**GEOLOGICAL SURVEY OF CANADA**
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**R.B. Taylor**

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# Impacts of the February 9, 2013 Storm Along the Atlantic Coast of Nova Scotia

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## 2014

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**Front Cover:** The distribution of seaweed illustrates the magnitude of wave overwash across the high gravel barrier at Miseners Long Beach during the storm of February 9, 2013.

# Abstract

Markers established at select coastal locations along Nova Scotia facilitate repetitive observations of physical shoreline changes caused by specific storms and a comparison of the impacts by different types of storms on shoreline stability. Following the storm of February 9, 2013, field observations of physical impacts were completed at five beaches along the Eastern Shore of Nova Scotia and information on storm impacts was gathered from local contacts at other locations farther along the Atlantic coast. Wave and tidal observations during the storm were provided from a wave gauge operated offshore of Halifax Harbour and from tide recorders operated by the Canadian Hydrographic Service, in Halifax Harbour, Yarmouth and North Sydney.

Field observations were restricted to the use of ground photography, a hand-held GPS recorder and tape measurements from beach line markers. Detailed cross-shore surveys following the storm were not completed. Flood and wave-run-up elevations onshore (CGVD28-Geodetic Datum) are based on the most recent survey completed at each site before the storm.

The storm on February 9, 2013 caused elevated water levels of 1.93 m (GD) just after high tide at Halifax but occurred closer to low tide in Yarmouth and North Sydney. The highest still water flood level observed was 1.1 m (GD) along the backshore lagoon at Conrads Beach. Wave run-up reached elevations commonly of 3.5 m and as high as 3.8 m (GD) along higher pebble-cobble beaches. Waves scoured the base of the highest pebble–cobble beaches and only overtopped lower barrier beaches and built the beach crest higher. Along sand beaches, waves scoured the upper beach and lower foredune. The duration and intensity of waves generated during the storm was not sufficient to force waves long distances across coastal dunes nor to cause significant damage to coastal infrastructure such as beach access stairs. Farther away from Halifax, local observers along the Atlantic coast of Nova Scotia reported reduced impacts from the February 9 storm because of the presence of snow, freezing rain, shorefast ice and a more favourable wind direction.

# Introduction

Environment Canada Issued a Blizzard warning for Halifax Metro and Halifax County West at 12:46 PM AST Saturday 09 February 2013.
*"A low pressure system will intensify as it slowly passes south of Nova Scotia today and tonight. This system will give heavy snow, very strong northeast winds gusting between 80 to 100 km/h and blowing snow to Nova Scotia. These blizzard conditions will persist today and tonight and into Sunday for Cape Breton and Eastern Nova Scotia.*

*Total snowfall amounts of 30 to 40 centimetres are expected throughout the province by dawn Sunday. The snow will become mixed with ice pellets along the eastern shore this afternoon.*

*Strong winds associated with this system are producing pounding surf along the Atlantic coast of Nova Scotia. High tide however has now passed as of 11AM and water levels are falling. Strong north easterlies over the Gulf of St Lawrence will give higher than normal water levels along Northumberland Strait later today into Sunday. Northumberland Strait is mainly ice covered and these strong winds will push pack ice into north to northeast facing shorelines. There is a risk of some coastal flooding due to the elevated water levels especially around high tide this evening."*

The following are descriptions of the storm and its impact taken from the Halifax Chronicle Herald newspaper published on February 10 and 11, 2013. A northeaster struck the Northeastern United States dumping up to 90 cm of snow and high winds. More than 650,000 homes and businesses were left without electricity and airlines cancelled more than 5300 flights as airports closed. At least eight deaths were blamed on the storm including three in Canada (Associated Press, 10 Feb. 2013).

In Nova Scotia as of late Saturday evening up to 50 cm of snow had fallen wind gusts exceeded 150 km/hr and elevated sea levels were recorded at Yarmouth and Halifax. The highest unofficial wind speeds were 164 km/hr at Woods Harbour and 133 km/hr at West Pubnico in SW Nova Scotia. Damage to trees, buildings and other infrastructure were reported at a variety of locations. The winds are well into Category 2 and almost Category 3 hurricane force winds. More than 20,000 customers were without electricity at one point on Saturday. Most areas received 20 to 30 cm of snow, Greenwood reported 50 cm and the highest unofficial snowfall was 66 cm at an automated station in Debert. Flooding from elevated water levels was reported in Shelburne, Lockeport and Liverpool Rocks and debris were tossed by waves onto several coastal roads in SW Nova Scotia (Chronicle Herald, 11 Feb. 2013).

The intent of this report is to document the physical impacts of the storm of February 9, 2013 on a variety of beach types along Atlantic Nova Scotia with a focus on sites along the Eastern Shore (Fig. 1). This is one in a series of reports (see references) that have documented storm impacts at the same coastal monitoring sites along Nova Scotia since the early 1990s.

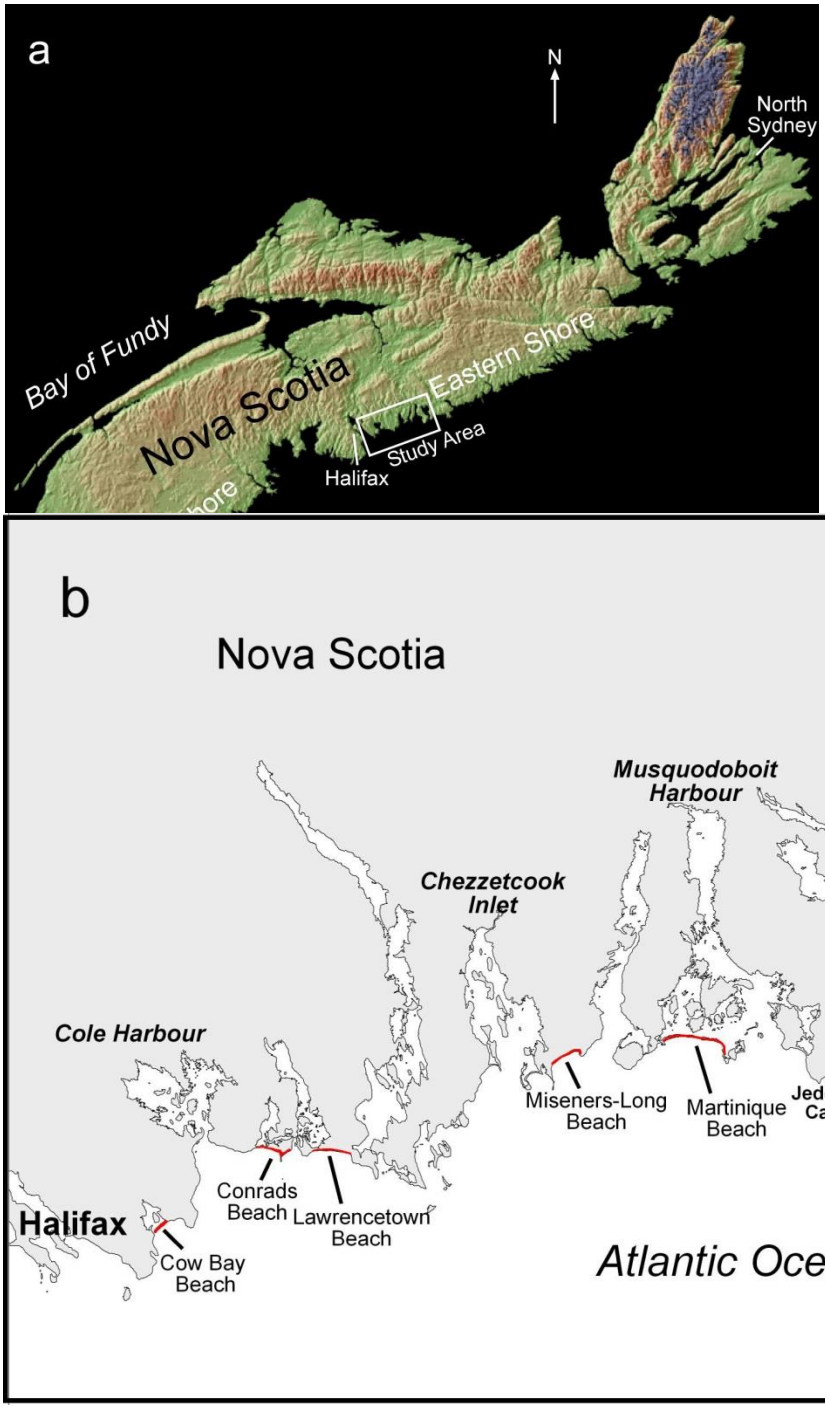



Figure 1. (a) Location map of Nova Scotia and (b) Eastern Shore where field observations were completed at five sites (marked in red) to assess the impacts of the February 9, 2013 storm.

