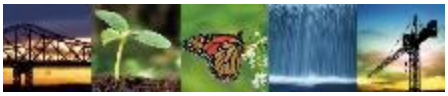


Known for excellence.
Built on trust.

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

188 Valley Street
Suite 300
Providence, RI 02909
T: 401.421.4140
F: 401.751.8613
www.gza.com

July 14, 2025
GZA File No. 01.0177618.00

Groton Long Point Association/University of Connecticut
3 Discovery Drive, Unit 6076
Storrs, CT 06269-6076

Re: Final Report for LIS Resilience Planning Support Services Projects
Groton Long Point Association

In accordance with our contract # 005-3-NV-043024 dated April 4th, 2024, GZA GeoEnvironmental, Inc. (GZA) is pleased to submit this Final Report to the Groton Long Point Association and the University of Connecticut.

This report summarized GZA's project activities including site reconnaissance, hazards and vulnerabilities, review of existing information, and development of conceptual design alternatives for select proposed project sites within Groton Long Point (Site). The assessment focuses on the approximately 0.5 square miles of Groton Long Point (GLP), containing residential development, sandy beaches, salt and freshwater marshes, a lagoon, and wooded areas featuring nature trails. GZA worked closely with GLP stakeholders to develop resilience improvement alternatives and concept designs for select measures as described in the report.

We appreciate your trust in us to complete this project. Please contact Michael Gardner at Michael.gardner@gza.com with any questions or comments.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Michael Gardner, WEDG
Project Manager

David M. Leone, P.E.
Principal-in-Charge

Stephen Lecco
Consultant Reviewer

Known for excellence.
Built on trust.

Final Report for
LIS Resilience Planning Support Services Projects
Groton Long Point Association

Groton Long Point, CT

July, 2025
File No. 01.0177618.00

PREPARED FOR:
Groton Long Point Association/University of Connecticut

GZA GeoEnvironmental, Inc.
249 Vanderbilt Ave | Norwood, MA 02062
781-278-3700

33 Offices Nationwide
www.gza.com

July, 2025
Final Report
01.0177618.00

EXECUTIVE SUMMARY

This report presents final summary results of the planning and engineering efforts for the On-Call Consultant Services, Contract #005-3-NV-043024, Project Name: LIS Resilience Planning Support Services Projects - Groton Long Point Association. This project presents conceptual design alternatives for select proposed project sites at Groton Long Point (Site). The concept design process began with development and approval of a Quality Assurance Project Plan (QAPP) that was built on GZA's knowledge of the site from previous work with the Groton Long Point Association. This was followed by an analysis of existing site data and stakeholder engagement, culminating in the conceptual design alternatives that mitigate minor flooding issues in Groton Long Point and enhance the community resiliency with anticipated sea level rise.

TABLE OF CONTENTS

Page No.

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

GZA GeoEnvironmental, Inc. (GZA) of Norwood, Massachusetts, was contracted by University of Connecticut (UCONN) on behalf of Groton Long Point Association (GLPA and grantee) to provide engineering services including visual site reconnaissance, document conditions, hazards, and vulnerabilities, and review existing information, with the goal of developing conceptual design alternatives for select proposed project sites within Groton Long Point (Site). These design alternatives were assessed using the PERSISTS (Permittable, Equitable, Realistic, Safe, Innovative, Scientific, Transferrable, Sustainable) decision support criteria that include constructability, cost, view-scape, hazard mitigation, lifespan, and adaptation capabilities.

All elevations in this report are presented in the North American Vertical Datum of 1988 (NAVD88) feet unless otherwise specified. See Limitations in **Appendix A** for further details.

1.1 OBJECTIVES

The objective of this project is to advance the work needed to develop conceptual design alternatives for select proposed project sites. The proposed project sites were selected based on the GLPA's opinion of historic problem areas and metocean data evaluation of the Site through elevation, flood frequency, and sea level rise analyses. Based on this analysis, Sites exposed to the most frequent flooding were targeted for this work. The work consisted of development and approval of a Quality Assurance Project Plan (QAPP), building on GZA's knowledge of the Site from previous work with the GLPA, site reconnaissance, and conceptual design. The QAPP was approved on November 6, 2024 and is included as **Appendix C**.

1.2 BACKGROUND

Groton Long Point (GLP) is located on a peninsula, bordered on the west by Mumford Cove and on the south and east by Fishers Island Sound and on the north by Groton Long Point Road (**Figure 1**). The GLP study area is approximately 0.5 square miles, containing residential development, sandy beaches, salt and freshwater marshes, a lagoon, and wooded areas featuring nature trails. A harbor has been created in the lagoon protected by a sandy spit (containing West Shore Ave.); the upper portion of the lagoon forms a sheltered pond (Upper Lagoon). GLP is accessible by car via the Palmer Cove bridge and causeway, or by foot or bicycle through Haley Farm and Mumford Cove Association.

GLP is administered by the Groton Long Point Association, a private association that was created by a Special Act of the Connecticut Legislature in 1921. The Association can tax and issue bonds to provide services independent of the Town of Groton.

In 2023, GZA developed a Climate Resilience Plan for the community of GLP and has since been awarded this project phase to advance resiliency measures laid out in the 2023 plan through development of conceptual designs at select project areas in need of mitigation measures.

Figure 1: Site Locus

2.0 SITE INFORMATION

2.1 EXISTING CONDITIONS

GZA conducted a Site specific metocean data analysis for bathymetry/ topography, water levels, and historic and projected sea level rise (SLR), summarized below.

