



International Great Lakes Datum

2024 Hydrographic Services Review Panel meeting

Detroit, MI

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On behalf of the Great Lakes Coordinating Committee

September 25, 2024

Image: Mackinac Bridge connects Lakes Huron-Michigan

Key Takeaways

1

Datums are the foundation for shoreline and waterway management

2

NOAA's NWLON and CHS' PWLN gauging networks are the backbone of our work and its data is needed to develop water level datums

3

IGLD (1985) is being updated to IGLD (2020) and our work in the Great Lakes is internationally coordinated

4

Lake levels are being studied to determine if a recalculation of Low Water Datum may be warranted

5

IGLD (2020) will be tied to the Modernized NSRS, connecting water level data with all geospatial data (on-shore, near-shore, and off-shore)

Setting Sail - Where are we headed?

Presentation Overview

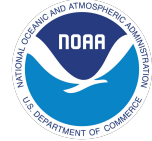
- *Define IGLD*
- *Significance of the Great Lakes and need for a common water level datum*
- *Binational coordination and mandates*
- *Why IGLD needs to be updated*
- *Updating the Datum*
 - *Crucial observational infrastructure*
 - *Differences in IGLD (1985) and IGLD (2020)*
 - *Future of accessing the datum*
 - *Status of IGLD (2020) development*
 - *Project milestones to roll-out*
- *Unresolved Questions: Low Water Datum*
- *Outreach efforts underway*



Image: The Inland Seas Education Association's tall ship Alliance - charged with teaching a new generation about the fragile ecosystem of the Great Lakes. Credit: tallshipsamerica.org/vessels/alliance-2/

What is IGLD?

International Great Lakes Datum



- **Common height reference system** needed to measure and relate water levels
- **Official vertical datum** used for water level measurements and navigation charts in the Great Lakes, their connecting channels and the St. Lawrence River
- Maintained by the binational **Coordinating Committee**
- **Updated approximately every 30 years** to account for land movement



Image: Great Lakes waterways, credit: International Joint Commission

A New IGLD will impact...

Updated water level references will need to be implemented for various operations:



Commercial and recreational navigation, including charts, ports/harbors



Water level **regulation and forecasting**



Coastal zone management and planning, including **flood & erosion prediction and response**, and **coastal structure design, construction & maintenance**

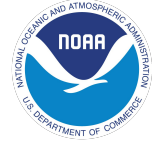


Legislation may need to be updated to reflect IGLD (2020)



The international **Coordinating Committee is conducting outreach** efforts like this one to inform and receive feedback from stakeholders

Great Lakes-St. Lawrence Region



- Drinking water source for ~**40 million** people in the U.S. and Canada
- Backbone for a **\$6 trillion** regional economy
 - **If the Great Lakes region were its own country, it would be the third largest economy in the world by GDP**
- 20% of the world's surface freshwater
- 8 states and 2 provinces
- >10,000 miles of shoreline
 - Longer than the U.S. East and Gulf coasts combined!




Image credit: greatlakesports.org - American Great Lakes Ports Association

Water Levels in the Great Lakes Basin



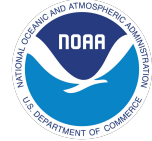
Sharing the Great Lakes Basin

U.S. land  U.S. water  Canada water  Canada land 



- Non-tidal
- Meteorologically-driven
- Seasonal Cycles
- Meteotsunamis
- Prevailing winds, seiche events
- Ice cover, ice jams
- Hydroelectric power generation and diversions
- Water level measurements - no mathematical filling of data gaps

Importance of Coordinated Water Levels



Marine Navigation

- *Safe marine commerce*
- *Storm warnings*
- *Real-time water level data availability*



Time Series Analysis

- *Water level variability (seasonal, annual, etc)*
- *Long-term trends*
- *Climate impacts*
- *Modeling /Forecasting*



Water Level Regulation

- *Hydroelectric power*
- *Treaty agreements*
- *Official vertical datum*

Boundary Waters

Boundary Waters Treaty of 1909

“Boundary waters are defined as the waters from main shore to main shore of the lakes and rivers and connecting waterways... international boundary between the United States and the Dominion of Canada passes...”