## Climatic and Oceanographic Processes

Wave data was recorded at wave gauge 44258 situated in 58 m of water south of Halifax Harbour (Fisheries and Oceans Canada http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/waves-vagues/index-eng.htm) and water levels were recorded at Canadian Hydrographic Service tide gauges located at the Bedford institute of Oceanography (BIO), Dartmouth, North Sydney and Yarmouth, Nova Scotia.

A significant wave height of 7.4 m and 11 second period was recorded at 08:20 hrs (AST) when winds at the gauge were ENE at 39 km/hr. The lowest atmospheric pressure was 99.5 KPa around 16:00 (AST) February 9. Significant wave heights exceeded 1.5 m for 44 hours from late on February 8th to late on February 10th (Table 1).

It should be noted that elevations of marine water levels (tides) are measured relative to Chart Datum (CD) (CHS, 1999) whereas traditional land survey elevations are relative to Geodetic Datum (GD- CGVD28 –see footnote p. 5). The difference in elevation between Chart and Geodetic Datum varies depending on location in Canada. In the Halifax area the difference in elevation is 0.8 m. For example, if water level is 2.8 m CD, it is equivalent to 2.0 m GD-CGVD28.

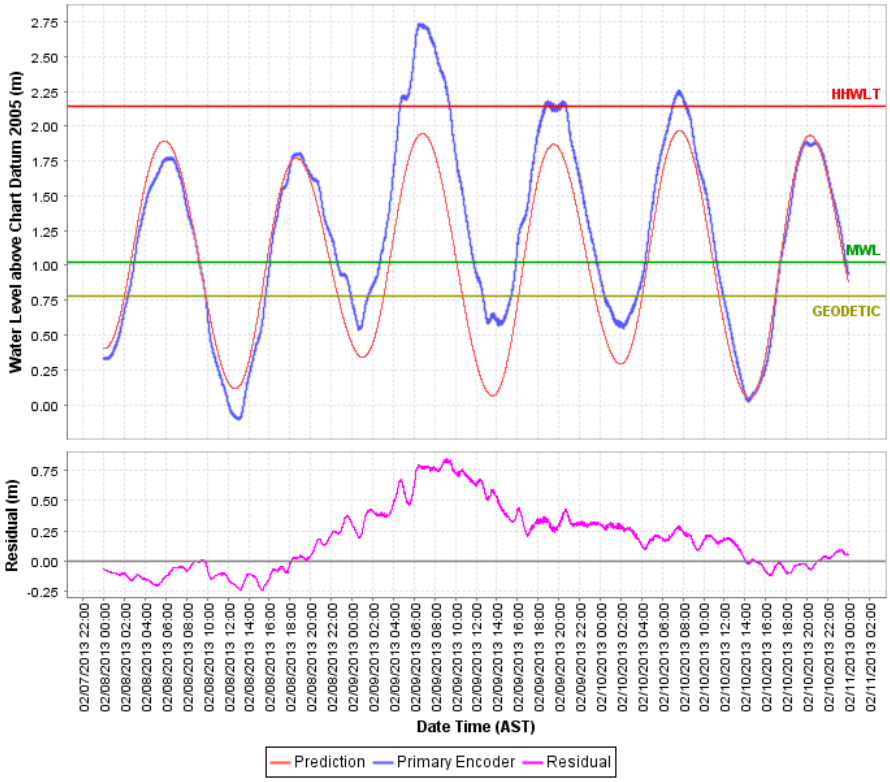
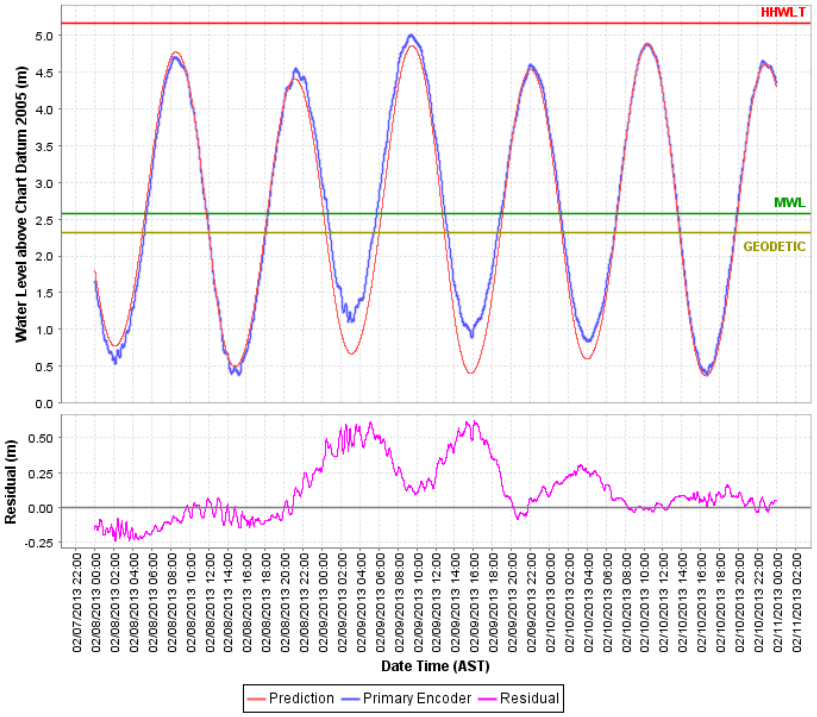



Figure 2. The tide gauge record from BIO, Dartmouth on February 8-10, 2013 shows a storm surge of 0.79 m at high tide on the 9th of February producing a maximum total water level of 2.73 m (CD) at 06:30 (AST). The storm surge peaked at 0.84 m a few hours after high tide and elevated water levels (> 0.6m) lasted just over seven hours on the morning of February 9th. (Chart courtesy of Canadian Hydrographic Service).

Figure 3. At Yarmouth, Nova Scotia although there was a slightly elevated water level at high tide, the total water level only reached 5.01 m (CD). The highest storm surge of 0.6 m coincided with both low tides on February 9, 2013. (Chart courtesy of Canadian Hydrographic Service).



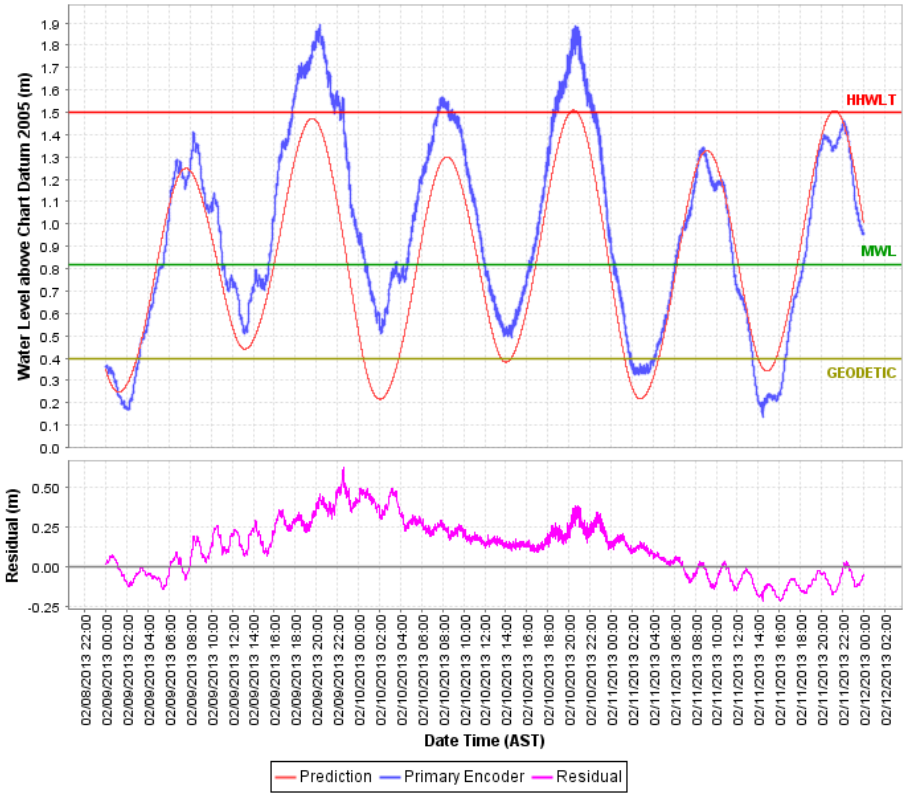




Figure 4. At North Sydney elevated water levels were less than 0.6 m with the maximum level 0.57 m near low tide at 22:35 (AST) on February 9. The highest elevated water coincided with the late evening tides of February 9 and 10, 2013 producing a similar total water level of 1.89 m (CD). (Chart courtesy of Canadian Hydrographic Service).

A comparison of tidal and wave conditions during the February 2013 storm with a number of other well-known storms that have struck Atlantic Nova Scotia since 2003 is provided in Table 1. Peak water levels on February 9 were 0.18 m lower than the record levels of 2.91 m (CD) during Hurricane Juan. Storm surge duration was relatively short at 6.8 hours compared with hurricane Juan when surge conditions lasted 28 hours. Maximum significant wave heights and period were similar to those generated by other northeasters and smaller than those generated by some hurricanes. The duration of significant wave heights over 1.5 m was only 44 hours.

