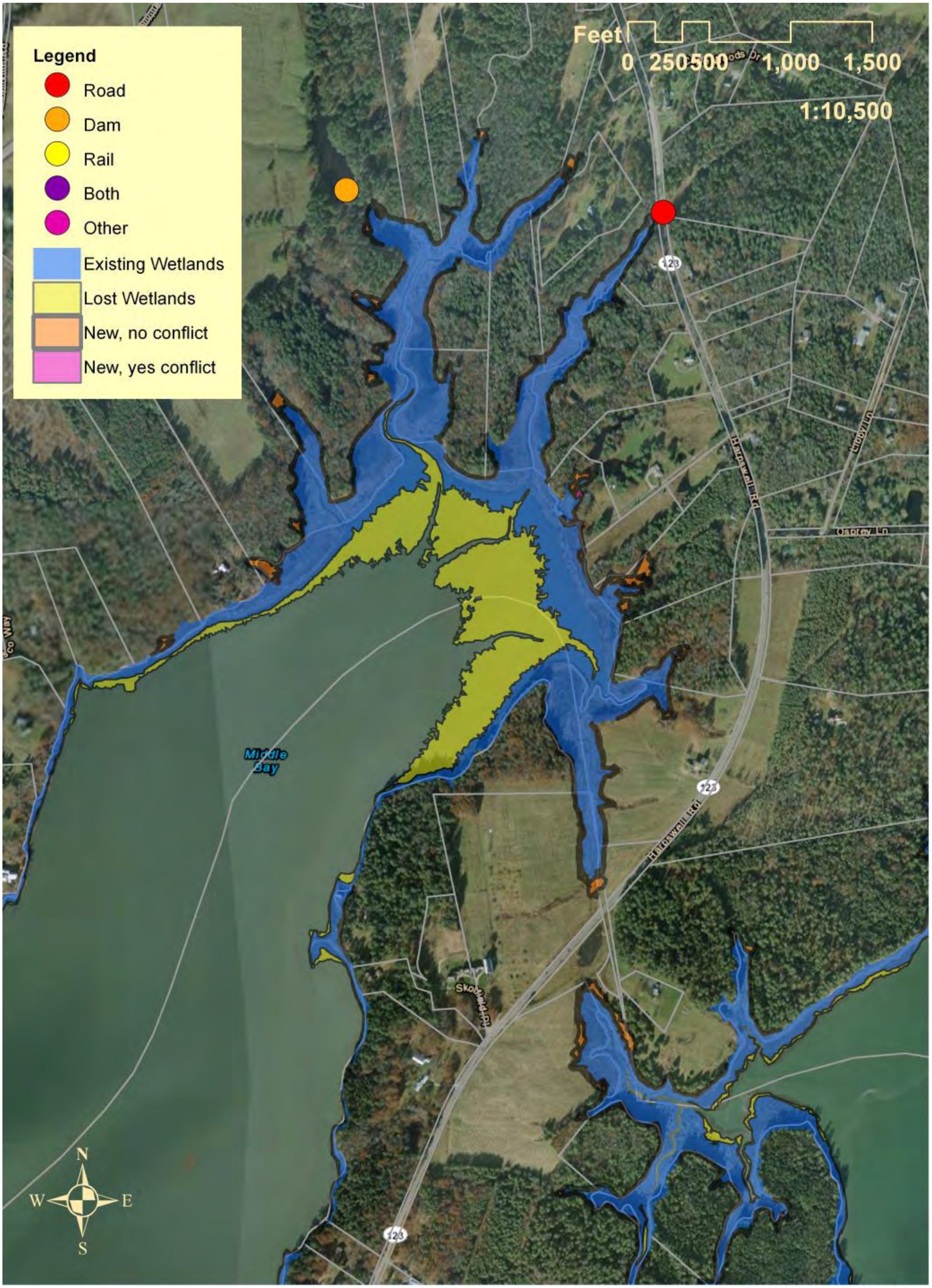


FIGURE 8: Br3

Middle Bay: 3 ft. Sea Level Rise

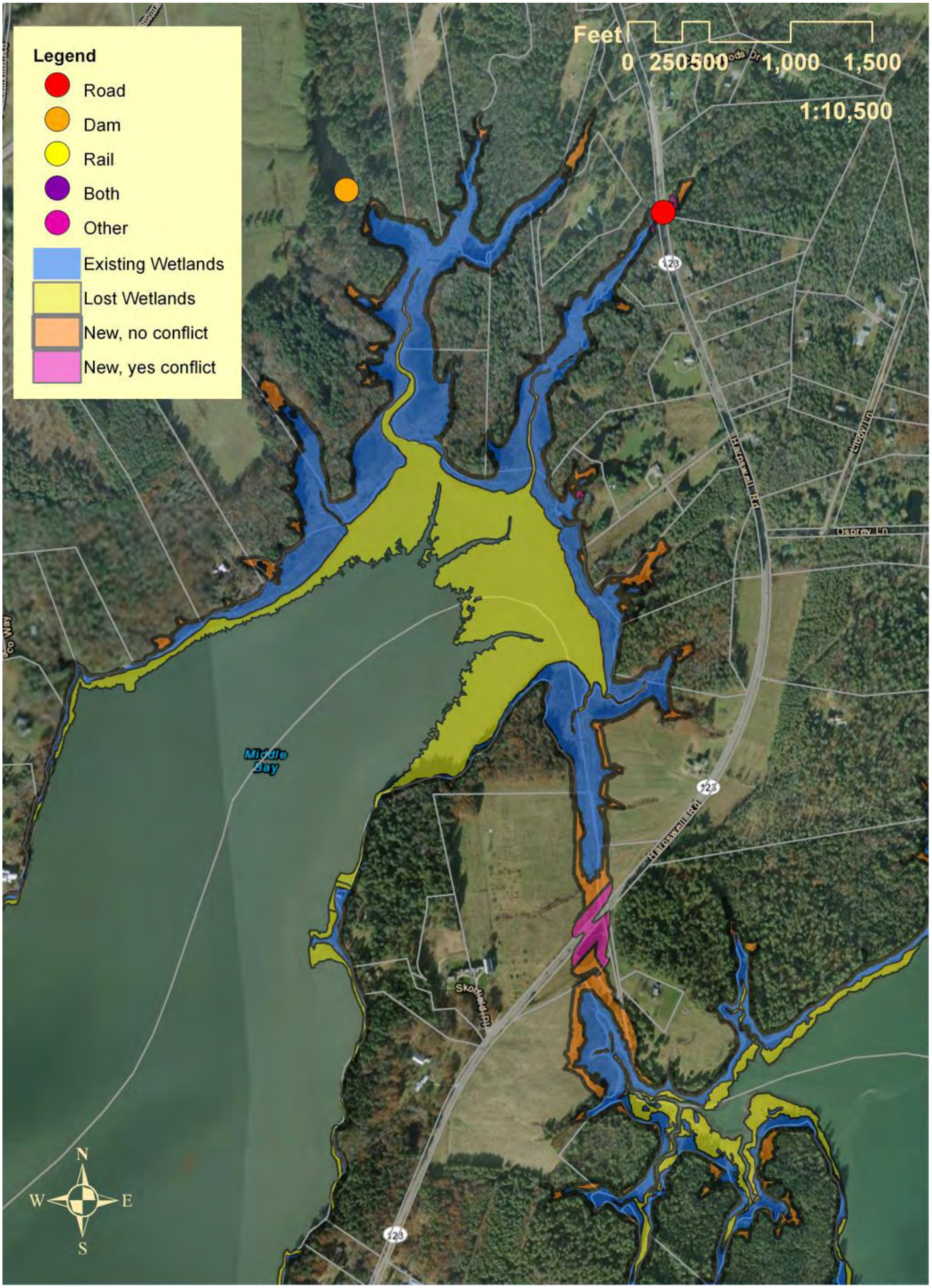


FIGURE 9: Br4

Harpswell Cove Area: 1 ft. Sea Level Rise

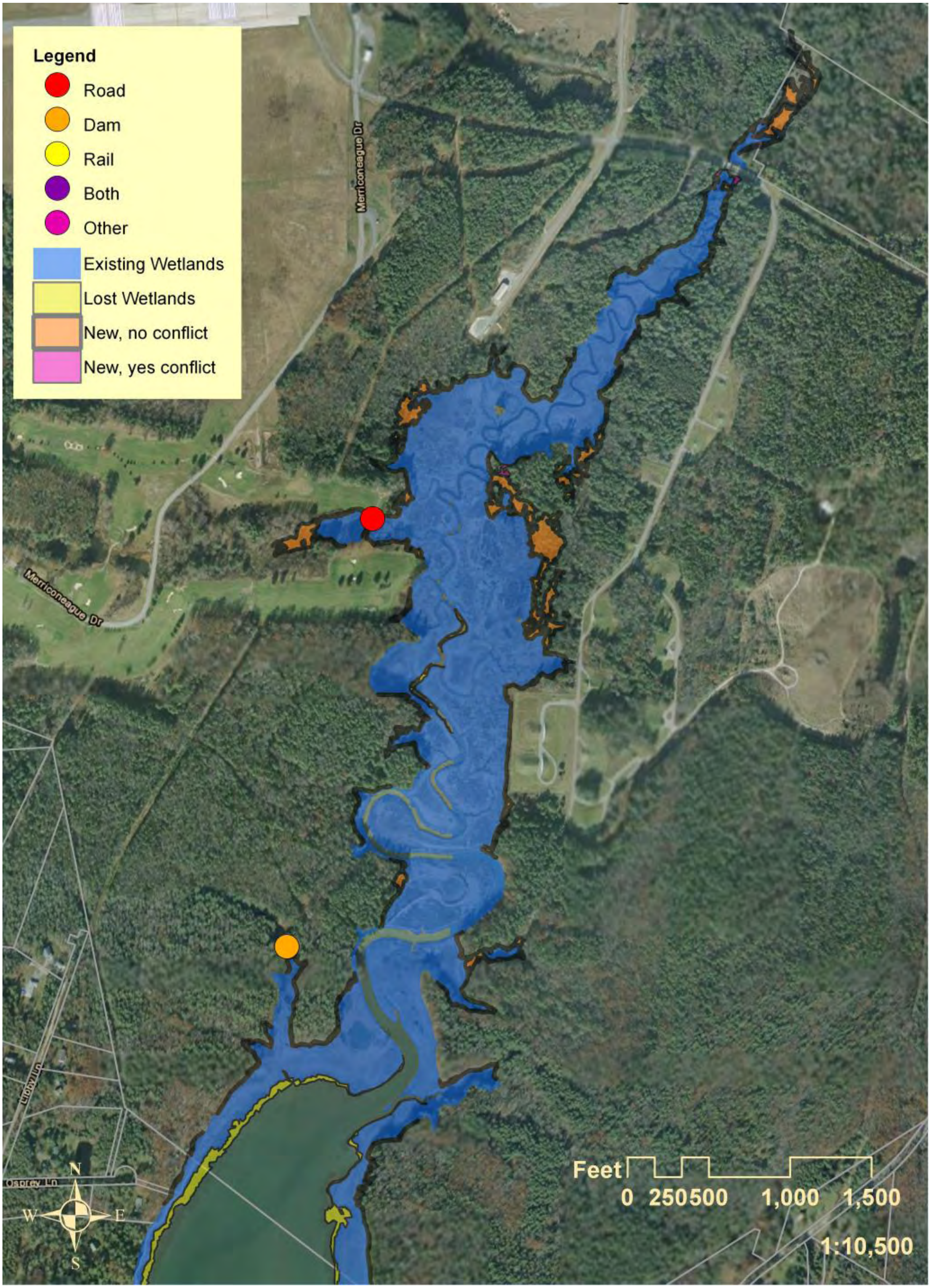


FIGURE 10: Br4

Harpswell Cove Area: 3 ft. Sea Level Rise

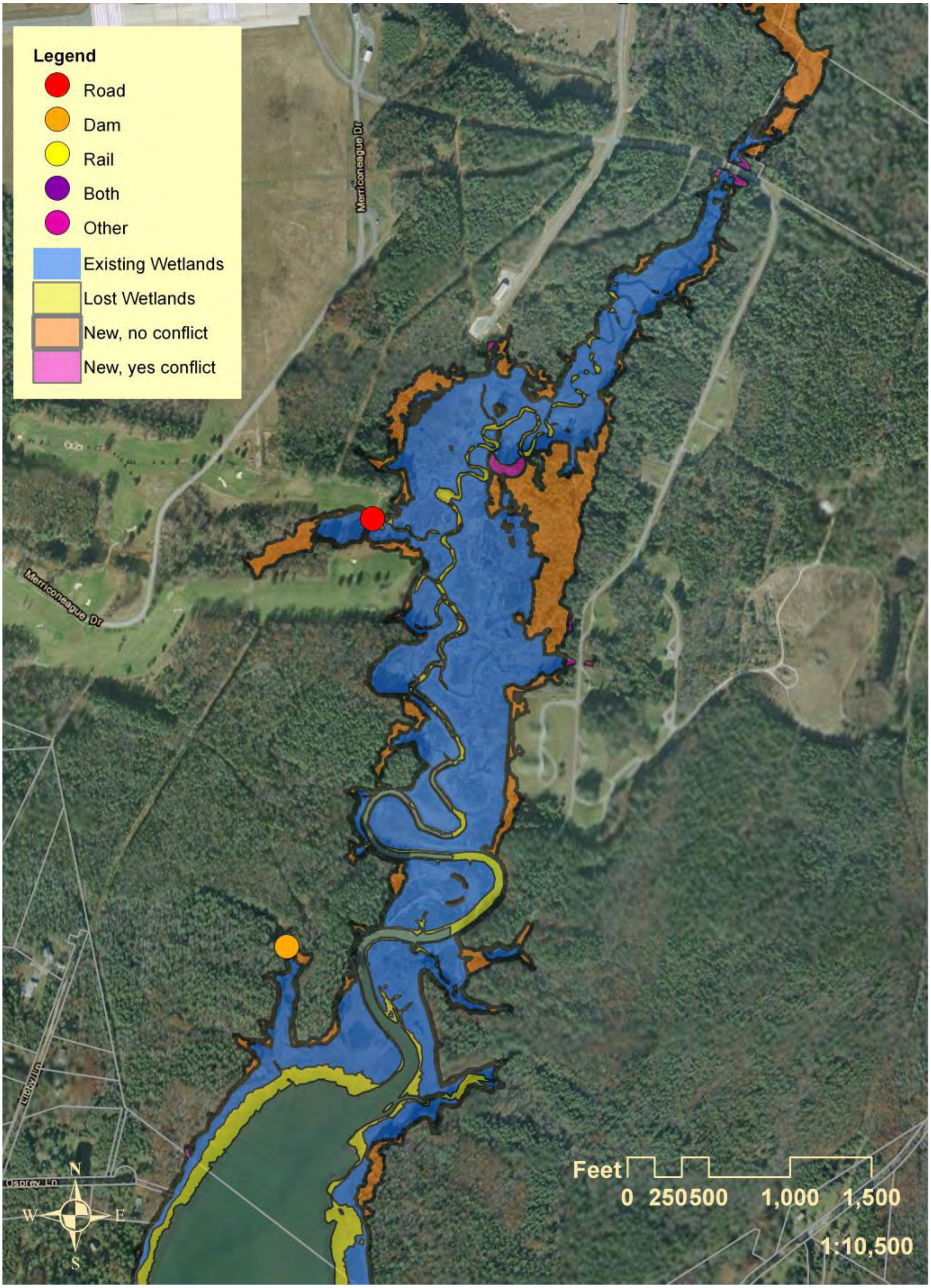


FIGURE 11: Br5

Buttermilk Cove: 1 ft. Sea Level Rise

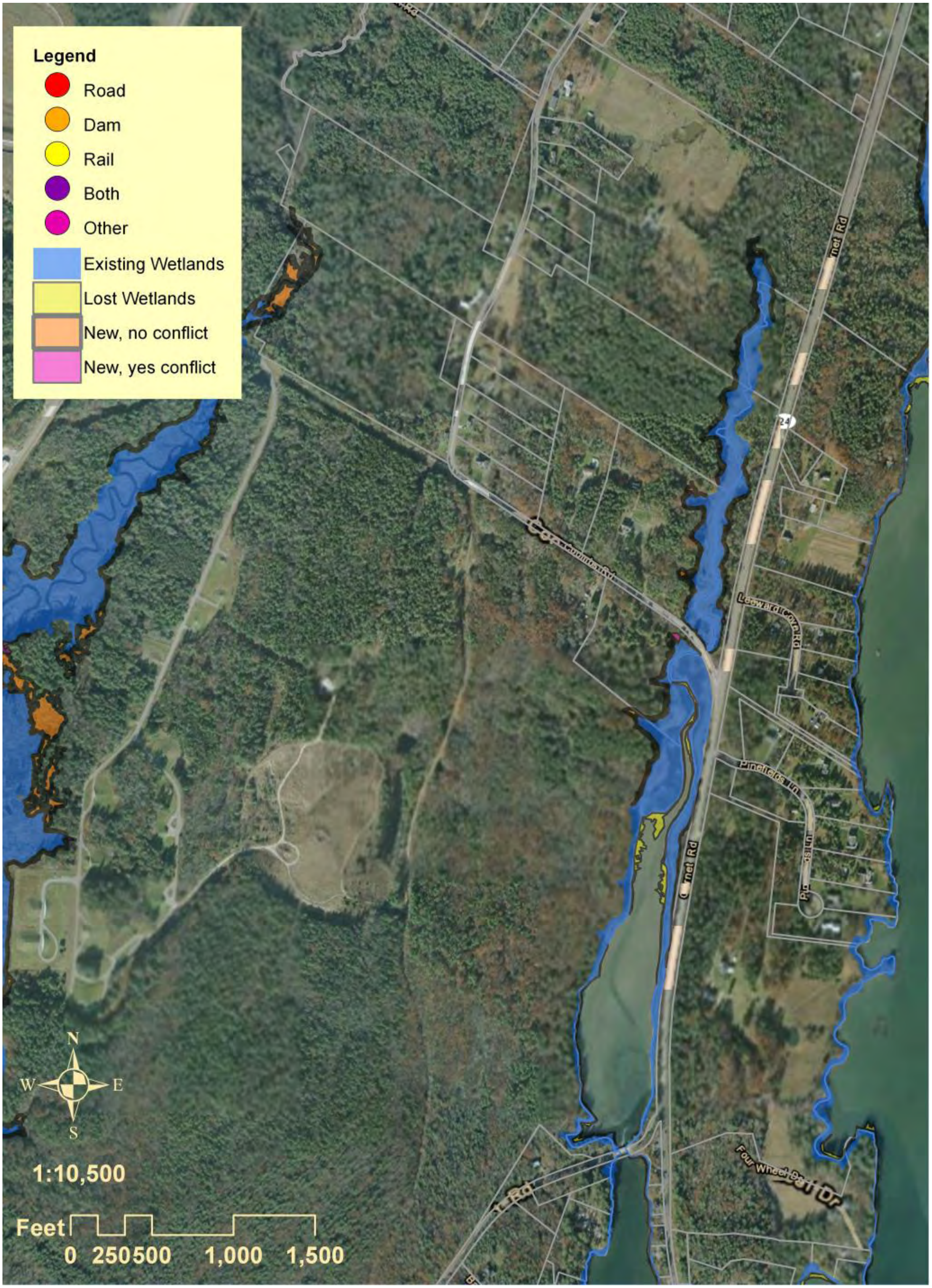


FIGURE 12: Br5

Buttermilk Cove: 3 ft. Sea Level Rise

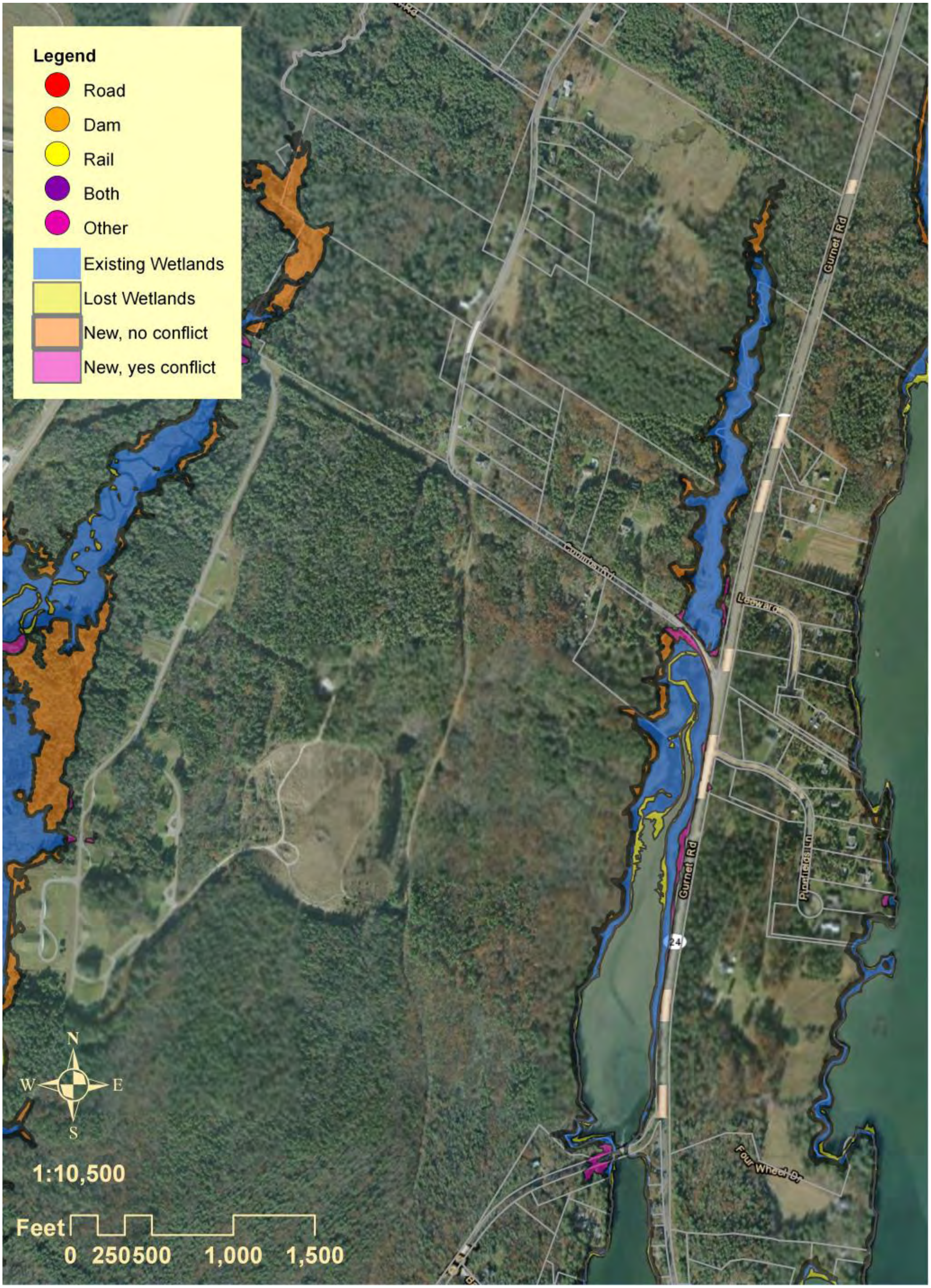


FIGURE 13: Br6

Woodward Cove: 1 ft. Sea Level Rise