Binationally Coordinated Reference System

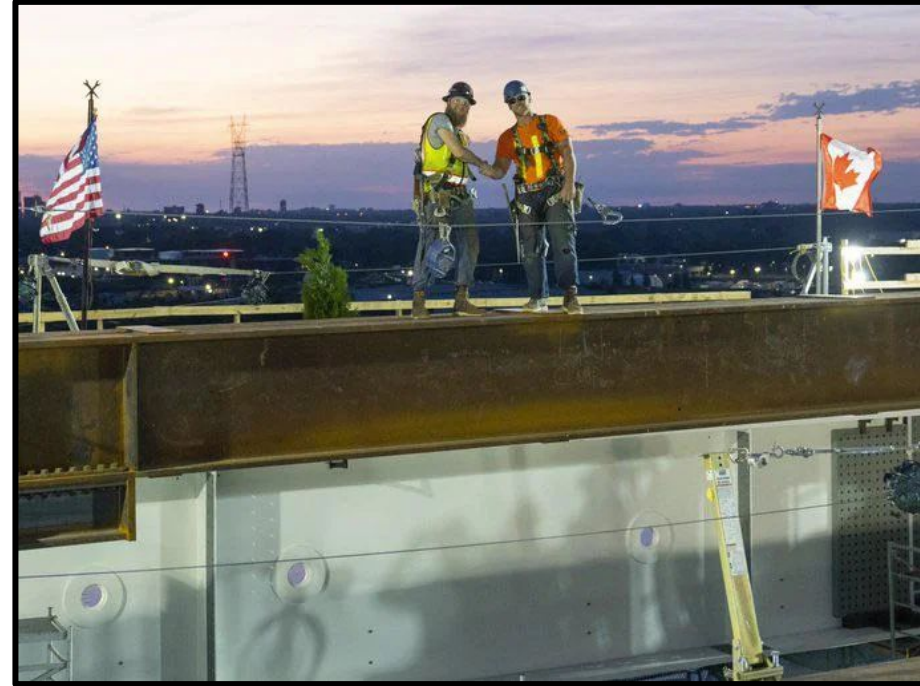


Photo Credit: Gordie Howe International Bridge project

Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data



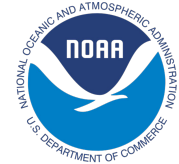
- Formed in 1953
- Federal experts from both the United States and Canada
- Support the International Joint Commission and their work to uphold the Boundary Waters Treaty of 1909

Current Members



Environment and
Climate Change Canada

Environnement et
Changement climatique Canada



Fisheries and Oceans
Canada

Pêches et Océans
Canada



Natural Resources
Canada

Ressources naturelles
Canada



**US Army Corps
of Engineers®**

Boundary Waters Treaty of 1909

International Joint Commission

International Lake Superior Board of Control

International Lake Ontario-St. Lawrence River Board

International Niagara Board of Control

International Great Lakes - St. Lawrence River Adaptive Management (GLAM) Committee

Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data

Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data

Coordinated Routing Model

Hydraulic

Hydrology

Vertical Control

Developing and Maintaining IGLD

Executive Committee

- Co-Chair - Bryce Carmichael (USACE)
- Co-Chair - Jacob Bruxer (ECCC)
- Secretary - Keith Kompoltowicz (USACE)
- Secretary - Jamie Ferguson (ECCC)
- **Member - Jesse Feyen (GLERL, NOAA)**
- Member - Michael Craymer (NRCan, CGS)

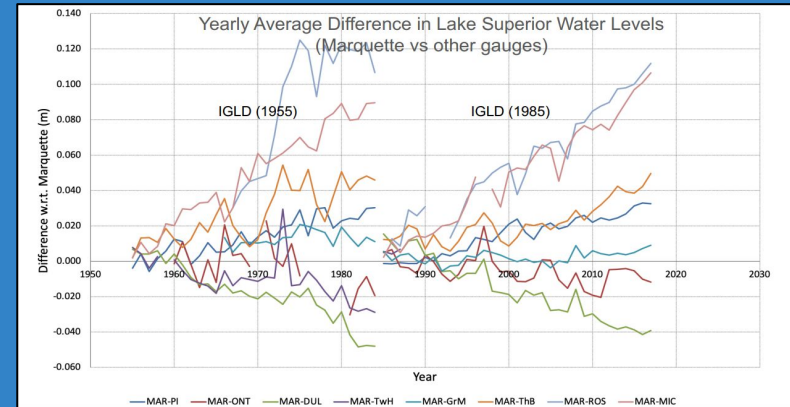
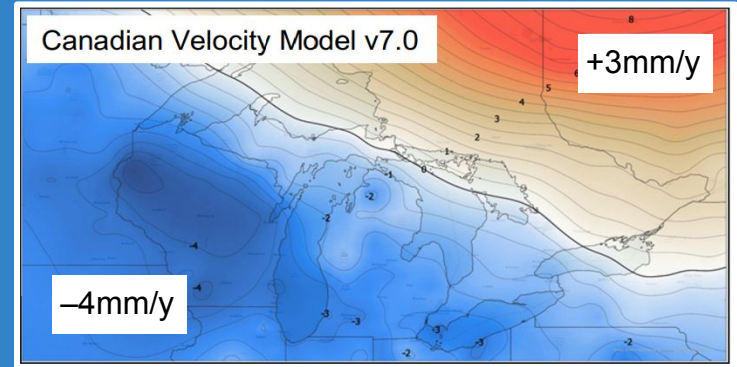
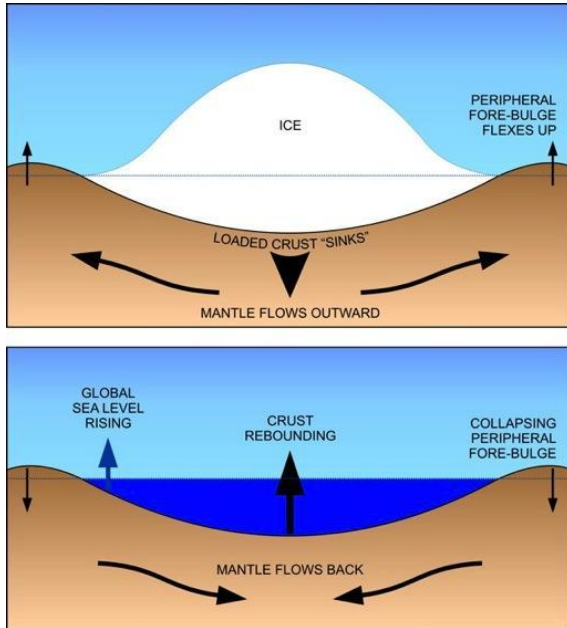
Executive Support Group

- **Deborah Lee (Director, GLERL, NOAA)**
- Kyle McCune (Chief of Water Management, USACE)
- Sandra Eberts (Director, Earth Systems Processes, USGS)
- Jean-Francois Cantin (Chief of Hydrological Operations, ECCC)
- Chris Marshall (Director of Hydrography, CHS)
- Vacant - previously held by Canadian Geodetic Survey

Why a new IGLD?