**[1] Canadian Geodetic Vertical Datum of 1928 (CGVD28)**

The Canadian Geodetic Vertical Datum of 1928 (CGVD28) is the former vertical datum for Canada. It was adopted by an Order in Council in 1935. CGVD28 is a tidal datum defined by the mean water level at five tide gauges: Yarmouth and Halifax on the Atlantic Ocean, Pointe-au-Père on the St-Lawrence River, and Vancouver and Prince-Rupert on the Pacific Ocean. In addition, the definition includes an elevation at a benchmark in Rouses Point, NY (next to Lake Champlain) accepted as fixed by the United States and Canada in 1925. The datum is propagated in land using geodetic levelling measurements. The vertical datum is accessible through some 94,000 benchmarks anchored to the ground and stable structures.
http://www.nrcan.gc.ca/earth-sciences/geomatics/geodetic-reference-systems/9054

**[1] Chart Datum** is by international agreement , a plane below which the tide will seldom fall.The Canadian Hydrographic Service has adopted the plane of Lowest Normal tides (LNT) as chart datum. (CHS, 1999).

Table 1. A comparison of oceanographic conditions for select storms that struck the Atlantic Coast of Nova Scotia in the last decade. Wave data was recorded at gauge 44258 situated in 58 m of water south of Halifax Harbour (Fisheries and Oceans Canada) and water levels were recorded at Canadian Hydrographic Service tide gauges located in Halifax Harbor (Dock Yard and BIO), Nova Scotia.

| **Storm Event** | **Date** | **Tidal Conditions** | | **Wave Conditions #** | | | |
|---|---|---|---|---|---|---|---|
| | | Surge Duration (hrs)* | Peak Water Level Elevations CD (m) (Time (Z) / Date) | Max. Sig. Wave Ht (m) (Time (Z) / Date) | Max. Wave Ht. (m) (Time (Z )/ Date) | Duration (Hrs) Sig. wave Ht Exceeds 1.5 m | Wave Peak period (sec) |
| **2003** Hurricane Juan | 27-30-Sept-03 | 28 | 2.91 (03:45 29th) | 8.5 (04:20 29th) | 19.9 (04:20 29th) | 69 | 13.5 |
| **2009** Hurricane Bill | 23-Aug-09 | 0 | 1.98 (07:00 23rd) | 9 | 18.3 | 40 | 14.9 |
| **2010** Northeaster | 2-Jan-10 | 9.5 | 2.81 (01:30) | 7.4 (01:20 -3rd) | 14.4 | 101 | 12.8 |
| Hurricane Earl | 4-Sep-10 | 3.25 | 1.83 (BIO) (14:45 4th) | 10.1 (18:20 4th) | 23.3 (18:20 4th) | 60 ( 3-6 Sept) | 17.1 |
| Northeaster | 6-Dec-10 | 7.5 | 2.86 (BIO) (07:00 6th) | 7.9 (13:20 6th) | 16.6 (11:20 6th) | 197 (2-9 Dec) | 11.6 (11:20 6th) |
| **2013** **Northeaster** | **9-Feb-13** | **6.8** | **2.73 (BIO)** (10:30 9th) | **7.4** (12:20 9th) | **20.3** (11:20 9$^{th}$) | **44** (8-10 Feb) | **11** |

# Field Observations of Wave Run-up and Coastal Flooding

Shoreline elevations that waves run-up or flood waters inundate an area are important parameters to measure particularly for issuing future flood warnings and for ground truthing wave modelling exercises. Since it is very difficult and unsafe to measure these parameters during a storm, they were recorded after the storm using indirect evidence, e.g. flotsam lines. In the case of the February 2013 storm, detailed beach surveys could not be completed, hence the elevations (CGVD28) provided are estimates based on the last detailed cross-shore and crest surveys at each site completed in November 2011. Other storms in October 27, 2012 and December 19, 2012 struck the coast since our last field observations however the elevations reported here are attributed to the February 9, 2013 storm.

**Wave run-up elevations** (edge of snow and flotsam debris)

| | |
|---|---|
| Cow Bay Beach | > 3.1 m |
| Conrads Beach | 2.9 to 3.0 m |
| Lawrencetown Beach | 3.4 to 3.8 m |
| Miseners long Beach | waves overtopped beach crests of 3.6 to 3.8 m |
| | waves overwashed beach crests of 3.2 m (front cover) |
| Martinique Beach | 3.4 to 3.8 m |
| Hirtles Beach – South Shore | ~ 3.0 to 3.2 m |
| Lockeport Beach- South Shore | ~3.0 to 3.5 m |

**Still water flood level** (backshore edge of snow and flattened marsh grass)

| | |
|---|---|
| Conrads Beach Lagoon | 1.1 m |

Cow Bay Beach -ice cakes from lake rafted to 1.7 m elevation along backshore

Figure 5. Conrads Beach: View from parking lot looking seaward. The saltmarsh vegetation not covered by snow (dash lines) outlines the area of backshore flooding during the storm of February 9, 2013. Estimated flood level reached 1.1 m (GD).

# Observations at Select Beaches along the Eastern Shore

## Cow Bay Beach

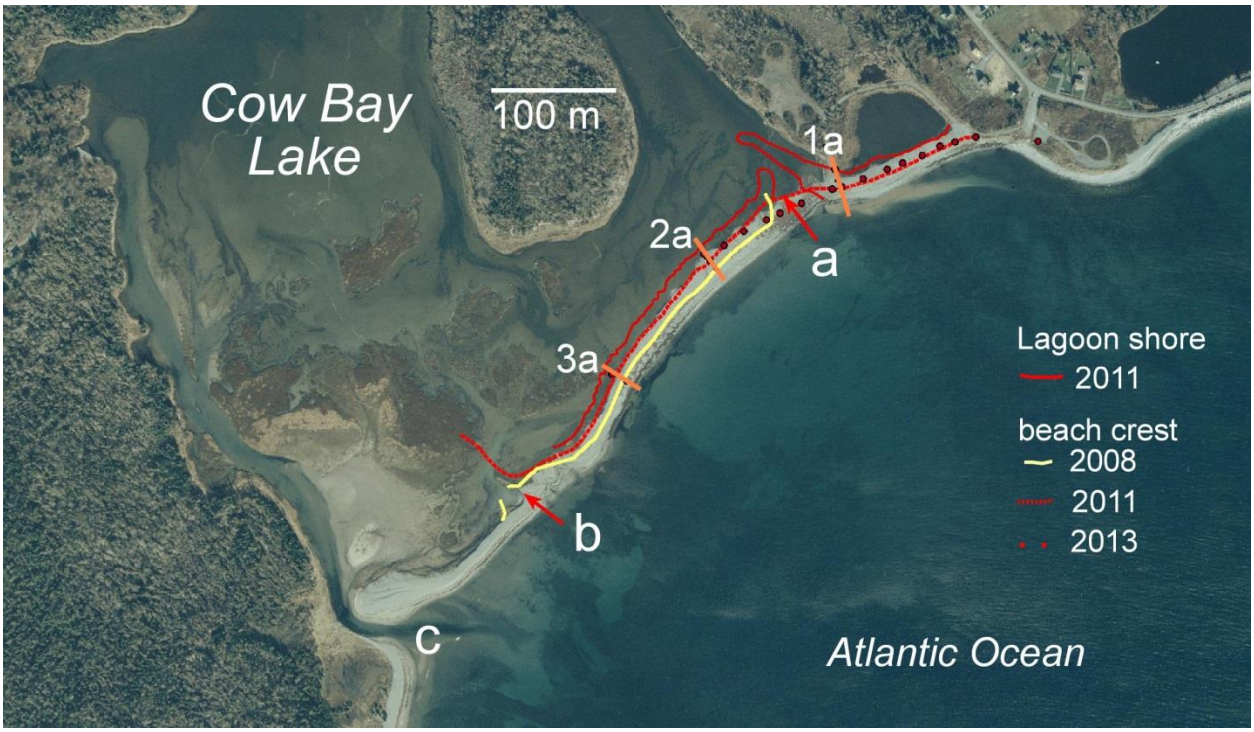



Figure 6. Cow Bay Beach: Map of cross-shore survey lines (1a, 2a, and 3a) and the position of the lagoon shoreline and beach crest in 2011 and 2013. The former washover channels and tidal inlets at "a" and "c" were closed off in 2013 and the only active inlet was at "b". The 2013 crest survey using a hand held GPS which was less accurate than previous surveys but it shows the rebuilding of the beach crest at inlet “a”. The air photo was taken in 2003 (photo Courtesy of Natural Resources Nova Scotia).