Bathymetry/ Topography: GZA developed a Site Digital Elevation Model (DEM) using bathymetric and topographic data for the project area based on the 2016 Connecticut Digital Elevation Model (DEM) data available via NOAA Digital Coast Data Access Viewer and a supplemental spot survey (**Figure 2**).

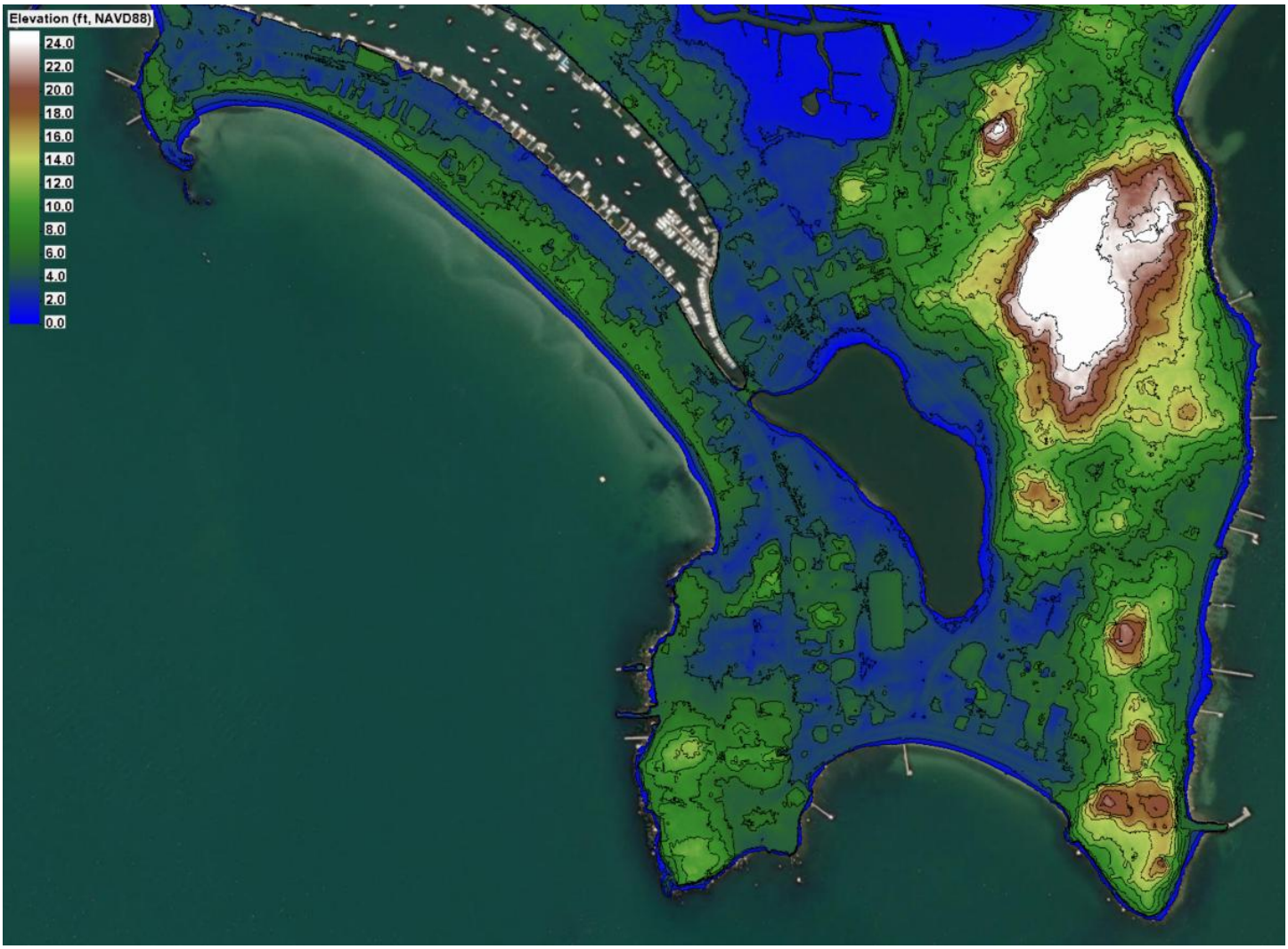


Figure 2: Groton Long Point Digital Elevation Model (DEM)

Water Levels: GZA reviewed extreme stillwater levels (coastal storm tide) for the project-specific annual exceedance probability flood events for the project area (**Table 1**) based on:

- The New London NOAA Tide Gauge (Sta. 8461490);
- USACE North Atlantic Coast Comprehensive Study (NACCS) Save Point; and
- The effective FEMA Flood Insurance Study (FIS) 09011CV001D and Coastal Transects.

The FEMA FIS 10-year stillwater elevation is 4.9 feet NAVD88 at Groton Long Point, with several FEMA coastal Transects covering the area (**Figure 3**). Images of modeled flooding of GLP under different coastal water level conditions can be found in **Figure 13** through **Figure 19**.

Table 1: Stillwater Elevations (feet, NAVD88)

Annual Exceedance Probability	FEMA	USACE Save Point 8354	NOAA New London Tide Gauge (1992)	NOAA New London Tide Gauge (2025)
Mean Lower Low Water (MLLW)	-	-	-1.8	-1.5
Mean Low Water (MLW)	-	-	-1.7	-1.3
Mean Sea Level (MSL)	-	-	-0.3	0.0
Mean High Water (MHW)	-	-	0.9	1.2
Mean Higher-High Water (MHHW)	-	-	1.2	1.5
1-Year (99%)	NA	3.3	2.4	2.7
2-Year (50%)	NA	4.3	3.5	3.8
5-Year (20%)	NA	5.3	4.3	4.6
10-Year (10%)	4.9	6.1	4.9	5.2

Figure 3: FEMA FIS Map of Groton Long Point

The top 10 water level events at the NOAA New London Tidal Gauge 8461490 are shown in **Table 2**. Of the top ten water levels observed at the gauge, six were generated by tropical hurricanes while the remaining were either extra tropical Nor'easters or anomalous tides. Tidal datums at the New London Tide gauge in the current tidal epoch (1993-2001) and present day (2025) are displayed in **Figure 5**.