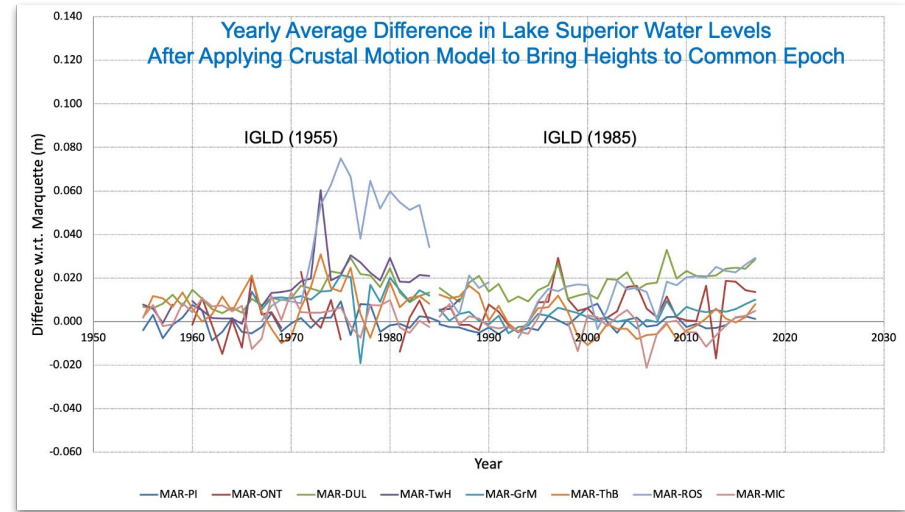
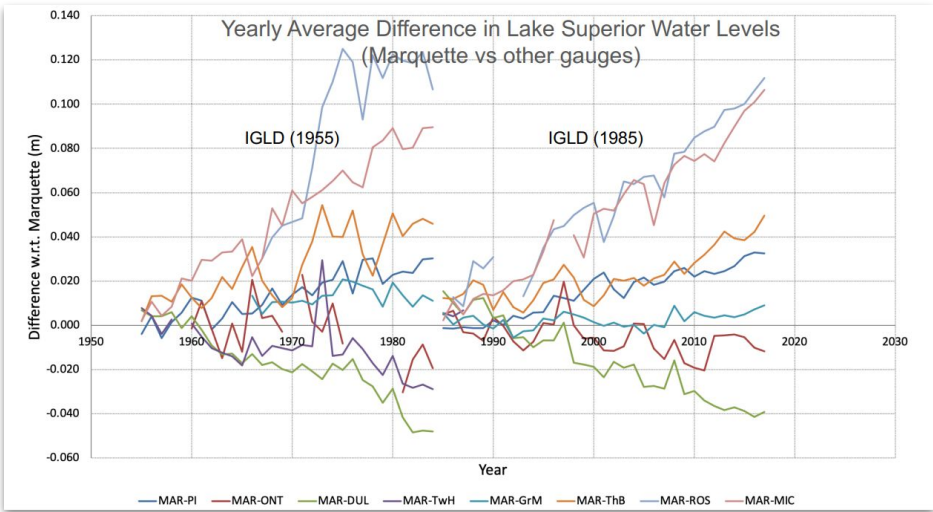


- Uplifting in north subsiding in south
- Overall tilting ~ 7 mm/year (21cm or 8" over 30 years)
- Need to update IGLD every 25-30 years => **overdue!**



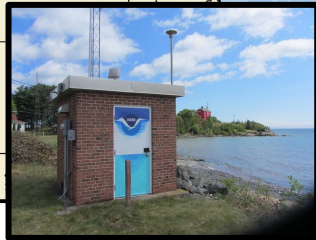
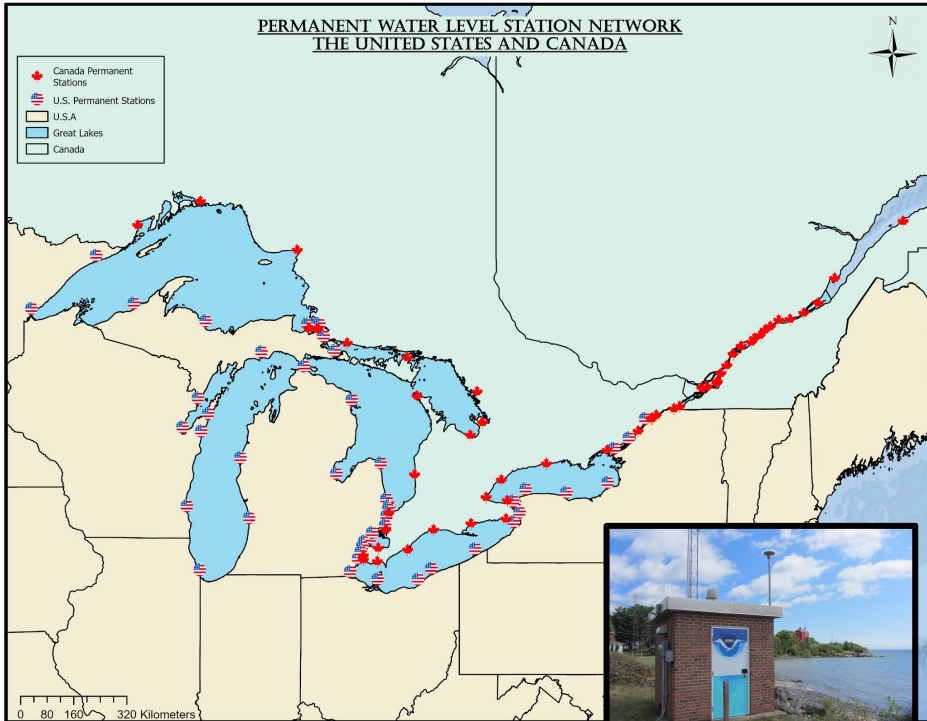
Effect of GIA on Water Level Measurements