Figure 7. Cow Bay Beach: Armour rock at the eastern headland protects the immediate backshore but it accelerated adjoining bank erosion and interfered with the natural building of a pebble-cobble storm ridge similar to the one observed on both sides of the armour rock. The storm ridge was built as the February 9, 2013 storm waned.

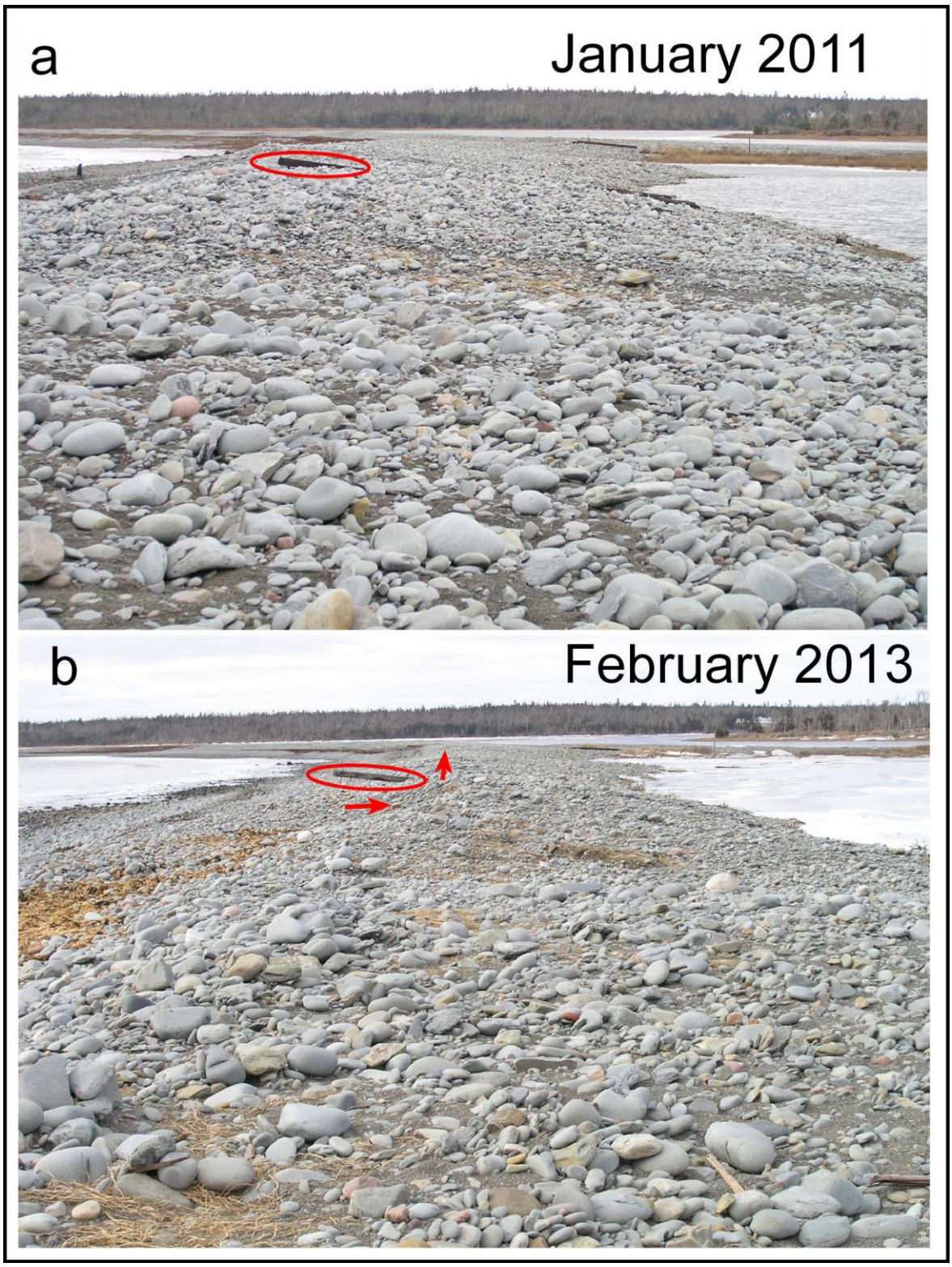



Figure 8. Cow Bay Beach: Views from the east end of beach in (a) January 2011 and (b) 23 February 2013. The upper beach was cut back as shown by the increased exposure of a large wooden beam (circled). Some sediment was added to the beach crest by wave overtopping and other sediment may have been transported westward to build or augment a new storm ridge built across tidal channel “a” (Fig.6) cut in 2003.

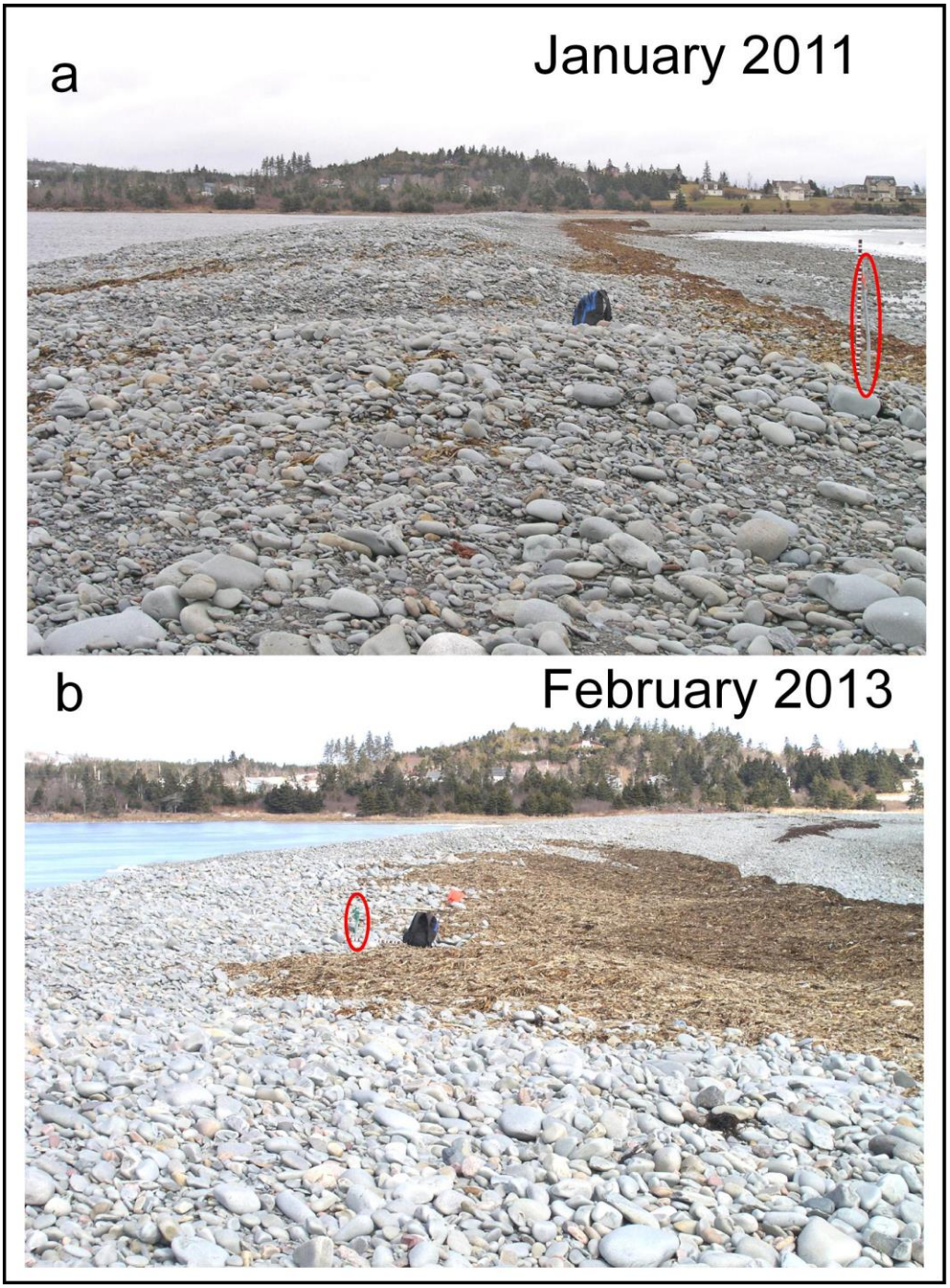



Figure 9. Cow Bay Beach: Looking east along the beach crest at Line 3a in (a) January 2011 and (b) 23 February 2013. Using the line marker (circled) as reference, the beach was built up by 0.4 m and had migrated farther seaward since November 2011. Most change is attributed to the storm on February 9, 2013. Kelp and sea ice cakes were deposited landward to the marker at an estimated elevation of 2.7 m (GD).

## Conrads Beach


Figure 10. Conrads Beach: Location of beach survey lines and parking area where flood lines were observed. Impacts from the February 9, 2013 storm were examined only between survey lines 2 and 4. The air photo was from 2003 (Photo courtesy of Natural Resources Nova Scotia).