FIGURE 14: Br6

Woodward Cove: 3 ft. Sea Level Rise

FIGURE 15: Br7

Thomas Bay: 1 ft. Sea Level Rise

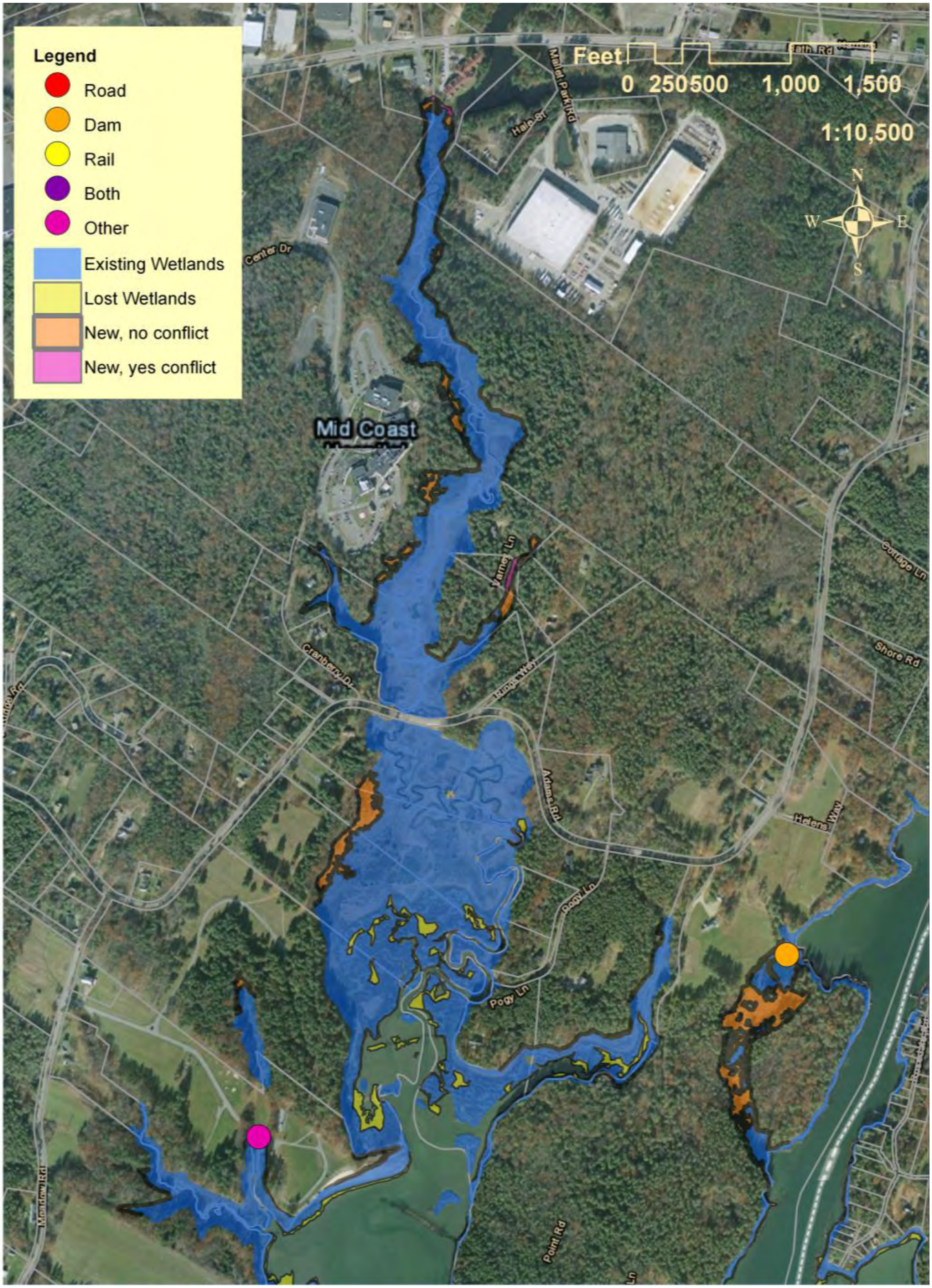


FIGURE 16: Br7

Thomas Bay: 3 ft. Sea Level Rise

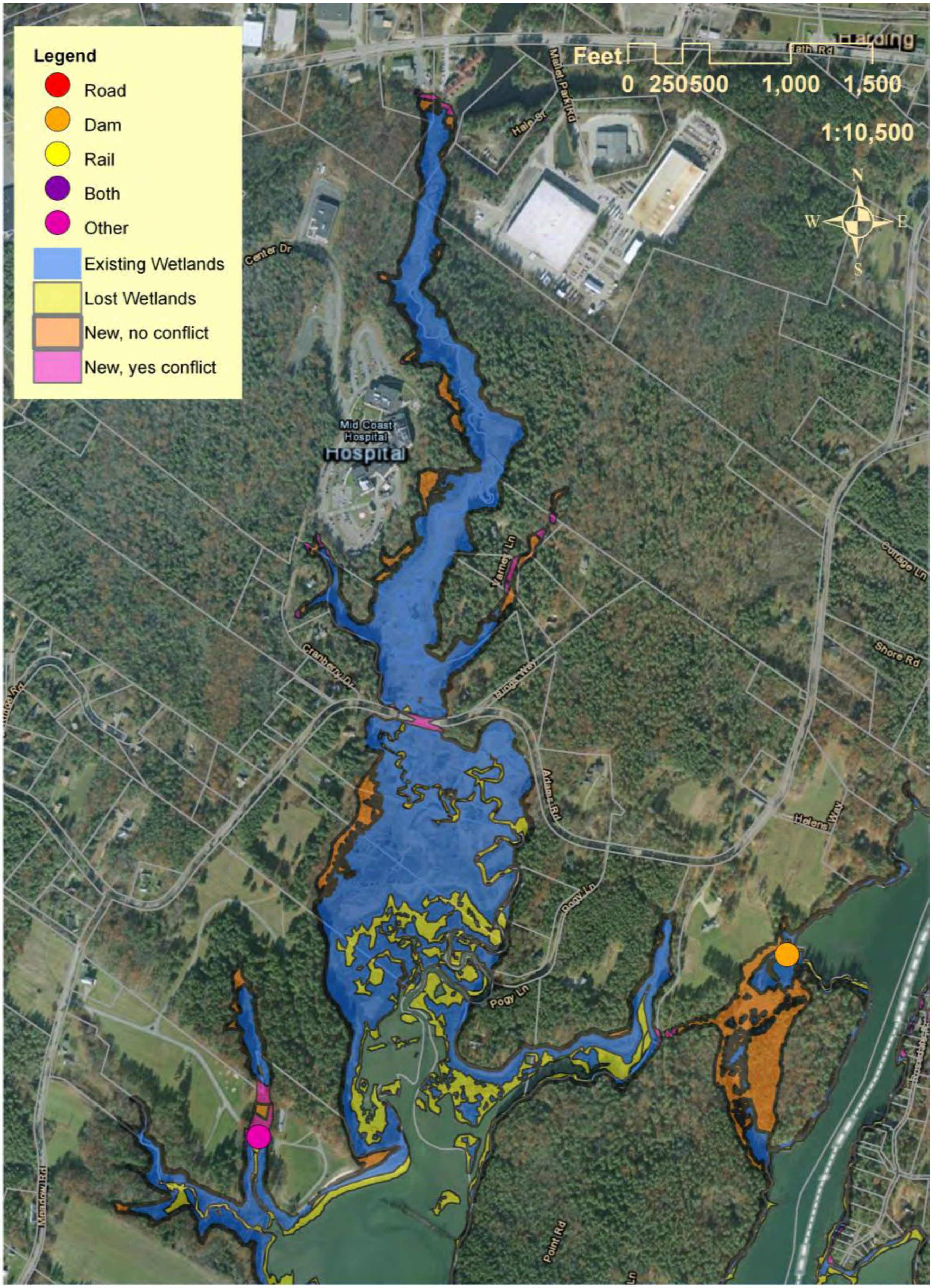


FIGURE 17: Br8 **Lower New Meadows 'Lake' Area: 1 ft. Sea Level Rise**

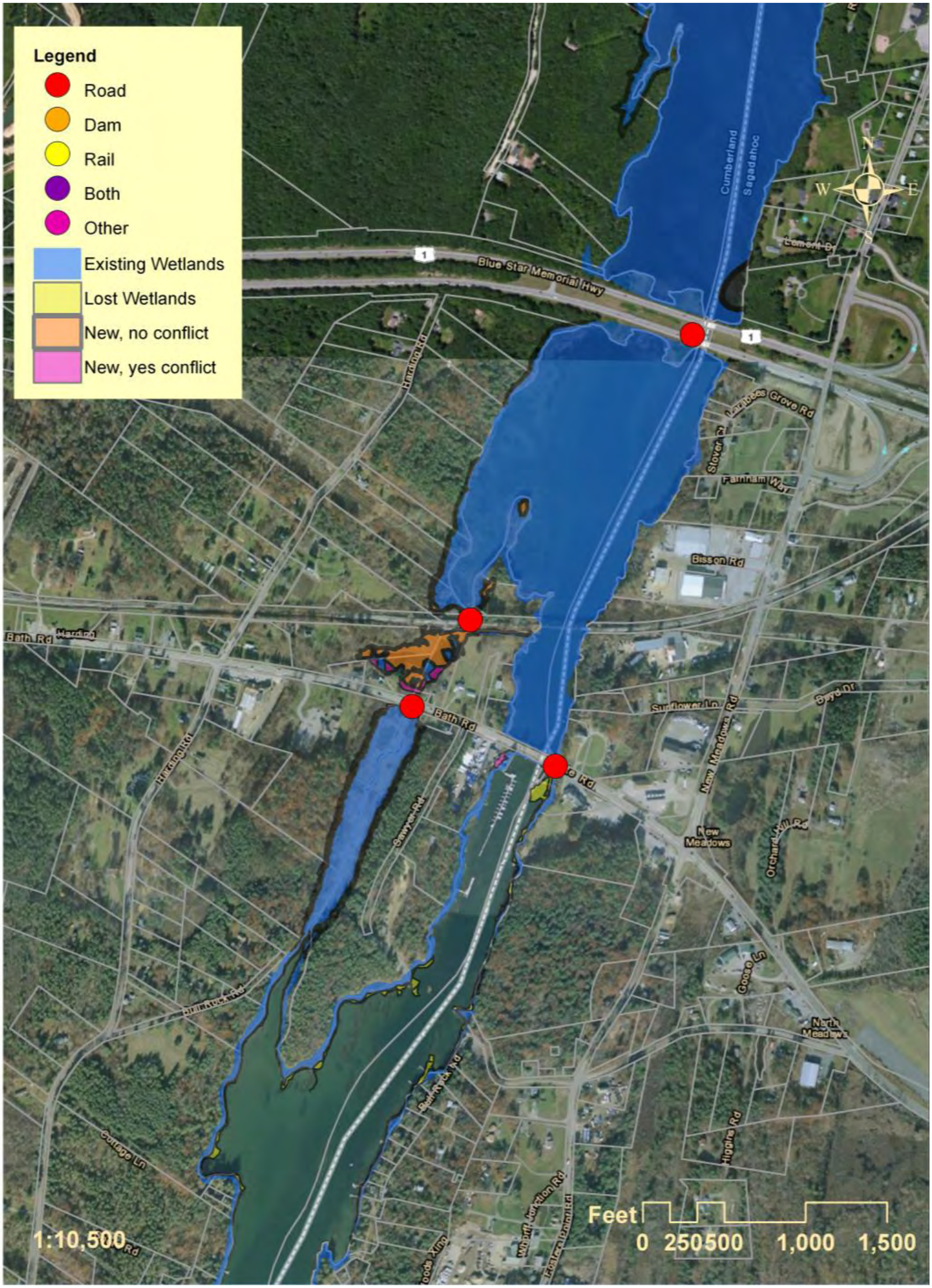


FIGURE 18: Br8 **Lower New Meadows 'Lake' Area: 3 ft. Sea Level Rise**

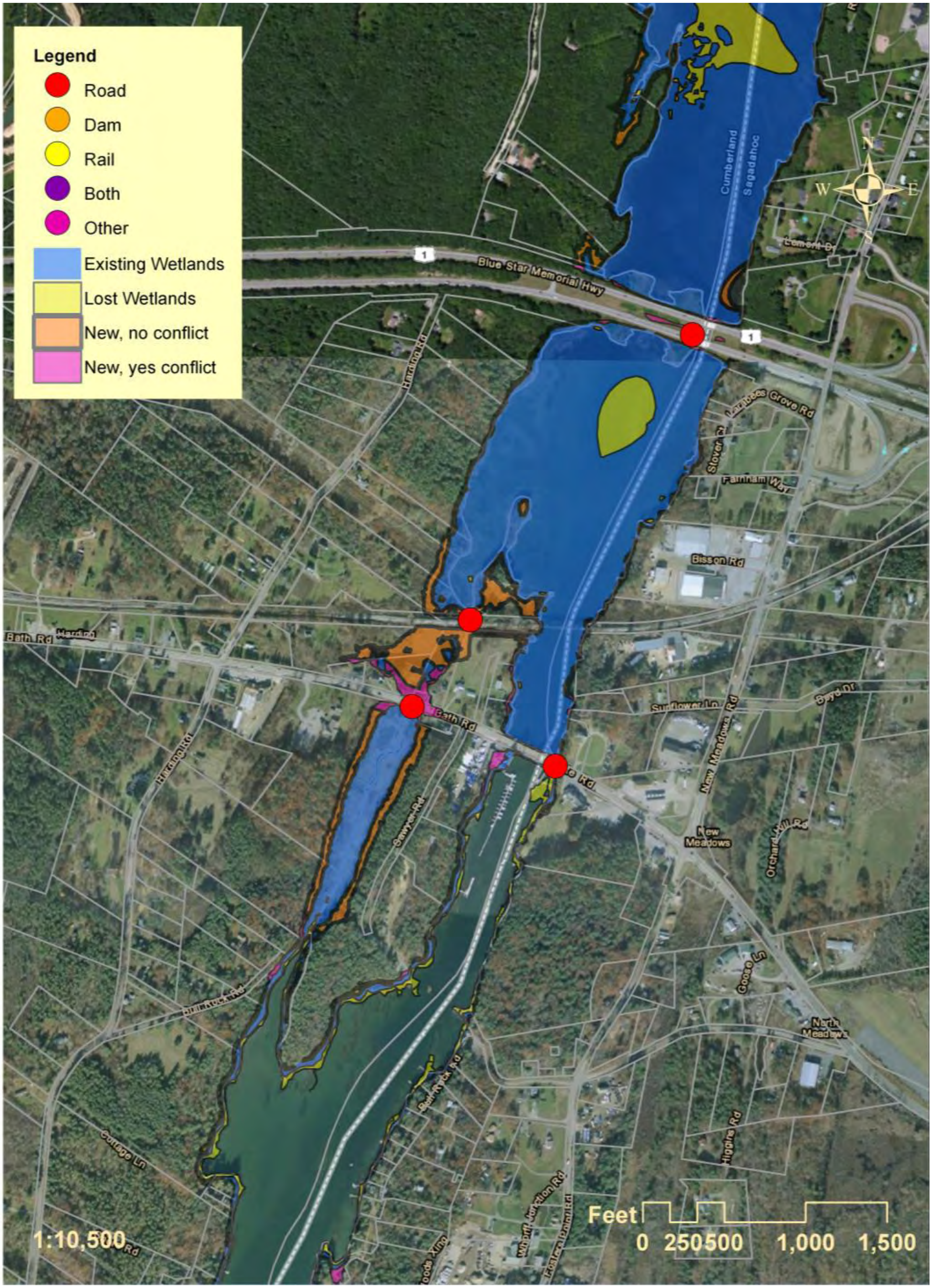


FIGURE 19: Br9 **Upper New Meadows 'Lake' Area: 1 ft. Sea Level Rise**

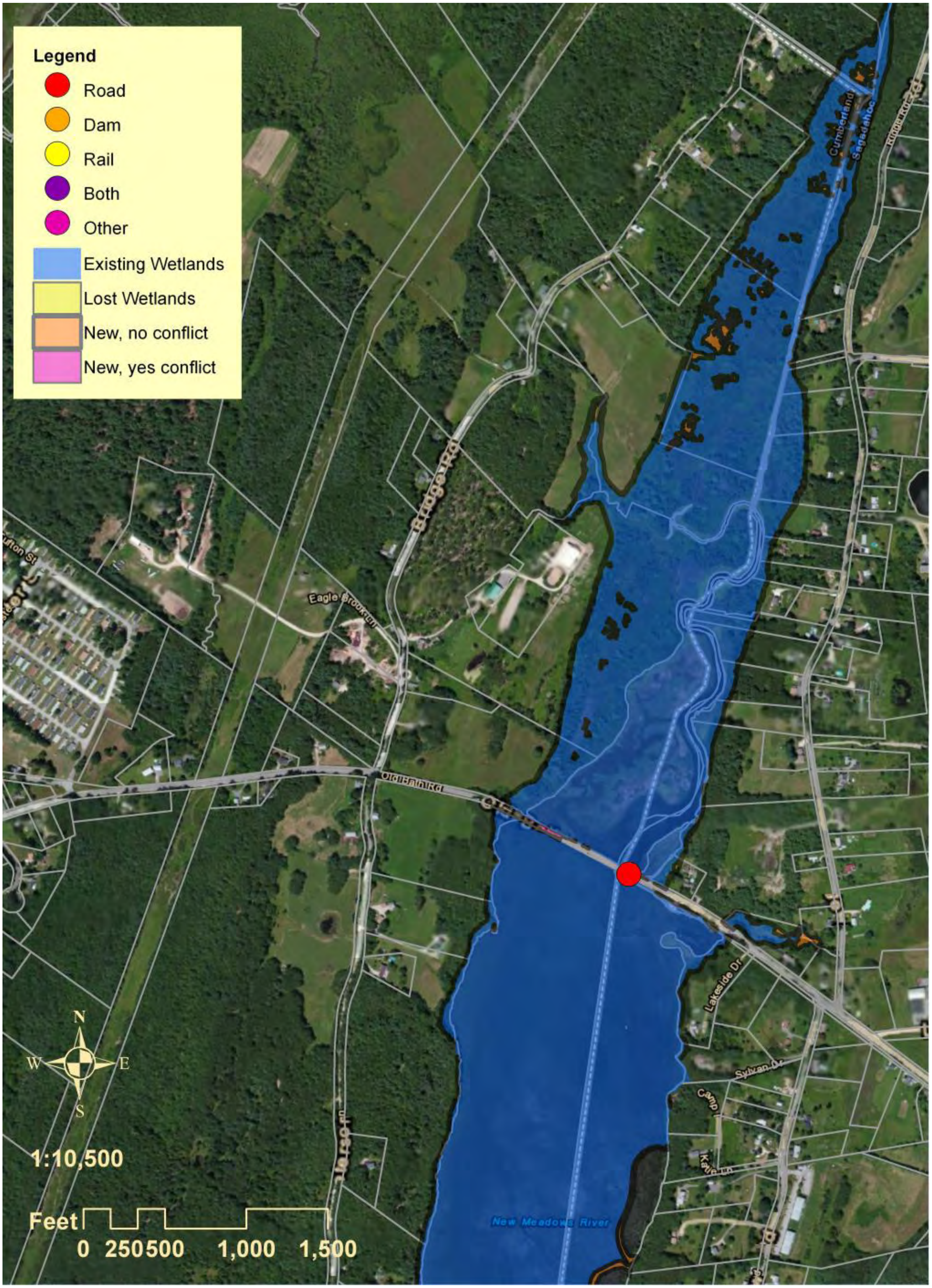