Water Level Measurements Corrected for GIA

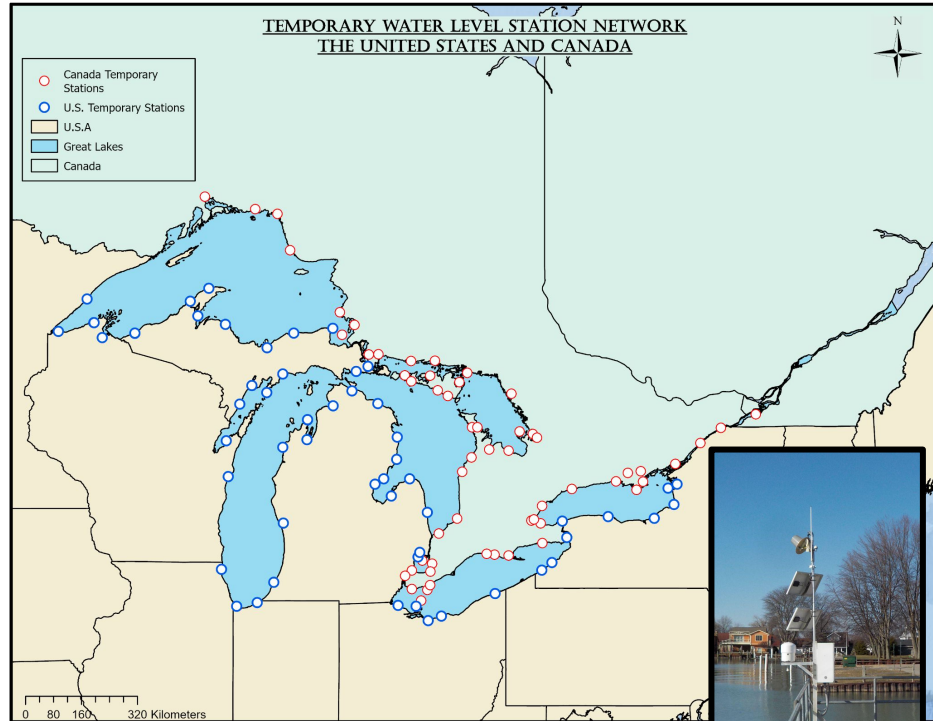


Observational Infrastructure

International Water Level Gauging (NOAA CO-OPS / Canadian Hydrographic Service)

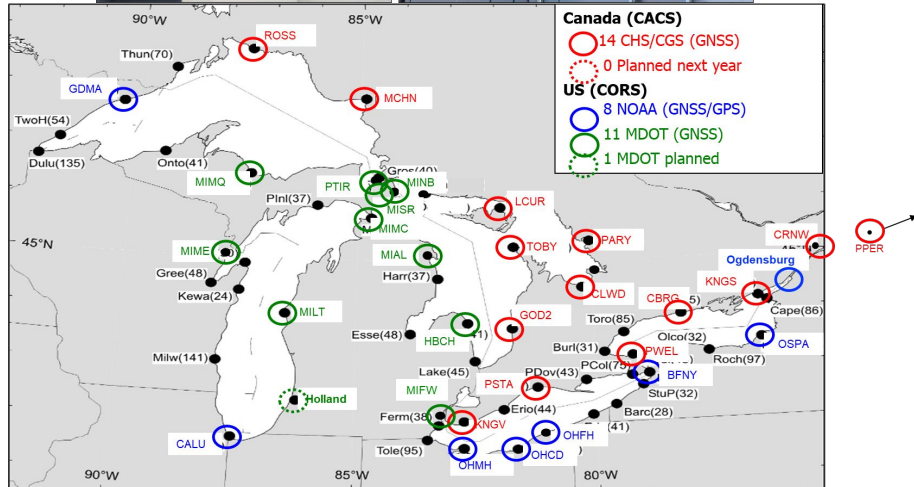
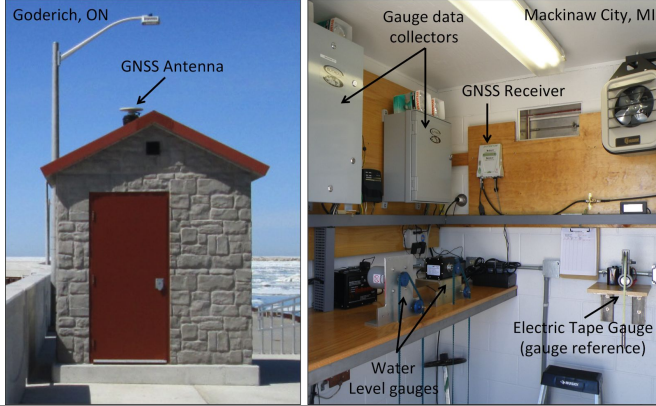