Figure 11. Conrads Beach:
During the storm on February 9, 2013, waves and backwash running off the dune carved small craters (circled) into the frozen foredune. By February 14 the lower foredune slope was no longer frozen but the craters had not collapsed.


Figure 12. Conrads Beach: Views of the coastal foredune at Line 2 on (a) 12 November 2012 and (b) 13 February 2013. Waves travelled upslope to an estimated 3 m elevation (nearly to the foredune crest) trimming off the lower dune slope and cutting a low scarp at the beach – dune interface. Sand from the upper beach was scoured and transported seaward exposing a pebble cobble substrate (Fig. 12b- red arrows) which had been buried for several years at and just east of line 2. Graduated pole (circled) for scale is 1.5 m long.

## Lawrencetown Beach

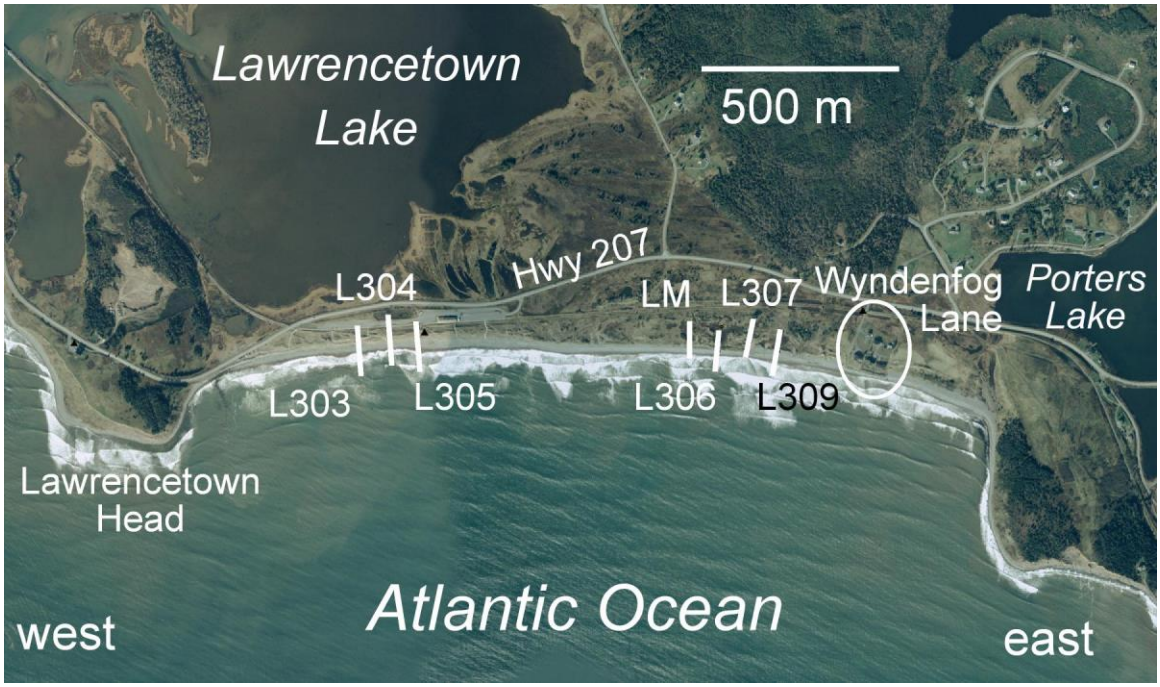



Figure 13. Lawrencetown Beach: Location of beach survey lines (303 to 309) where the impacts from the February 2013 storm were documented. Wyndenfog Lane (white circle) is a residential area outside the provincial park. The air photo was taken in 2003 (photo courtesy of Natural Resources Nova Scotia).

Figure 14. Lawrencetown Beach-east end: Waves scoured and overtopped the present foredune to elevations of 3.6 to 3.8 m (GD). Where the exposed foredune was higher, as shown in this photo, waves scoured the base of the dune, causing large chunks of frozen dune to break off. The graduated rod for scale is 1.5 m long.

Figure 15. Lawrencetown Beach - East End: Photos taken in (a) late December 2010 and (b) February 2013 showing the seaward edge of the foredune at line M. The T-bar shown in (Fig15a-red arrow) at the edge of the dune was eroded by late 2011. The dune retreated a further 0.5 m since late 2011. Much of the erosion is attributed to the February 9 storm when waves overtopped at least 5 m landward across the foredune. The same cobble is circled for visual reference and the graduated pole is 1.5 m long.

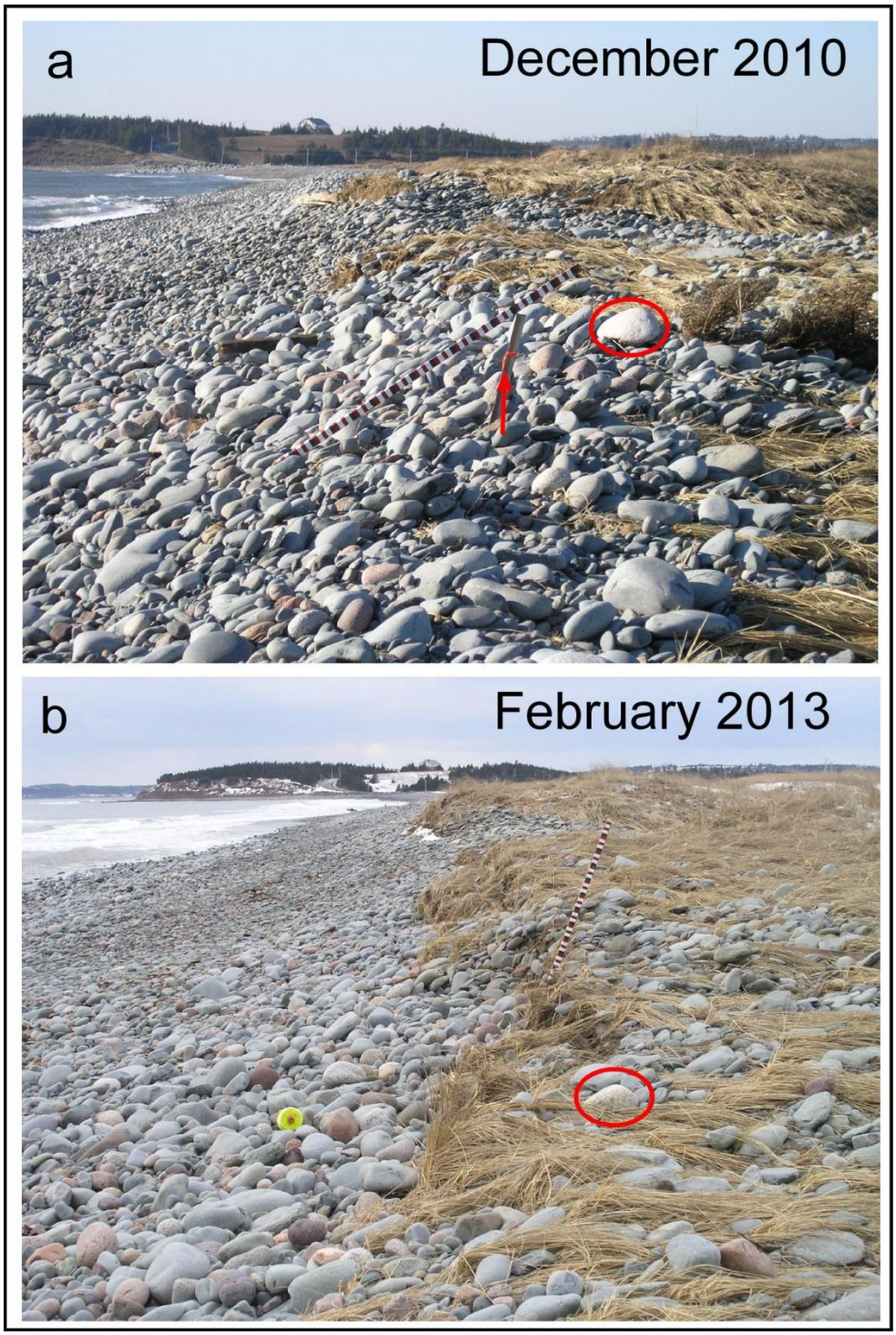
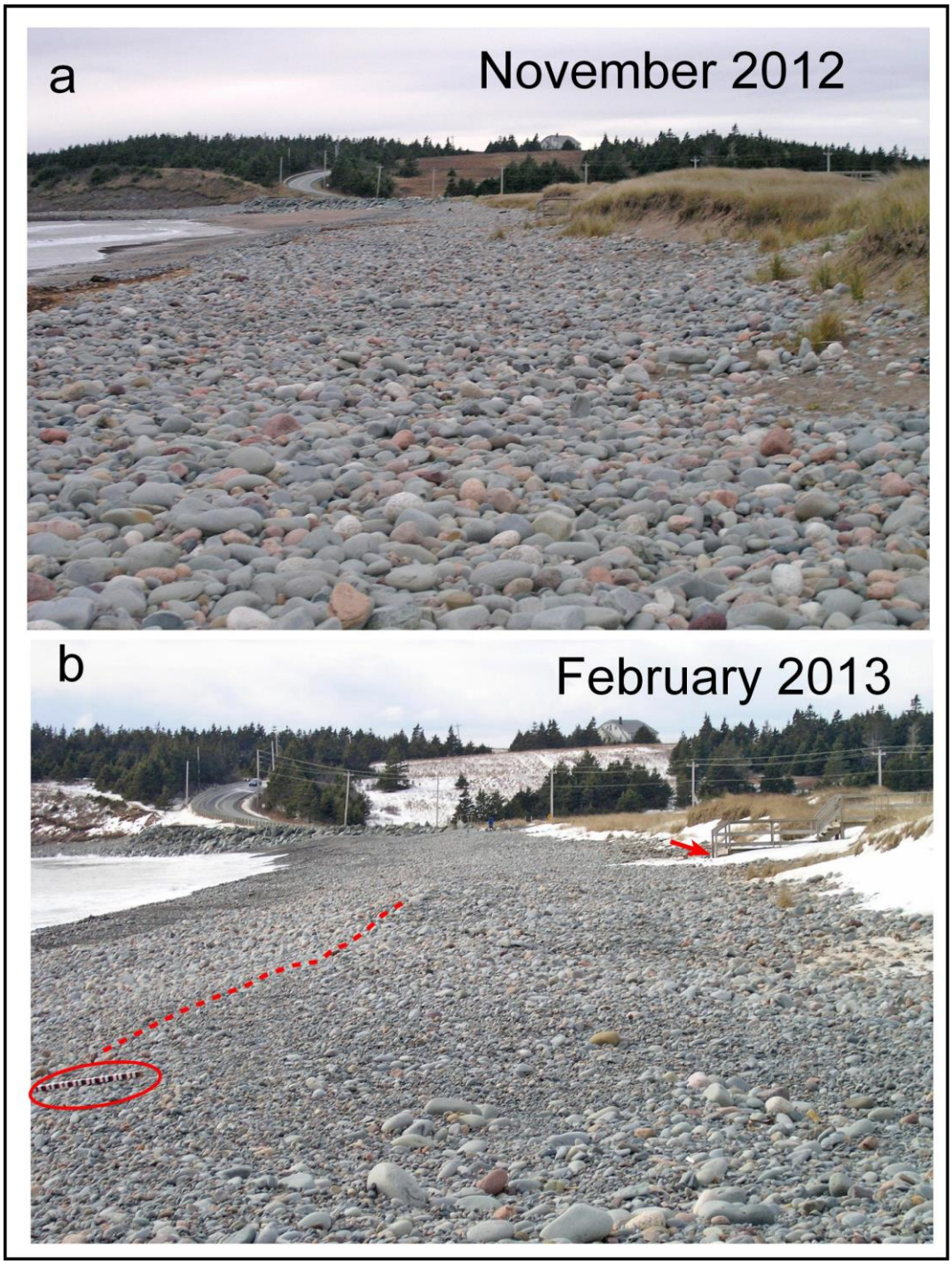