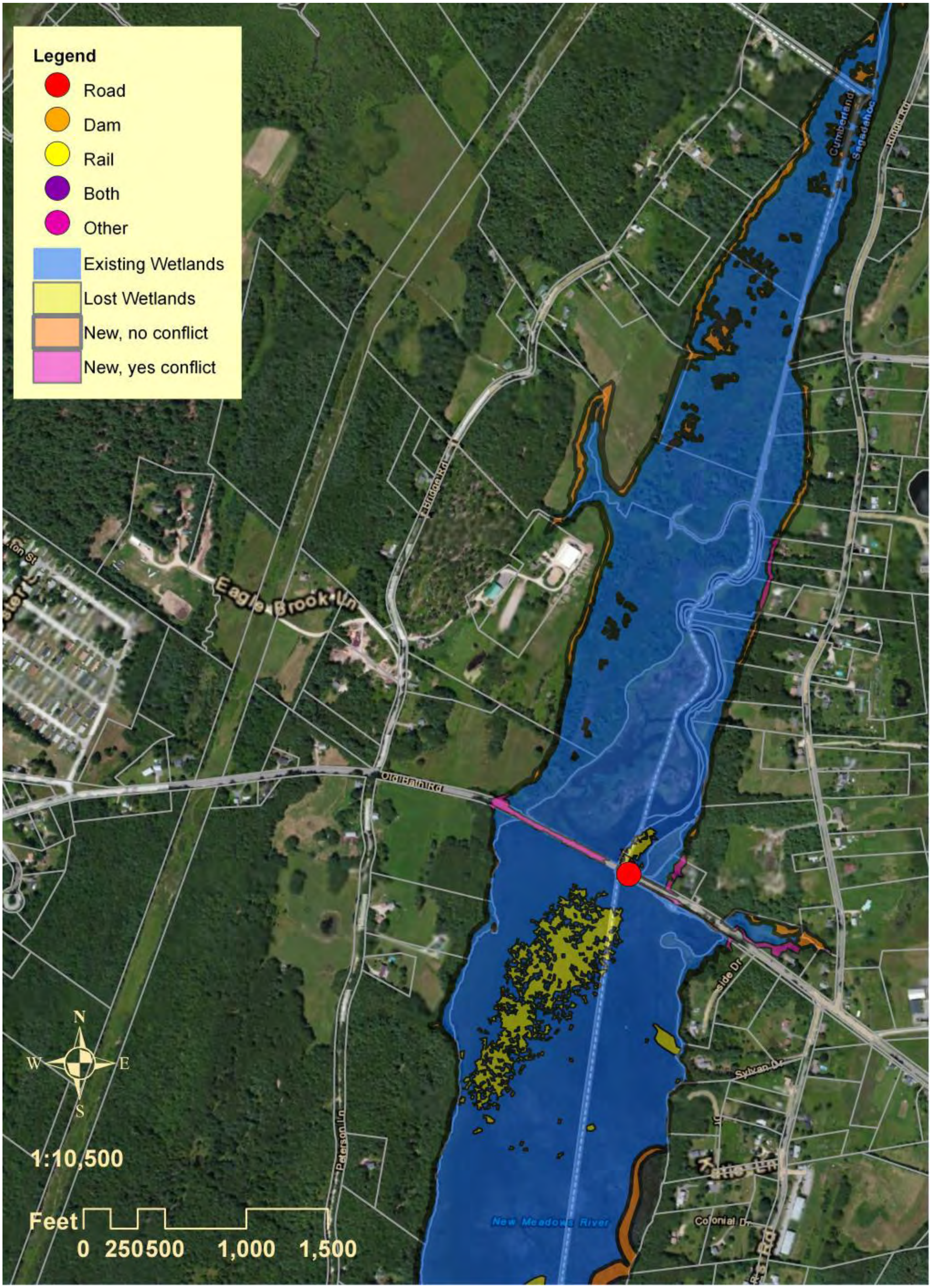


FIGURE 20: Br9 **Upper New Meadows 'Lake' Area: 3 ft. Sea Level Rise**



Suggested Uses of this Information:

The next logical questions after reviewing your town's report might be to ask "how do we use this information?" and "what can we do about the predicted effects of sea level rise on our coastal marshes?" As stand-alone information, your town's maps can provide the basis for starting community discussions on the potential impacts of sea level rise. These maps can be used in conjunction with current planning processes or