9099018 Marquette C.G., MI



9034057 New Baltimore, MI

Permanent GNSS Stations



- Continuously Operating Reference Stations (CORS) in the U.S.
- Canadian Active Control Stations (CACS) in Canada
- Stations are processed to determine the reference frame, connecting water levels to the global geometric frame
- Some water level gauges have a CORS/CACS attached to the gauge house
- US: Maintained by NGS and partners (CO-OPS, Michigan DOT)
- Canada: Maintained by CGS

Water Level Gauges

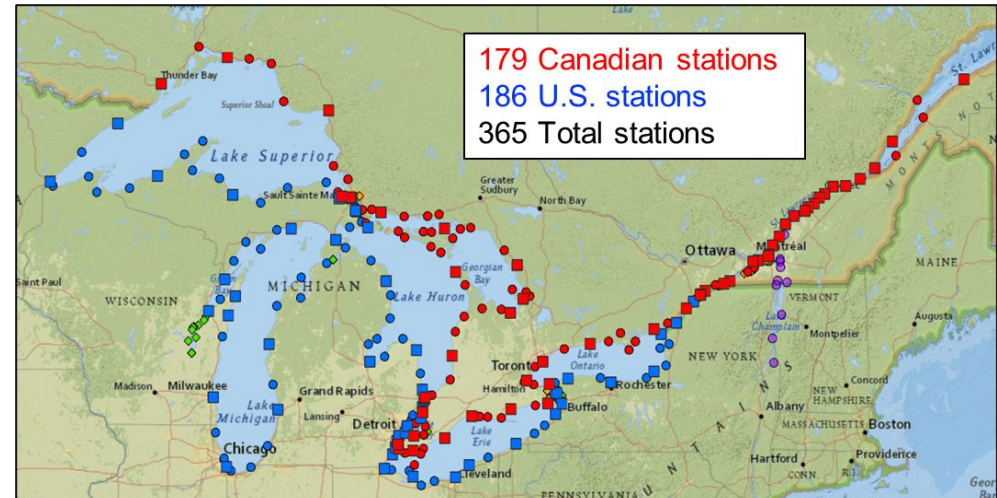
- Monitor water levels
- Each country operates permanent stations
 - NOAA (52)
 - 18 with CORSSs
 - CHS (58)
 - 14 with CACs
 - Entities partners
 - USACE, ECCC, USGS, Seaway (Canada & U.S.), NYPA, OPG
- Seasonal gauges are installed temporarily and fill gaps
- All gauges had bench marks occupied with GNSS in 2022



9075080 Mackinaw City, MI



11250 Killarney, ON



IGLD (1985)



Reference surface developed through survey leveling

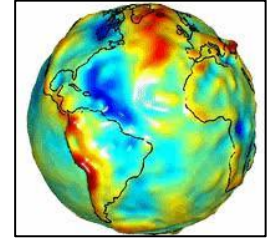


Static datum does not account for land motion



Accessible through leveling connection to local bench marks (metal markers in ground)

IGLD (2020)



Reference surface defined by geoid model, based on gravity (instead of leveling), aligns with the modernized NSRS



Time-dependent datum accounts for land motion, which will allow for more seamless updates



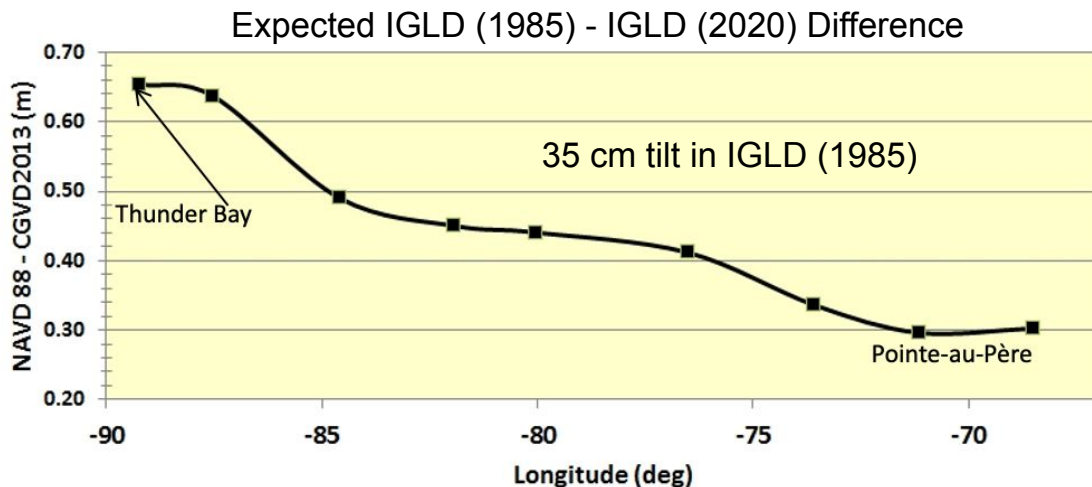
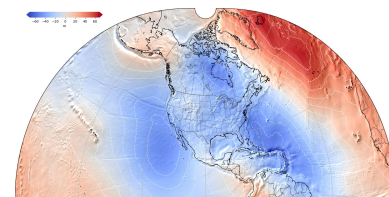
Accessible through GNSS connections to bench marks (*Global Navigation Satellite System*)

Expected Changes

Water level reference heights expected to change 30-65 cm (12" to 26") from the existing IGLD (1985)