Table 2: Top Ten Water Level Events at NOAA New London Tidal Gauge

Date	Elevation (Feet above NAVD88)	Event Category	Event	Source
September 21, 1938	8.74	Tropical	Great New England Hurricane	High Water Mark
August 31, 1954	7.74	Tropical	Hurricane Carol	Inferred Water Level
October 30, 2012	6.16	Tropical	Hurricane Sandy	Observed Peak Water Level
November 25, 1950	5.74	Extra Tropical	Storm of 1950	Inferred Water Level
September 14, 1944	5.24	Tropical	1944 Great Atlantic Hurricane	Inferred Water Level
September 12, 1960	5.04	Tropical	Hurricane Donna	Observed Peak Water Level
November 7, 1953	4.98	Extra Tropical	Nor easter	Inferred Water Level
December 23, 2022	4.81	Other	Above Normal Tides & Coastal Low Pressure	Observed Peak Water Level
January 13, 2024	4.80	Extra Tropical	January 13-14 East Coast Winter Storm	Observed Peak Water Level
August 28, 2011	4.72	Tropical	Hurricane Irene	Observed Peak Water Level

Sea Level Rise: GZA reviewed historical observed sea level trends in the region, provided by the NOAA New London Tidal Station. NOAA tidal gauge levels are relative to water levels measured over the 1983-2001 tidal epoch (average of 1992) and have also been translated to water levels at present day (2025) using historic long-term sea level change trends (Figure 4) to represent current conditions and sea level rise (SLR) realized since 1992. Since installation of the New London gauge, sea levels have risen at an average rate of 0.1 inches/year or approximately 0.3 feet over the past 33 years. Since 1992, sea level rise rates have increased and have approximately doubled in recent years. This exponential increase in sea level rise has not been accounted for at this stage of the project and only linear trends have been used.

For sea level rise projections, GZA referred to Connecticut State guidance, which encourages communities to prepare for sea level rise of up to 20 inches (1.7 feet) by 2050 in Long Island Sound. This guidance uses the year 2000 as a baseline. For further information on SLR, the most recent NOAA sea level rise data (NOAA et. al 2022) has similar SLR projections to the state guidance, with the low, intermediate, and high projections at 1.2, 1.5, and 1.8 feet of SLR, respectively (with a 1992 baseline).