documents in your town, such as municipal and Shoreland zoning, your comprehensive plan, open space plan, or capital improvement plan, and related ordinances such as your floodplain ordinance, to begin to develop adaptation strategies that would work best in your community in order to preserve and protect what is important to your community and reduce costs resulting from increasing levels and frequency of inundation. The following actions and questions can help your town begin to integrate this information into your community discussions and local decision-making:

- Review the maps to identify those areas where coastal marshes will try to migrate landward;
- Determine if there are obstacles to that happening. If not, who owns those lands? How might they be managed to allow marsh migration to occur in undeveloped areas? Are these areas part of the town's future investment and development strategies? If there is already development in those places, what stands in the way of marsh migration? Roads or other infrastructure? How vulnerable might that infrastructure be?
- If your town has zoning, how are those areas zoned now? Is that appropriate in light of the predicted effects of sea level rise?

The Maine Coastal Program, Maine Geological Survey and the Municipal Planning Assistance Program, all at the Maine Department of Agriculture, Conservation and Forestry, have been working with regional councils, communities and regions along the Maine coast to address these questions and develop local responses. Because the impacts are unique in each community, responses will be as well. To date, municipal responses that might be transferable to your community have included: changes to freeboard required in the flood plain ordinance; strategic conservation actions to ensure that marshes can migrate; adoption of Highest Annual Tide elevation from the LiDAR data into the Shoreland Zoning Ordinance; identification of tidal restrictions; and addition of sea level rise chapters into comprehensive plans. For more information on these or for help developing other adaptation strategies, contact your regional planning organization (Greater Portland Council of Governments or Midcoast Council of Governments) or the Municipal Planning Assistance Program at the Department of Agriculture, Conservation and Forestry.