New IGLD (2020) Definitions

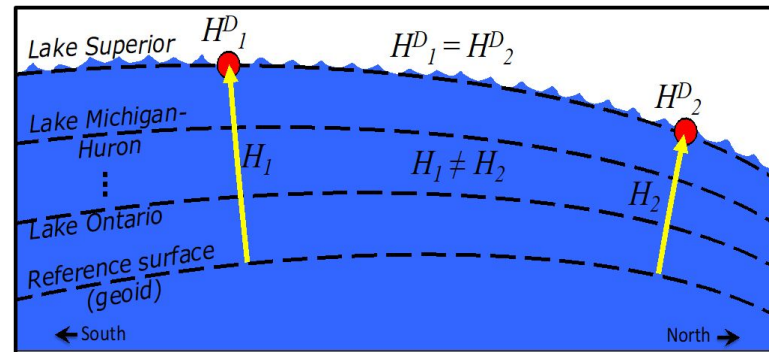
- Based on the North American-Pacific Geopotential Datum of 2022 (NAPGD2022)
- **Reference zero** is mean sea level around the coasts of North America
- **Reference surface** (datum) extended inland using a geoid model
 - Geoid model based on gravity data, not leveling
 - Defined everywhere, not only where leveling bench marks exist
- Using **dynamic heights**
- Heights defined at **reference epoch 2020.0** (mid-point of 7 year water level obs period)



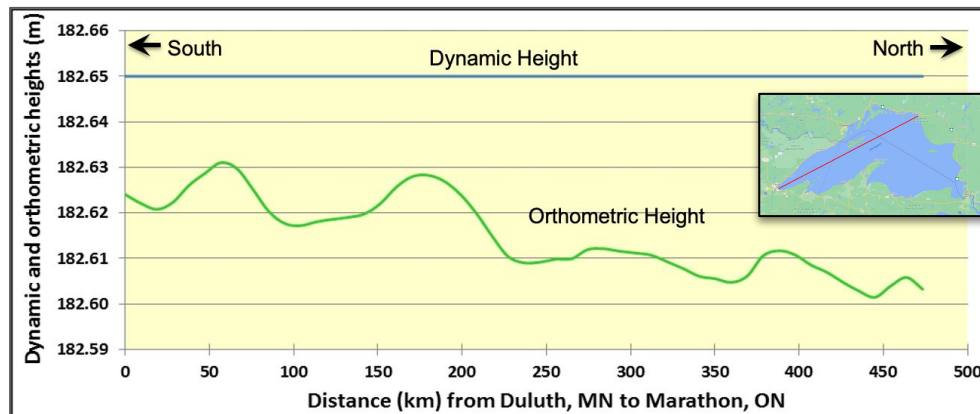
IGLD (2020) Using Dynamic Heights

- Orthometric heights (H)
 - Typical heights used in most applications
 - Physical distance above reference surface (geoid)
 - Not constant along a level surface (like a lake) because equipotential convergence as you go north
 - Geopotential numbers scaled by local gravity

- Dynamic heights (H^D)
 - Geopotential numbers scaled by a constant gravity value
 - Constant along a level (lake) surface by definition
 - Enables the measurement of hydraulic head for water level management
 - Used by all IGLD realizations



Dynamic heights, H^D , and orthometric heights, H .



Determining Heights via GNSS

$$h \rightarrow H \rightarrow H^D$$

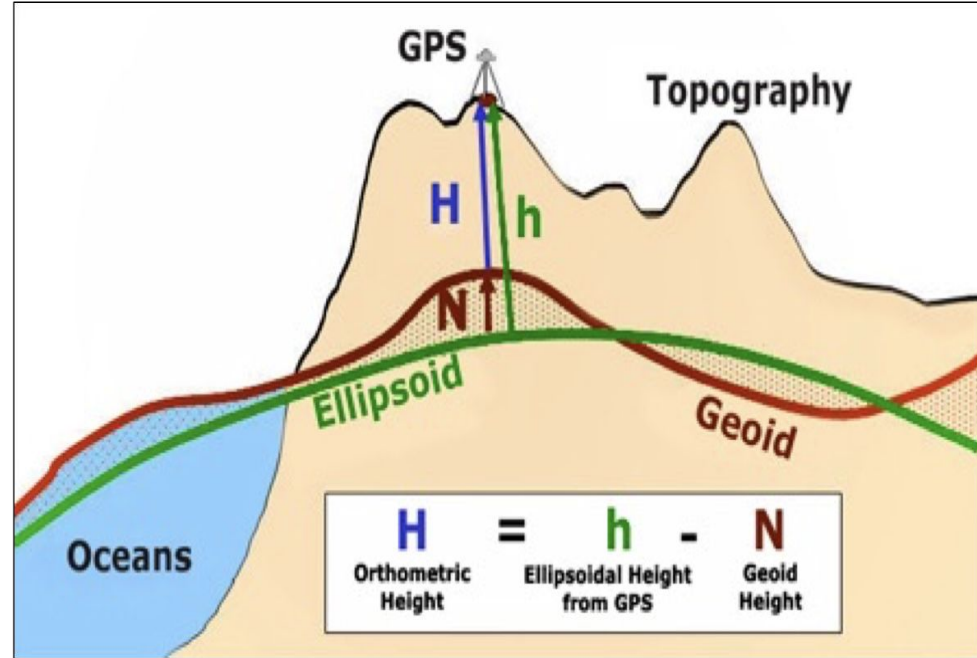
h = ellipsoidal height obtained from GNSS