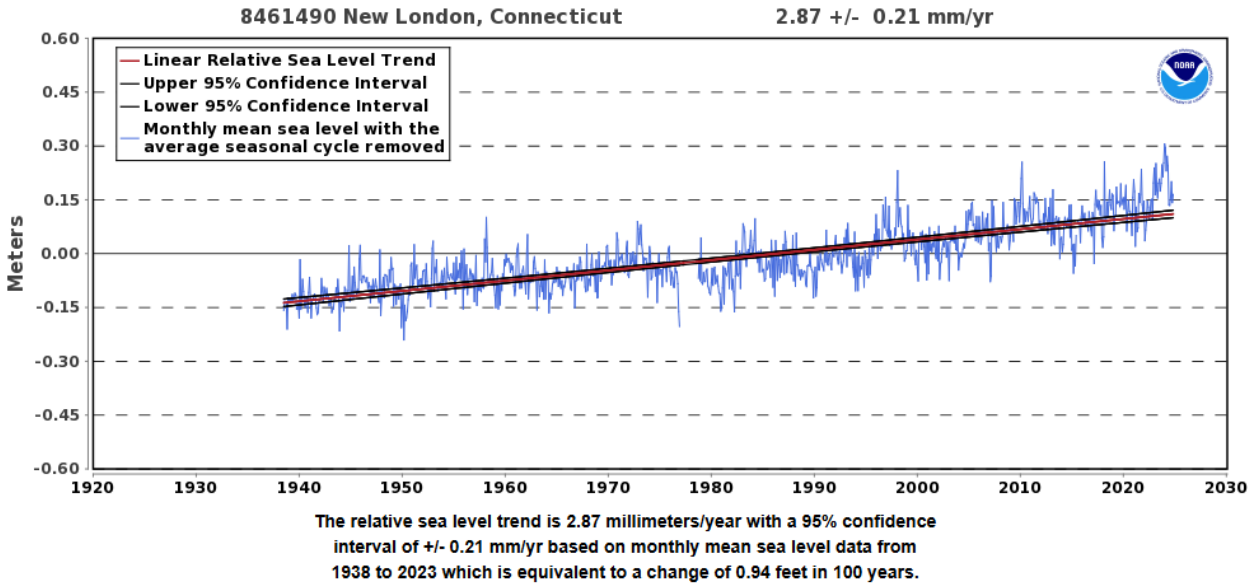


Figure 4: New London Historic Long-Term Sea Level Change Trends

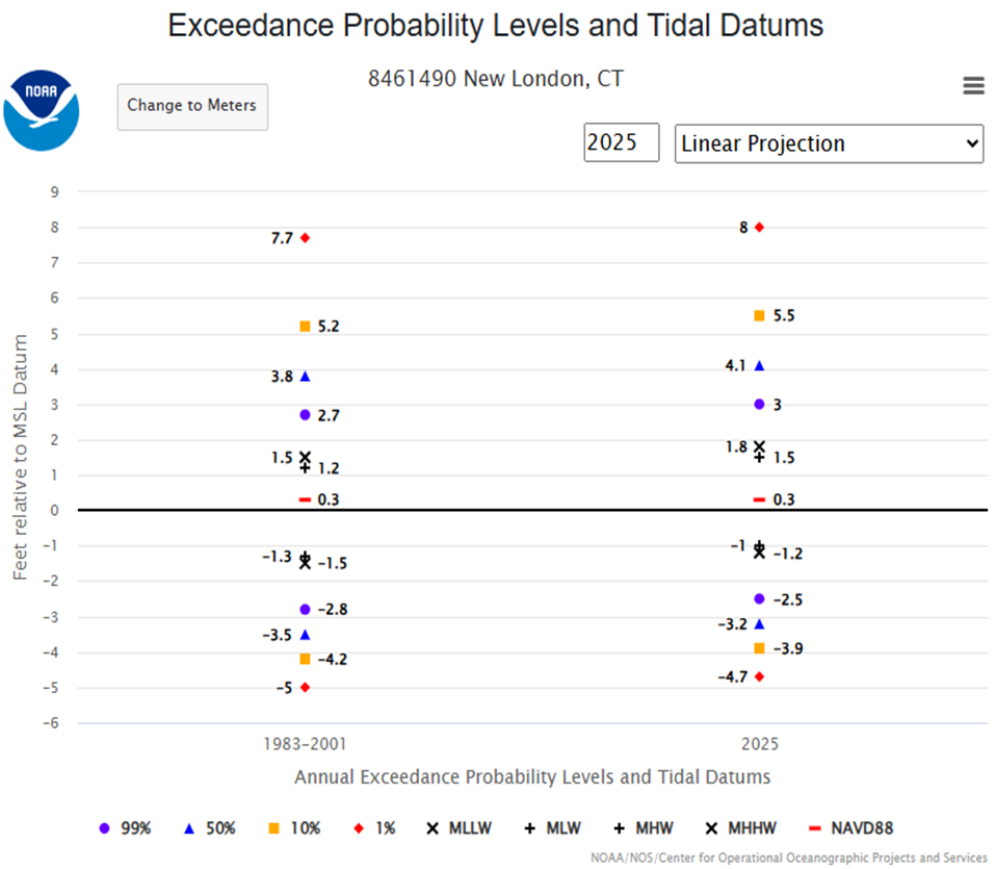


Figure 5: Tidal Datums (right column is present day, 2025) and Exceedance Probabilities at NOAA New London Gauge

Waves: GZA reviewed wave characteristics for the project site based on the USACE NACCS Save Points and the FEMA FIS coastal transects. Based on these sources, large wave heights can be expected during coastal storm events under existing conditions, however the conceptual project areas focus on less exposed parts of Groton Long Point and waves do not play a significant role in design.

2.1.1 Pertinent Existing Elevations

To provide an overall sense of exposure of the community, the following existing elevations are referenced to the NAVD88 datum and are based on the topographic LiDAR survey from the 2016 Connecticut DEM and Annual Exceedance Probability (AEP) elevations in **Table 3** are based on the FEMA FIS, the New London NOAA Tide Gauge, and USACE NACCS save points, unless otherwise noted. The FEMA and USACE water levels were previously adjusted to a slightly more recent timeframe and have not been adjusted to present day conditions in this report.

1. Highest Roadway Elevation: approximately 27 feet on Ridge Rd.
2. Lowest Roadway Elevation: approximately 2.5 feet in several locations
3. GLP Fire Department: approximately 3.5 feet
4. West Shore Ave. Elevations: approximately 2.5 to 4.6 feet
5. Atlantic Ave. Elevations: approximately 2.4 to 5.0 feet
6. Upper Lagoon Walking Path Elevations: approximately 1.4 to 4.3 feet

Table 3: Recommended Design Stillwater Elevations (feet, NAVD88)

Annual Exceedance Probability	Recommended Present Day Design Stillwater Elevation (feet, NAVD88)	Recommended 2050 Design Stillwater Elevation (feet, NAVD88)[1]
Mean Lower Low Water (MLLW)	-1.5	-0.1
Mean Low Water (MLW)	-1.3	0.1
Mean Sea Level (MSL)	0.0	1.4
Mean High Water (MHW)	1.2	2.6
Mean Higher-High Water (MHHW)	1.5	2.9
1-Year (99%)	2.7	4.1
2-Year (50%)	3.8	5.2
5-Year (20%)	4.6	6.0
10-Year (10%)	5.2	6.6

[1] The current tidal epoch (1983-2001) was used along with State of CT guidance (20 inches by 2050) and linear SLR trends from 1992 to 2000 to approximate water levels in 2050

2.1.2 Existing Conditions Assessment – Site Reconnaissance

GZA performed two Site visits for this conceptual design project phase. GZA first visited the Site on October 18th, 2024 to meet the GLP team and make initial observations of current conditions in the community for informational purposes. The

initial visit was planned during a king tide. Water was observed at the top of storm drains in low-lying areas of the roadway, as well as on the path around the northwest side of Upper Lagoon (**Figure 6 and 7**). Detailed information was gathered in a supplemental site visit, after the QAPP was approved.

Figure 6 and Figure 7: Site Visit Photos During a King Tide

GZA performed a second site visit on January 7th, 2025 to take GPS spot elevation measurements and inspect catch basins and storm drainage. During this site visit, GZA was able to identify potential problem catch basins, identify previously installed back flow preventors, and take further measurements to help inform conceptual design. GZA, with the help of GLP stakeholders, located critical stormwater outfalls, damaged and potentially problematic outfalls, and those containing back-flow preventors (**Figures 8 and 9**).