Figure 16. Lawrencetown Beach -West End: Views of the upper beach near Line 304 on (a) 12 November 2012 and (b) 14 February 2013. During the storm on February 9 waves reworked the beach landward to the edge of the storm ridge (Fig16b- red dash line) where kelp fronds were deposited. Wave run-up and splash reached the base of the foredune in several places and base of the access steps (Fig16b- red arrow) but there was no evidence of dune scouring. The storm was a beach ridge building event. Waves transported and deposited finer pebble upslope across the top of the storm ridge (Fig16b). Pole (circled) is graduated at 2 cm intervals) for scale.



## Miseners Long Beach

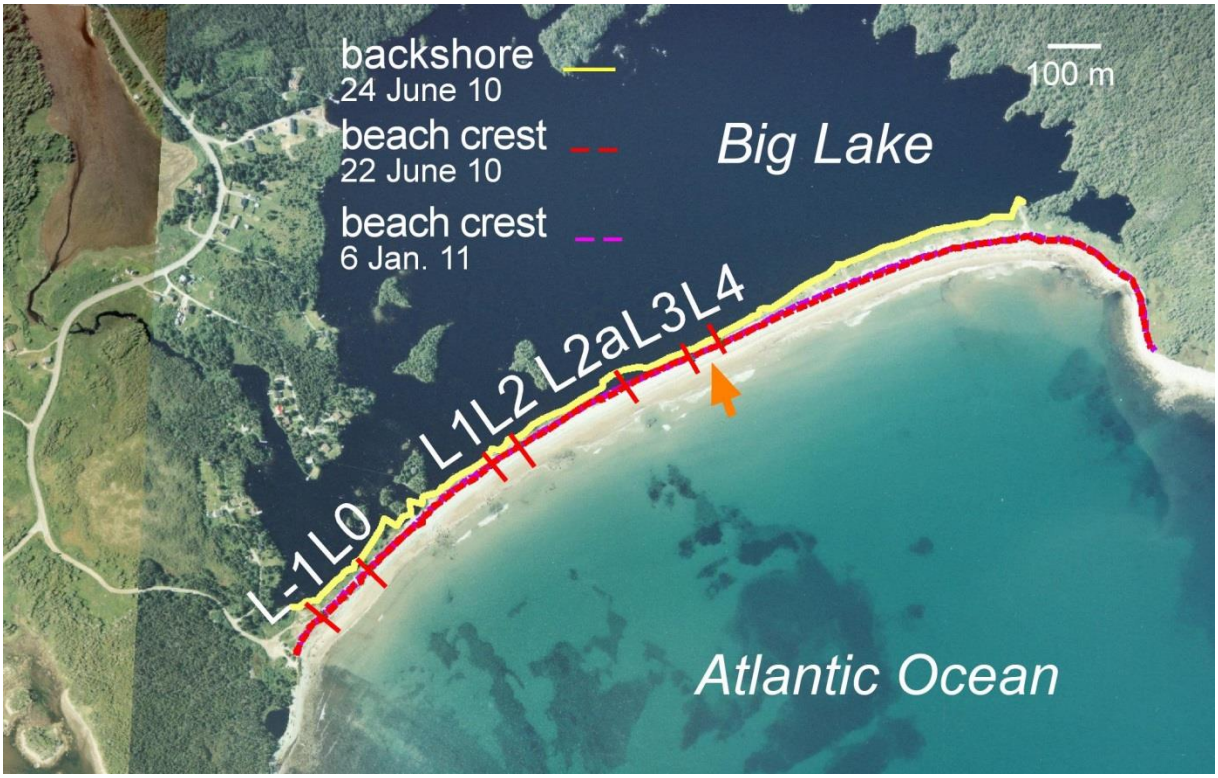
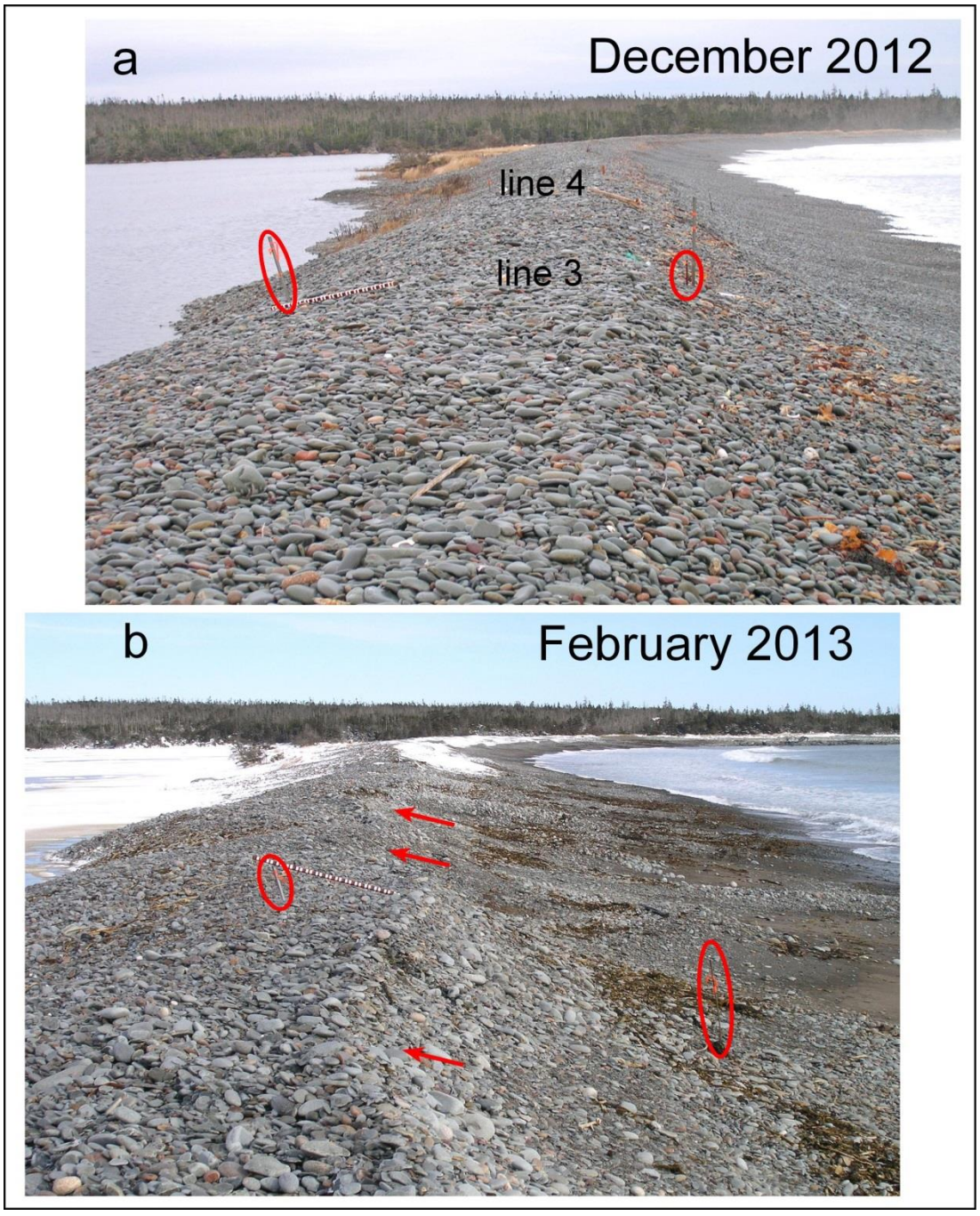