N = geoid height obtained from geoid model
(provided by CGS & NGS)

H = orthometric height

H^D = dynamic height obtained from H using
gravity model (provided by CGS/NGS)

Online conversion tools provided by CGS &
NGS



Status of IGLD (2020) Development



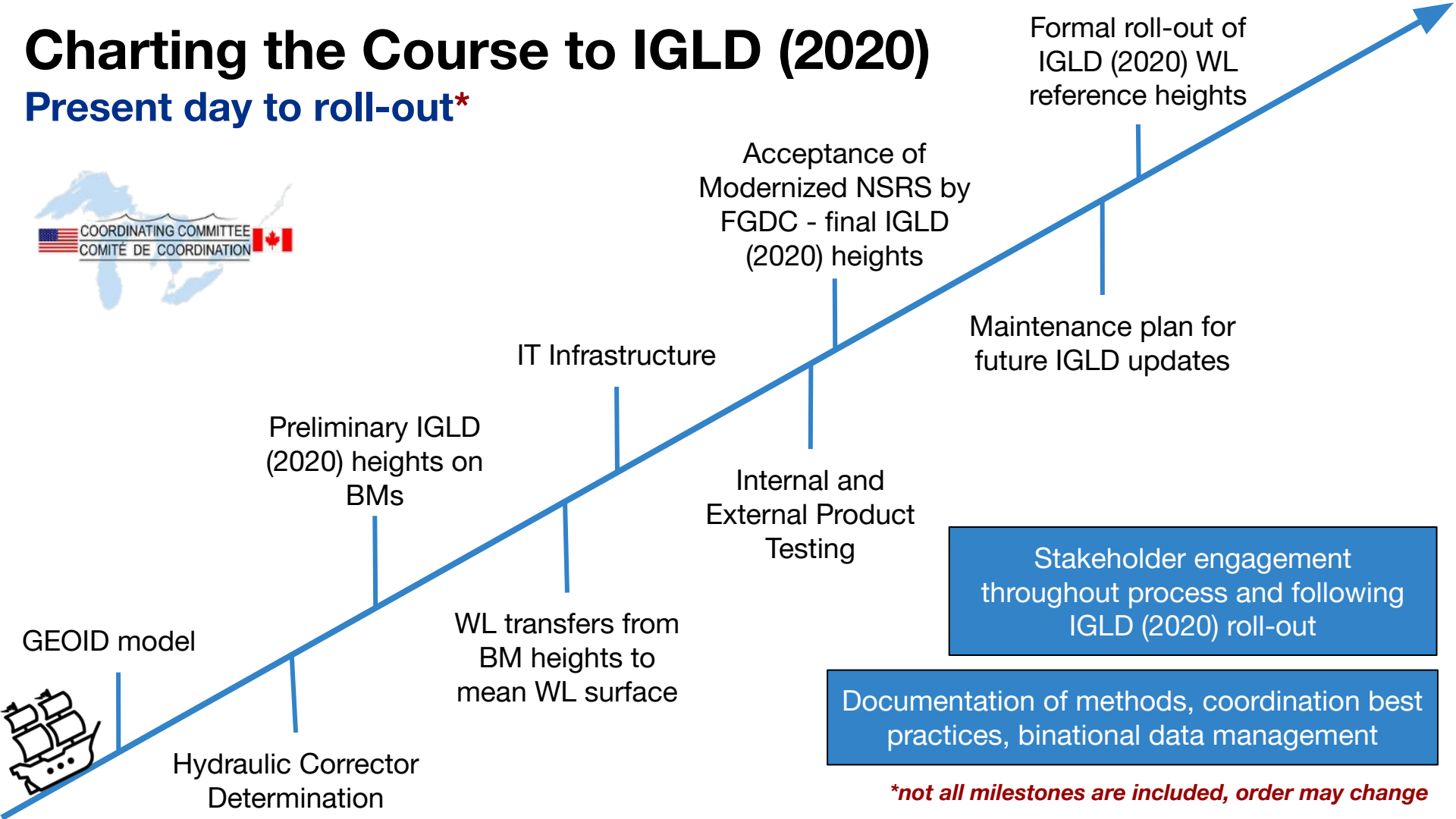
- Water level data collection for IGLD (2020) is complete
- Conducted GNSS surveys in 1997, 2005, 2010, 2015 to prepare for IGLD update
- 2022 GNSS survey expanded to include:
 - Permanent gauges (federal, state, partners)
 - Seasonal gauges for determination of hydraulic correctors
- Processing GNSS data nearly complete
 - The data will be used to determine the heights of all water level gauges as part of an update to the International Great Lakes Datum (IGLD)



Image: GNSS occupation of bench mark in Grand Marais, MN; Photo credit: Gavin

Charting the Course to IGLD (2020)