Figure 8 and Figure 9: Examples of Outfalls Reviewed During the Site Visit

During each Site visit, to best understand the on-ground features, GZA met with GLP Stakeholders and discussed the project, problem areas, and conceptual solutions.

2.1.3 Existing Conditions Assessment – Secondary Data Collection

GZA completed the collection of secondary data, consisting primarily of publicly available GIS-format data from authoritative sources such as USGS, FEMA, CTDEEP, and CIRCA. Most secondary data collection was completed as part of the 2023 Resiliency Plan effort (covered in QAPP for NFWF Project No. 73368, November 2022). Most of this information is presented in section 2.1, Existing Conditions. Elevation data was also compiled from the GPS RTK unit used during the second site visit. This catch basin and elevation information showed low-lying problem areas and allowed for the creation of an existing conditions GIS map (

Figure 10). This also map had locations of key stormwater components, as well as their elevations.

As noted, the low-lying nature of Groton Long Point means it is highly exposed to flooding from coastal storm events. Most of the area falls within the 100-year FEMA flood zone and only a small portion at the highest elevation within the community are outside of the 500-year FEMA flood zone (**Figure 11**). Flooding within the community begins during much lower storm events with the 1 to 2-year storm event (100% to 50% AEP) causing flooding pathways through: 1) the sports field towards Atlantic Avenue; 2) the Harbor to West Shore Avenue; 3) the Upper Lagoon; the West end of Atlantic Avenue; and 4) South Beach over South Shore Avenue (shown in Figure 12 and Figure 14, Figure 15Figure 16) Further, precipitation during storm events has nowhere to go and can compound the flooding of the area. Presently flooding in these low-lying areas is worsened by stormwater outfalls that directly connect inland areas to the ocean and serve as a flood pathway.

Potential vulnerabilities with this flood exposure include 1) the flooding of roadways; 2) flooding of private homes; 3) flooding of public buildings such as the GLP Casino and Fire/ Police Department; and 4) standing water causing reduced emergency services access. These areas will continue to be vulnerable in the future but the frequency of occurrence can be reduced by implementing the right mitigation solutions.