Figure17. Miseners Long Beach: Location of beach survey lines (L-1 to L4) where field observations were made after the February 2013 storm. The beach was eroded and nearly breached between Lines 3 and 4 (orange arrow). Changes in the position of the beach crest between June 2010 and January 2011 is hard to differentiate at this scale whereas washover lobes built into the lake since 2003 (year of the air photo) are easier see (Base photo, Courtesy of Natural Resources Nova Scotia).


Figure 18. Miseners Long Beach: The cover of seaweed and presence of melt holes (arrows) in the lake ice provide evidence of the extent of wave overwash just west of Line 2 (line markers circled). Beach crest elevation before the storm ranged from 3.7 to 3.9 m (GD).

Figure 19. Miseners Long Beach: Waves overtopped and overwashed most of the high gravel barrier beach to 3.8 m elevation (GD). At most survey lines the beach crest was built higher during the February 2013 storm event however at Line 3 shown here in (a) December 2012 and (b) February 2013 the beach crest was cut back (marked by red arrows) by 1.3 m since November 2011 and possibly as much as 2.6 m landward farther east at Line 4. The beach crest was nearly breached between lines 3 and 4 but similar scouring has occurred in the past and the beach has recovered. Where Miseners Long Beach was breached and artificially repaired in January 2010 the beach crest was built seaward by 0.7 m during the February 2013 storm. The same markers at line 3 are circled on both photos for a visual reference of the changes.



## Martinique Beach

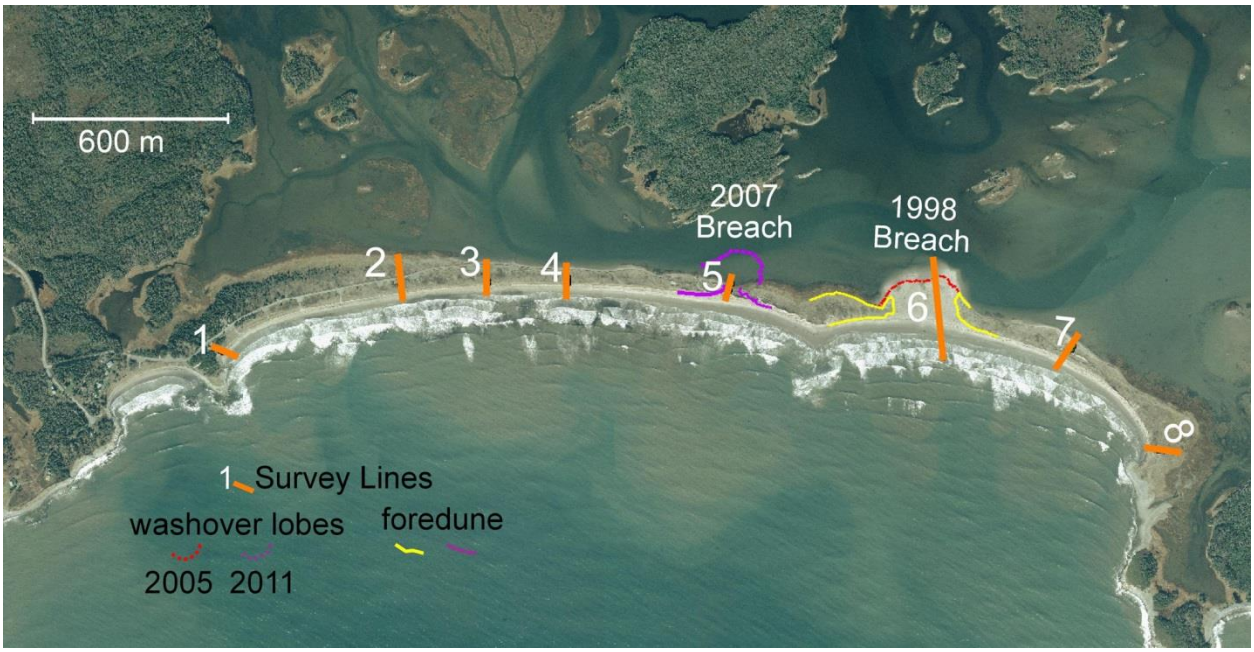



Figure 20. Martinique Beach: Location of cross-shore survey lines (1 to 8) and the two breaches cut through the foredune in 1998 and 2007. Sediment transported through the breaches forms a wide washover lobe which provides a foundation for dune rebuilding. A new foredune had built across the 1998 breach by 2005 but water still flowed through the 2007 breach during elevated water levels on February 9, 2013.

Figure 21. Martinique Beach: Waves scoured sediment from the upper beach and base of the foredune during the February 9, 2013 storm. Beach access stairs became more exposed and sheets of frozen sand across the dune face (red arrows) collapsed and slid downslope after the storm.