Present day to roll-out*

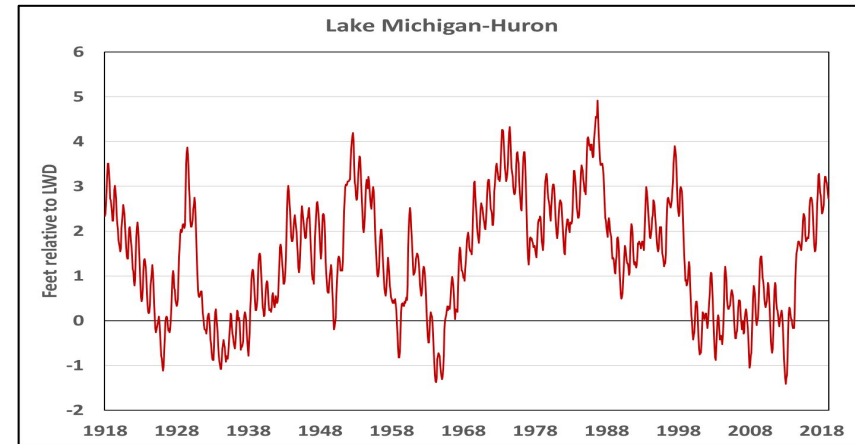
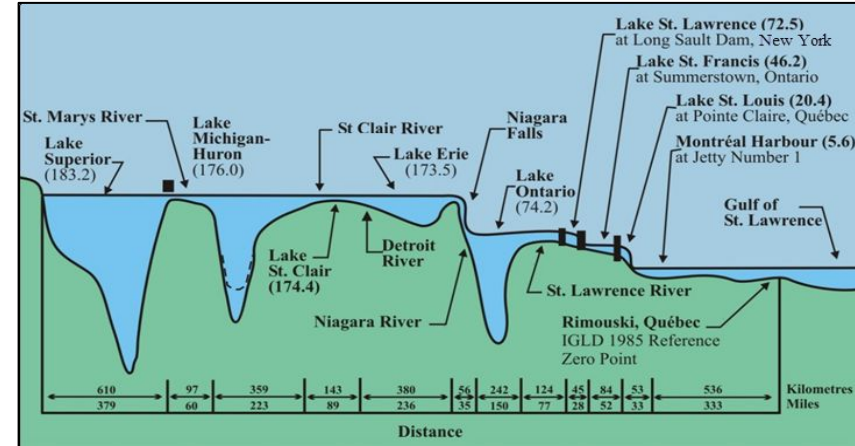


**not all milestones are included, order may change*

Unresolved Questions:

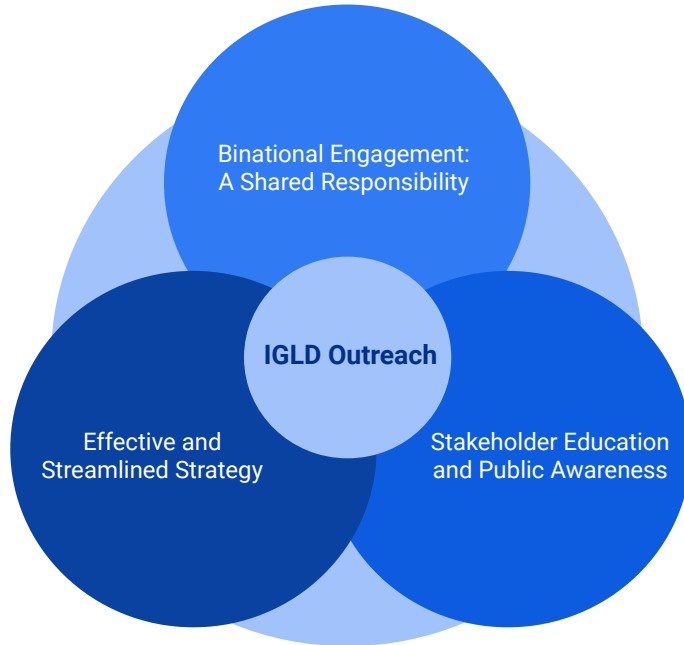
Low Water Datum Updates

- LWD (aka Chart Datum) is **the reference/level below which water levels seldom fall (typically 5% of time)**
 - Used as navigational chart datum, one for each of the Great Lakes and Lake St. Clair
 - Depths for harbor improvement authorizations are also referred to LWD
- With each IGLD update, LWD simply received updated reference heights
 - Channel modifications, erosion, outflow regulations, and climate change since the original establishment of LWD
 - **We are reviewing LWD in conjunction with the IGLD (2020) update**
 - **Ongoing progress - TBD if LWD will be updated**



Outreach Efforts

International Great Lakes Datum



RECENT ENGAGEMENTS

- All-Interested Congressional briefing (May 2024)
- Canadian Hydrographic Conference (May 2024)
- Canadian Geophysical Union Conference (May 2024)
- IAGLR (May 2024)
- Soo Locks Engineers Day (June 2024)
- Michigan Sea Grant briefing (Jan 2024)
- Illinois Coastal Management Program briefing (Sept 2024)

UPCOMING

- Coordinating Committee's ESG (TBD)
- Boards of Control (Spring 2025)
- 2024 Great Lakes Conference, Chicago, IL
- US Hydro 2025, Wilmington, NC
- IAGLR 2025

Key Takeaways

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Resources

Coordinating Committee IGLD Website:

<https://www.greatlakescc.org/en/international-great-lakes-datum-update/>

NOAA CO-OPS' IGLD Website:

<https://tidesandcurrents.noaa.gov/datum-updates/igld/index.html>

Modernized NSRS:

<https://geodesy.noaa.gov/datums/newdatums/index.shtml>

Reference System Updates in Canada:

<https://natural-resources.canada.ca/maps-tools-and-publications/geodetic-reference-systems/height-reference-system-modernization/9054>

info@GreatLakesCC.org

Coordinating Committee on Great Lakes
Basic Hydraulic & Hydrologic Data

**Updating the
International Great Lakes Datum (IGLD)**

Prepared by the
Vertical Control – Water Levels Subcommittee
on behalf of the
Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data

September 2017

End Presentation