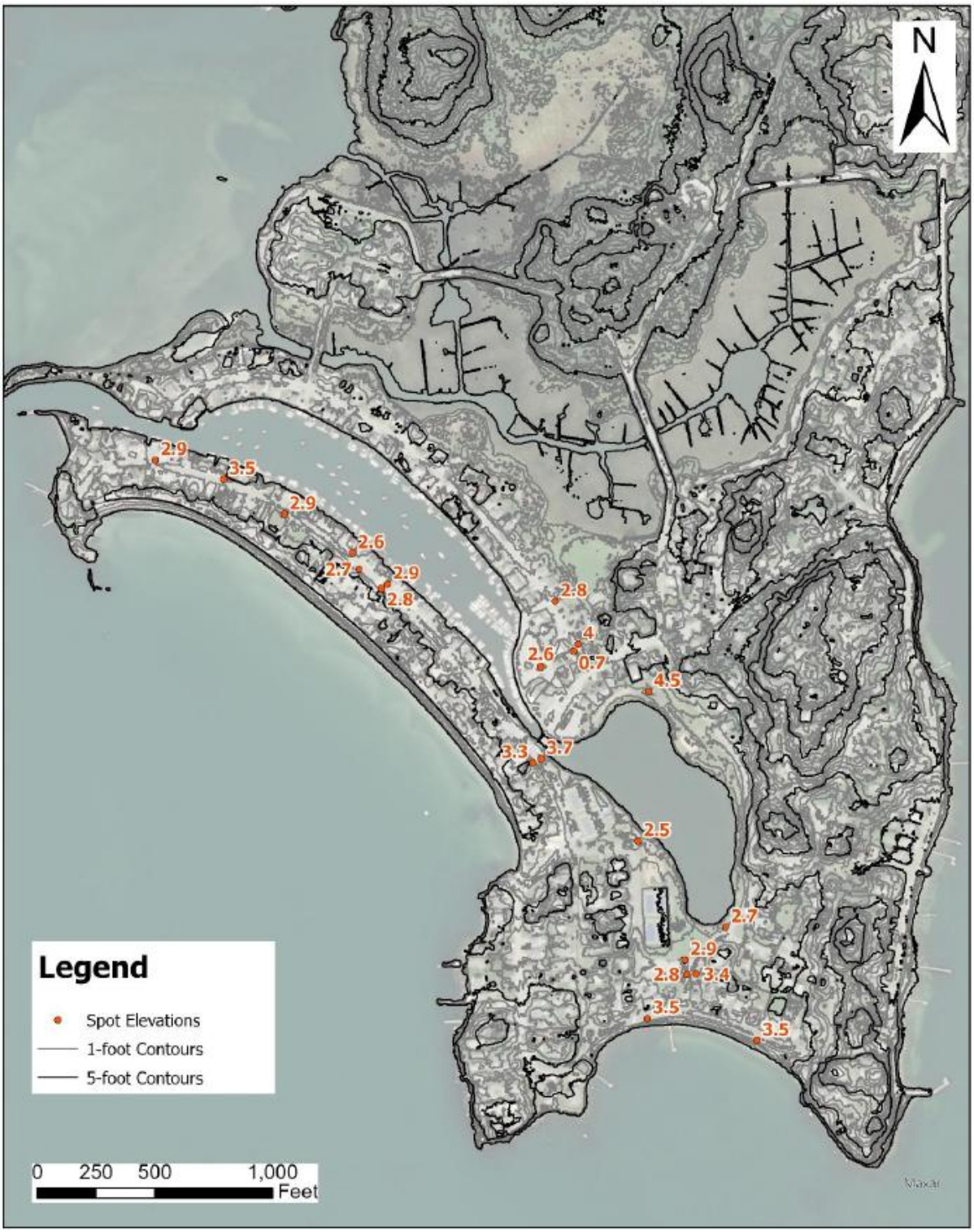


Figure 10: GIS Elevation Data with Some GZA Leica Survey Spot Points

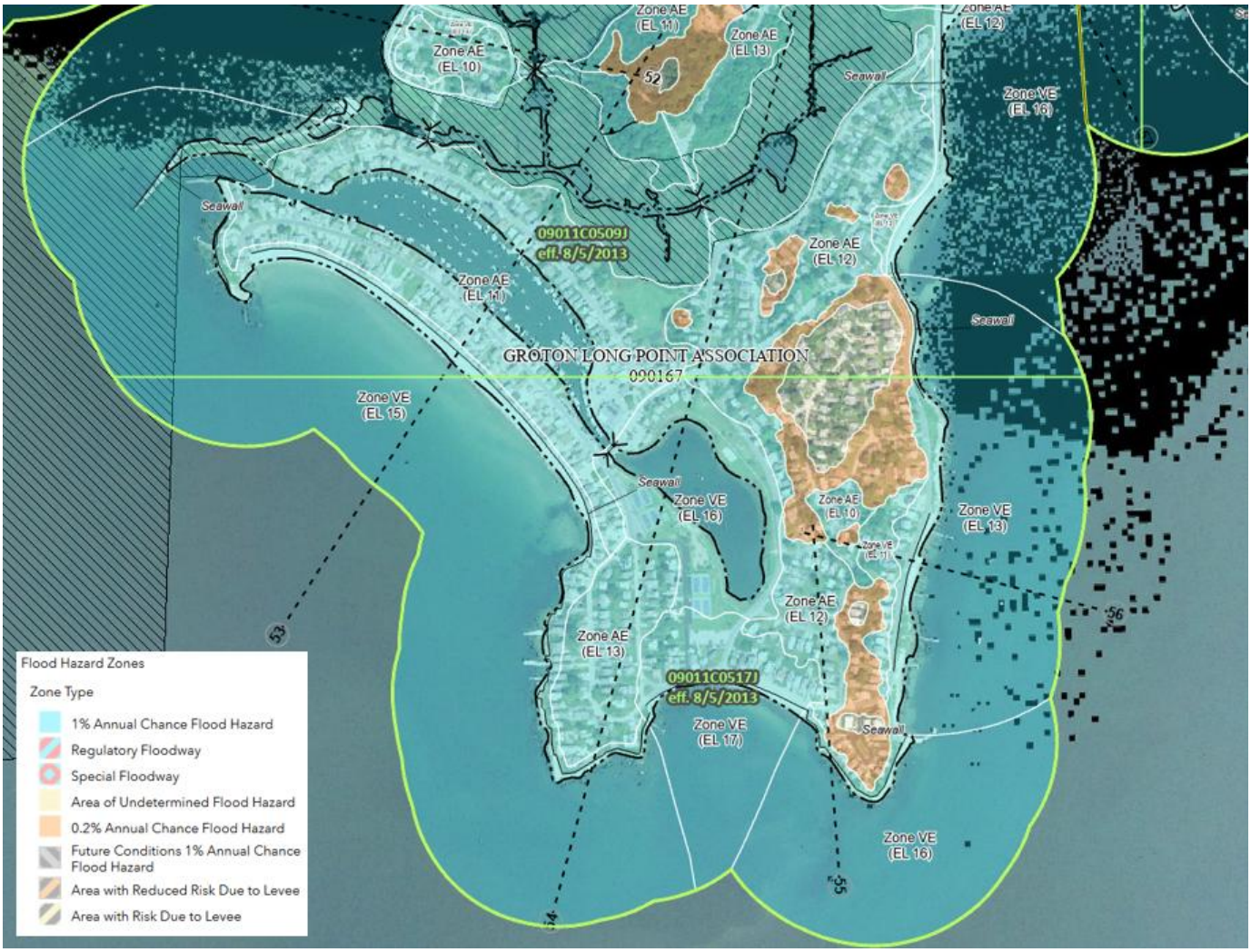


Figure 11: FEMA FIS Map

Figure 12: Flooding Pathways at Lower Stillwater Elevations - During Large Tides and 1-2 Year Storm Events

2.1.4 Updated Existing Conditions Plans

This portion of the project work was completed after the supplemental site visits, completed in January 2025. Existing Conditions Plans were developed at a conceptual design level for this project phase and can be seen in **Appendix D**. These drawings were developed in accordance with GLP Stakeholder feedback and guidance after review of a provided assessment using the PERSISTS decision support criteria, order-of-magnitude opinion of cost, permits likely, and potential funding sources.