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Appendix:

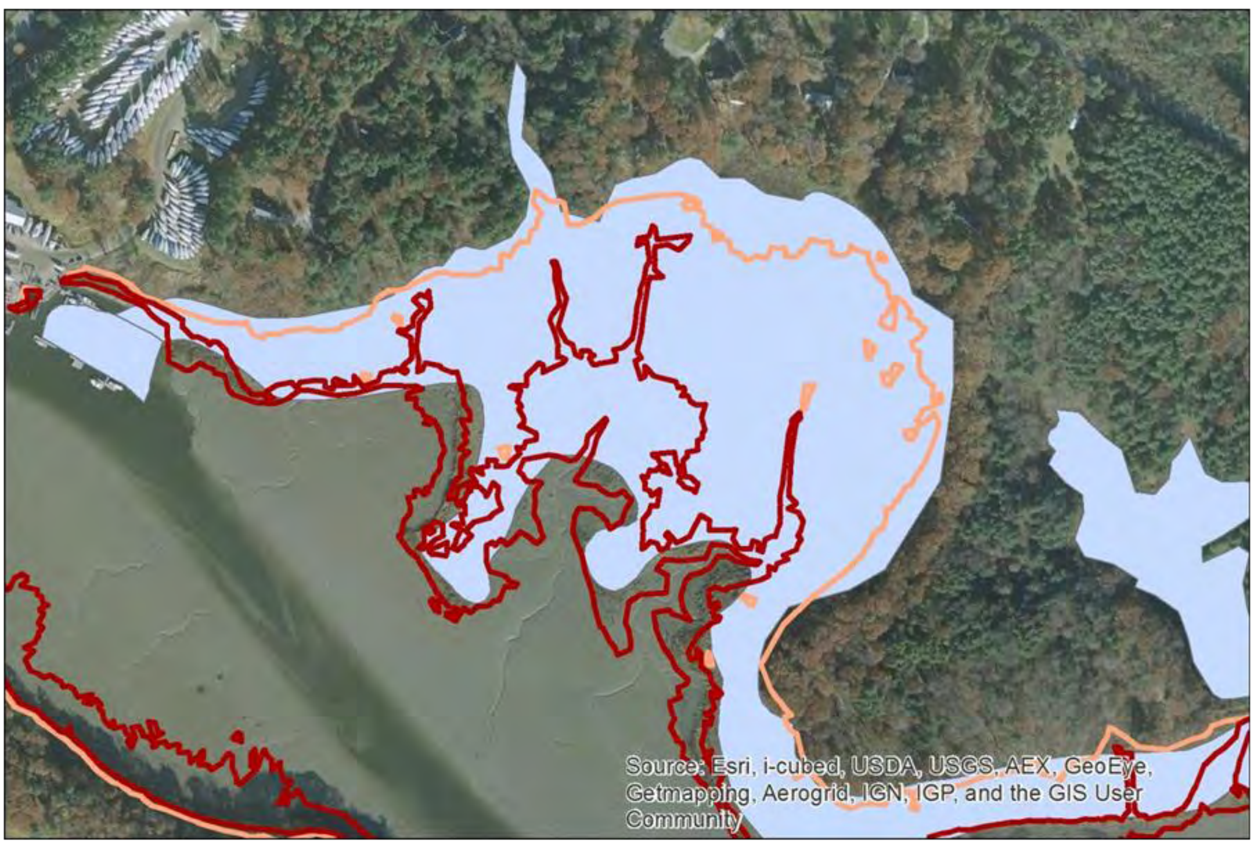
Methods:

The study is based on a detailed analysis of high resolution terrestrial elevations derived from "LIDAR" (Light Detection and Ranging) data. LIDAR is a technology similar to RADAR that uses light waves instead of radio waves to measure distance from a plane to the ground. Raw LIDAR data is post-processed to produce a "Digital Elevation Model" (DEM) that shows estimated ground elevations free of buildings, trees, and other obstructions. The resulting DEM can be highly accurate, with elevations estimated every few feet (horizontally), absolute vertical errors typically less than a foot, and relative vertical errors much smaller than that on a local scale.

Two sources of LIDAR data were used in this analysis: (1) FEMA South Coast LIDAR 2006, (2) LIDAR for the Northeast 2011. Both data sets were acquired as DEM tiles from the University of Southern Maine's Geographic Information Systems Laboratory in the spring of 2011. As received, the two data sets were based on different units of measure (feet vs. meters), so the LIDAR for the Northeast 2011 data set was scaled and resampled using bilinear interpolation before the two data sets were combined to produce a single composite LIDAR DEM for the study area.

LIDAR data was combined with information on tidal heights compiled by NOAA for the Portland tide gauge (station 8418150) in order to identify portions of the shoreline that lie within the upper intertidal zone (between the Mean Tide Level [MTL] and the Highest Annual Tide [HAT]). These elevations are roughly coincident with the lower (MTL) and upper (HAT) limit of tidal wetland development in Maine. Not every location between these elevations will develop tidal wetland. Tidal wetlands only occur where other environmental conditions are also suitable, such as having suitable soils, low slopes, and low to moderate wave exposure. Nevertheless, in areas with existing tidal wetland, the overlap between existing tidal wetland and areas identified solely on the basis of elevation is quite good. Figure 21 shows an overlay of CBEP's elevation polygons (outlined in red and orange as high and low marsh areas) compared to wetlands identified in the National Wetlands Inventory (light blue), for a tidal wetland in Maine. The accuracy is sufficient for the purpose of this study.

FIGURE 21



It is important to note that the maps we have produced are not maps of flood risk, but maps of the projected upper intertidal zone. The areas highlighted in these maps are, in the absence of efforts to protect them from the ocean, expected to be flooded on a regular basis (ranging from daily to annually) due to the action of the tides. Significantly larger areas may be at risk of inundation or flooding due to storms. Because the maps we have produced to date are based solely on elevation, there may be areas in your community which show up as sitting at the proper elevation for tidal wetland development, but that do not now harbor tidal wetlands. Typically such areas are beaches, rocky shores, or the base of steep bluffs, so there is little chance for confusion, but the maps need to be read with this in mind.

To predict where the upper intertidal zone (and thus tidal wetlands) may exist in the future, we developed a pair of maps showing elevations suitable for tidal wetland development, one showing a 1' rise in sea level, and one a 3' rise in sea level. While these scenarios are hypothetical, they are consistent with climate change and sea level rise modeling efforts. A recent analysis of climate change for the Casco Bay region commissioned by CBEP suggests that an increase in sea level on the order of 1' is likely by the middle of this century, while increases of 2' to well over 3' are possible by 2100 (Table 1).

In general, Casco Bay's shoreline is characterized by steep rocky slopes, so we are more fortunate than our southern neighbors in that our coastline may not be as affected by tidal inundation. However, where we have mapped upper intertidal zone areas, we do see places where existing development (as determined by 2007 data on impervious surfaces) may be vulnerable to inundation in the future, or may be in conflict with landward migration of tidal wetlands as sea level increases.

TABLE 1:

Estimates of future stillwater elevations at the Portland tide gauge under lower and higher greenhouse gas emissions scenarios (all estimates in feet relative to NAVD 1988; based on CBEP 2010 report).

Scenario	Lower Emissions		Higher Emissions	
Year	2050	2100	2050	2100
Subsidence	0.024	0.043	0.024	0.043
Dynamic	NE	0.52	NE	0.79
Eustatic	0.66	1.6	1.4	4.6
Total Predicted Stillwater Elevation (ft)	9.5	11.1	10.3	14.3
Net Change in Sea Level	**0.6**	**2.2**	**1.4**	**5.4**