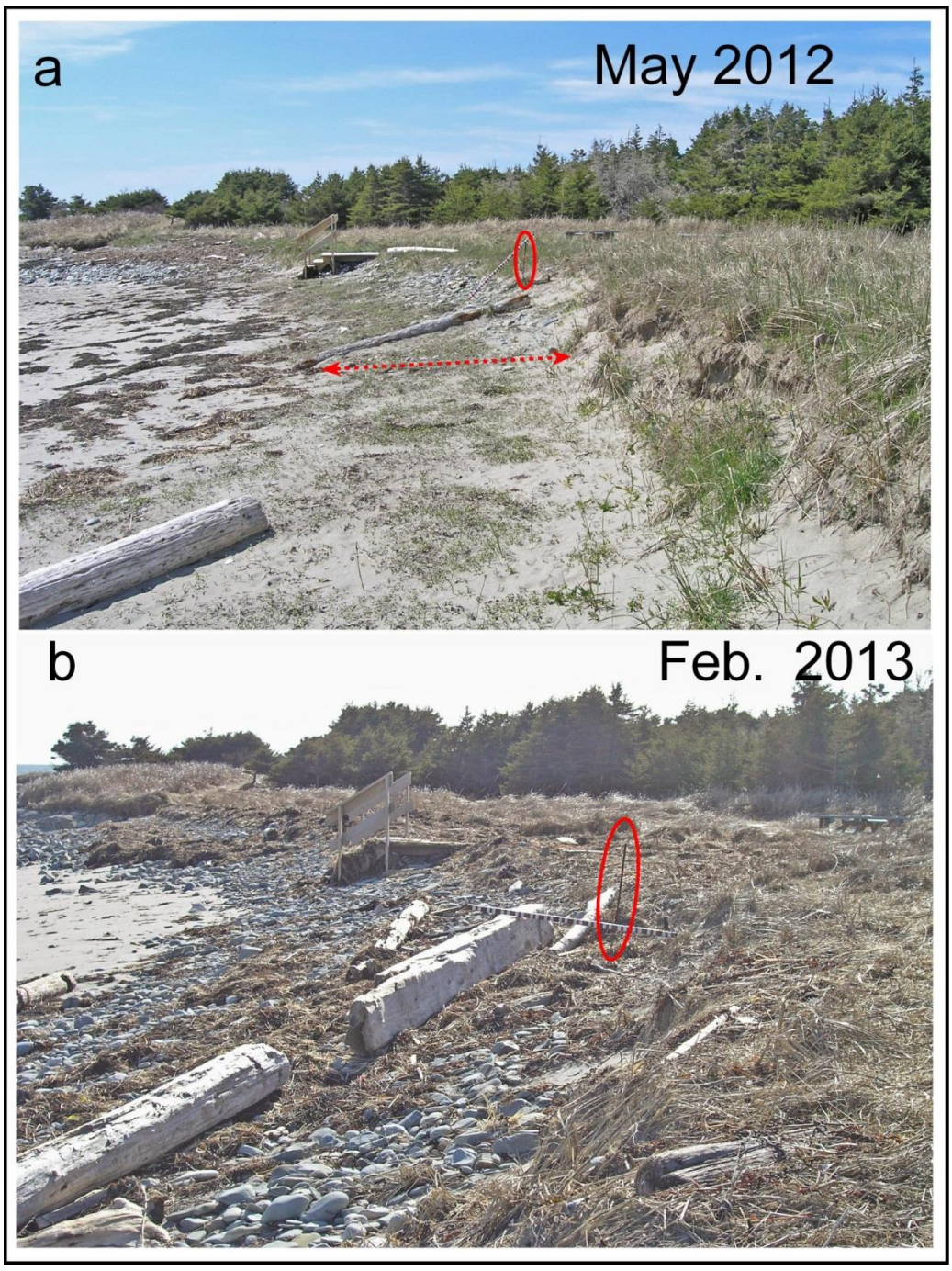



Figure 22. Martinique Beach: During the storm of February 9, 2013 debris was washed 5 m inland of the marker (circled) at line 1 but there was little backshore erosion or damage to stairs. Previous dune building across the upper beach in 2012 (Fig 22a- marked by red dashed line) was scoured and sand was transported seaward exposing the cobble substrate.


Figure 23. Martinique Beach: Repetitive photos taken at line 3 on (a) May 2012 and (b) February 2013 illustrate the loss (marked by red line) of a wide sand ramp which had heralded dune stability and growth in 2012. Waves during the February 9, 2013 storm scoured the upper beach and trimmed the foredune but were insufficient to damage beach access stairs. The wooden graduated pole marks the location of line 3 and provides a scale -it is graduated in 2 cm intervals.

## Beach Observations at Lockport, South Shore, Nova Scotia

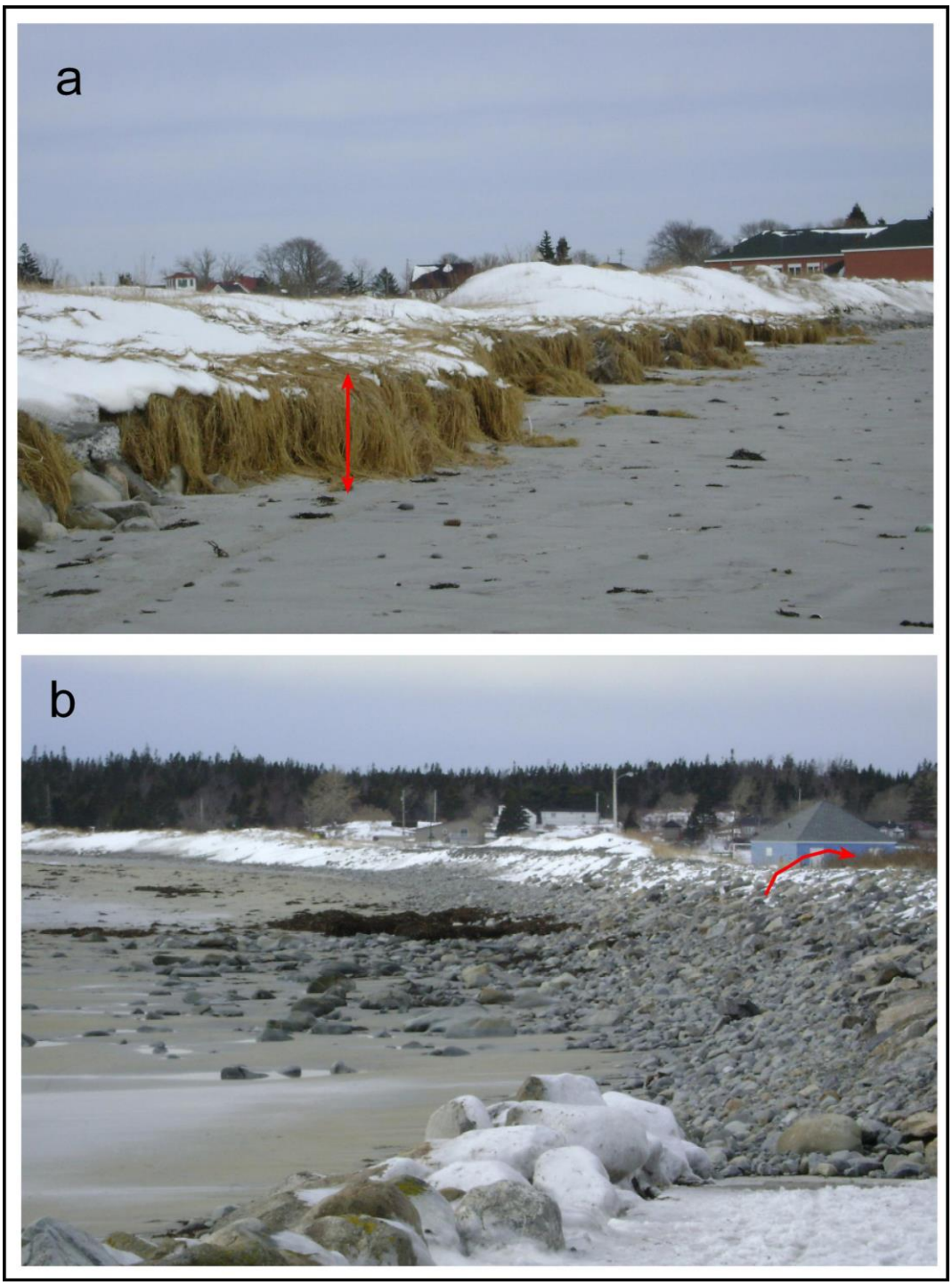



Figure 24. Lockeport: Views of (a) the central natural and (b) eastern armoured, sections of Crescent Beach, 11 February 2013. (a) The natural sand dunes were cut back by 1 to 1.5 m leaving an estimated 1 m high scarp (red arrow). Waves did not overtop the dunes as shown by the presence of snow. (b) Waves removed sand from the upper beach and overtopped the armoured shore (red arrow) even though the beach ridge had been raised 0.5 m higher by machinery in 2010. (Photos courtesy of B. Atwood, Lockeport, NS).

## Summary

During 2012 coastal foredunes along the Eastern Shore of Nova Scotia had experienced considerable sand accumulation and seaward extension as a sand ramp. The storm on February 9, 2013 caused elevated water levels which allowed waves to extend inland to the base of coastal foredunes. Wave run-up commonly reached elevations of 3.5 m and as high as 3.8 m (GD) along some steeper pebble-cobble beaches. Waves eroded the foredune base and scoured the upper part of sand beaches. Waves scoured the base of higher gravel ridges and overtopped and built the crest higher along other parts of gravel barrier beaches. The duration and intensity of waves generated during the storm was not sufficient to force waves long distances across the coastal dunes nor to cause significant damage to coastal infrastructure such as beach access stairs. The frozen state of the beach sediment resulted in more collapsing of larger (1- 1.5 m wide) blocks of vegetated dune that were undercut by waves. At a few locations higher water levels had broken up lagoon ice cover and mobile ice cakes were transported upslope across the backshore. At Cow Bay Beach ice cakes were buried in seaweed accumulations near the beach crest as the storm waned. The storm of February 9, 2013 can be summarized as a dune trimming and mid to upper beach scouring event with minor crest building where gravel beaches were > 3.5 m elevation. Lower barrier beaches experienced more wave overwash and localized scouring of wave washover channels. Coastal flooding was reported in some communities along the South Shore of Nova Scotia but flooding and damage was not as severe as during previous large storms. Initial observations along other shores, for example at Louisbourg, suggest that the presence of snow, freezing rain, shorefast ice and a more favourable wind direction reduced the impacts of the February 9 storm (R. Duggan, Parks Canada, Louisbourg).

## Acknowledgements

The author wishes to thank the coastal residents who provided invaluable photos and observations of changes along their shores following the February 9 2013 storm. Although not all information provided was used in this report it did provide a better overall understanding of the impacts of this storm. The author also acknowledges the support from Phil MacAuley (Tidal Section, Canadian Hydrographic Service, Dartmouth) and to Fisheries and Oceans and Environment Canada for maintaining the wave gauge off Halifax Harbour. Thanks are also extended to David Frobel for GIS support and to Dustin Whalen for reviewing this manuscript.

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