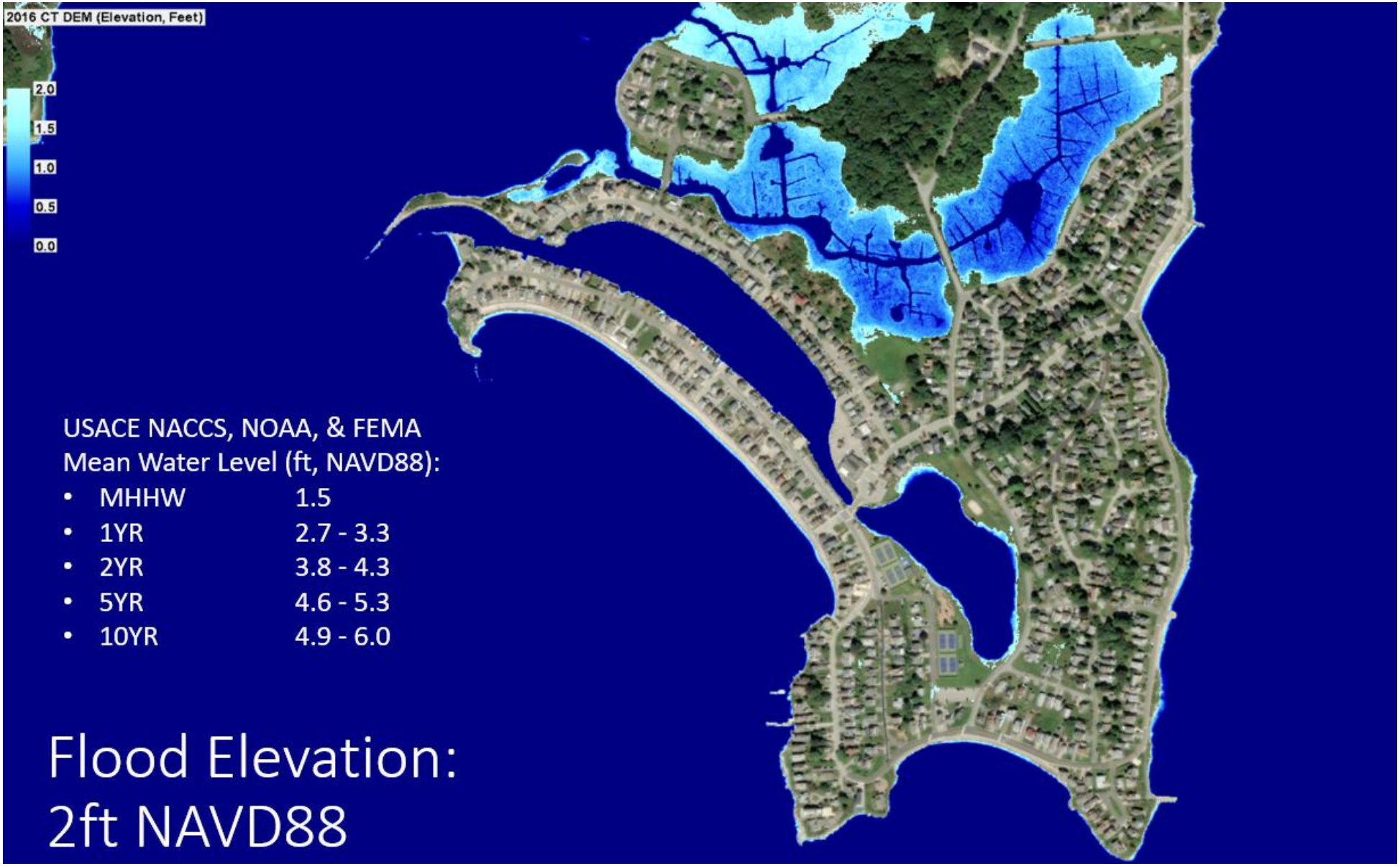


Figure 13: Modeled Flooding of GLP with a Stillwater Elevation of 2.0 Feet, NAVD88

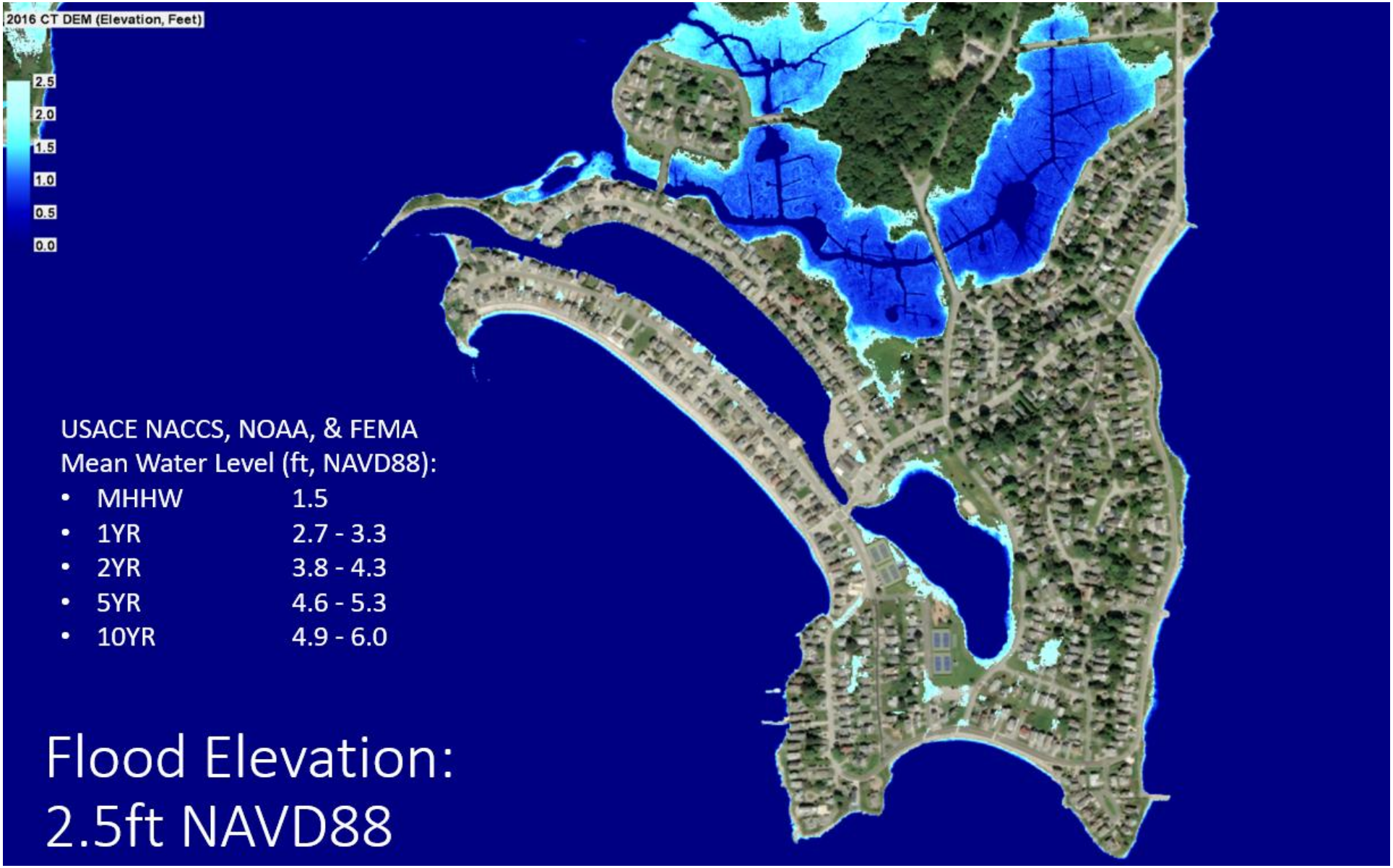


Figure 14: Modeled Flooding of GLP with a Stillwater Elevation of 2.5 Feet, NAVD88

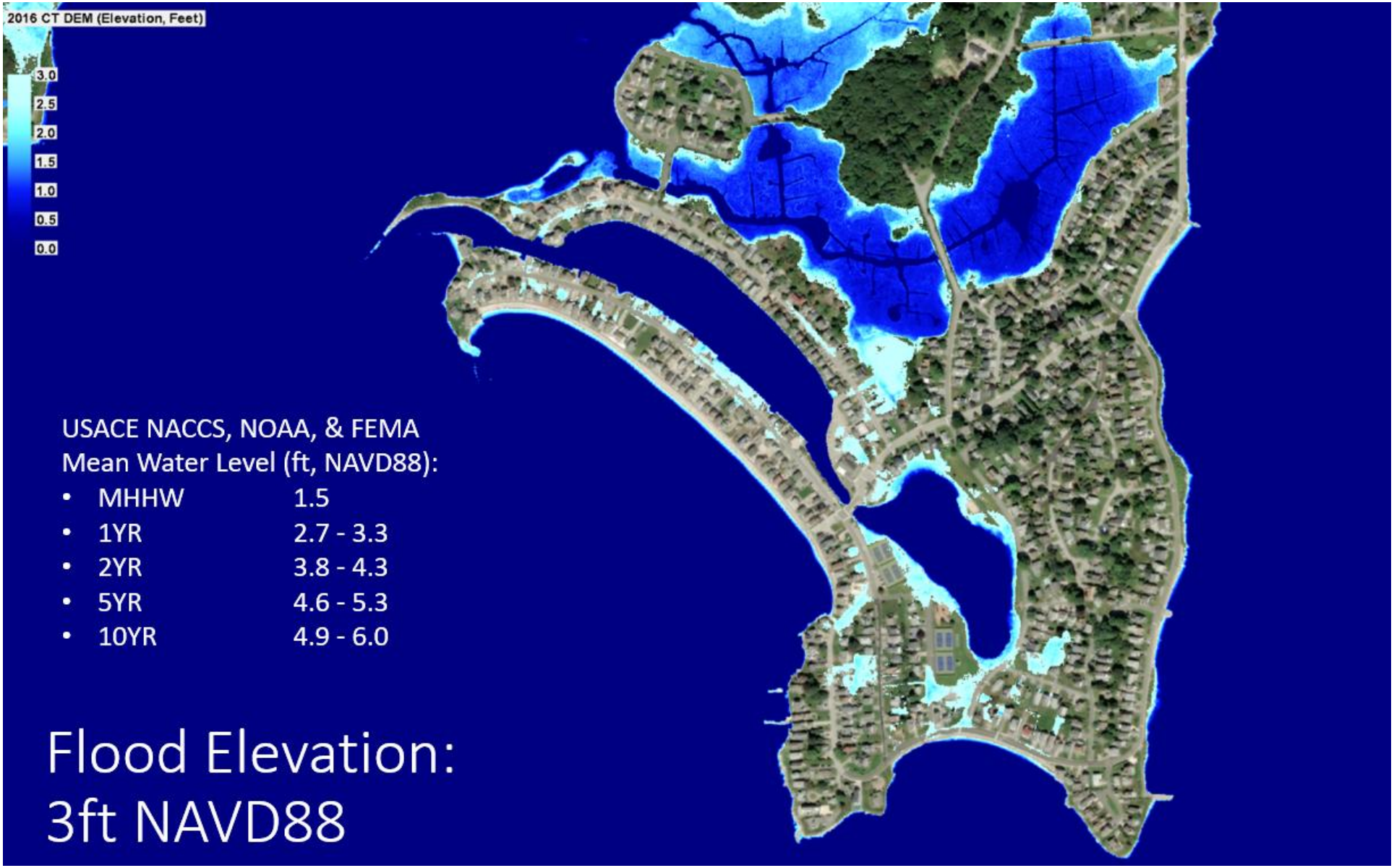


Figure 15: Modeled Flooding of GLP with a Stillwater Elevation of 3.0 Feet, NAVD88

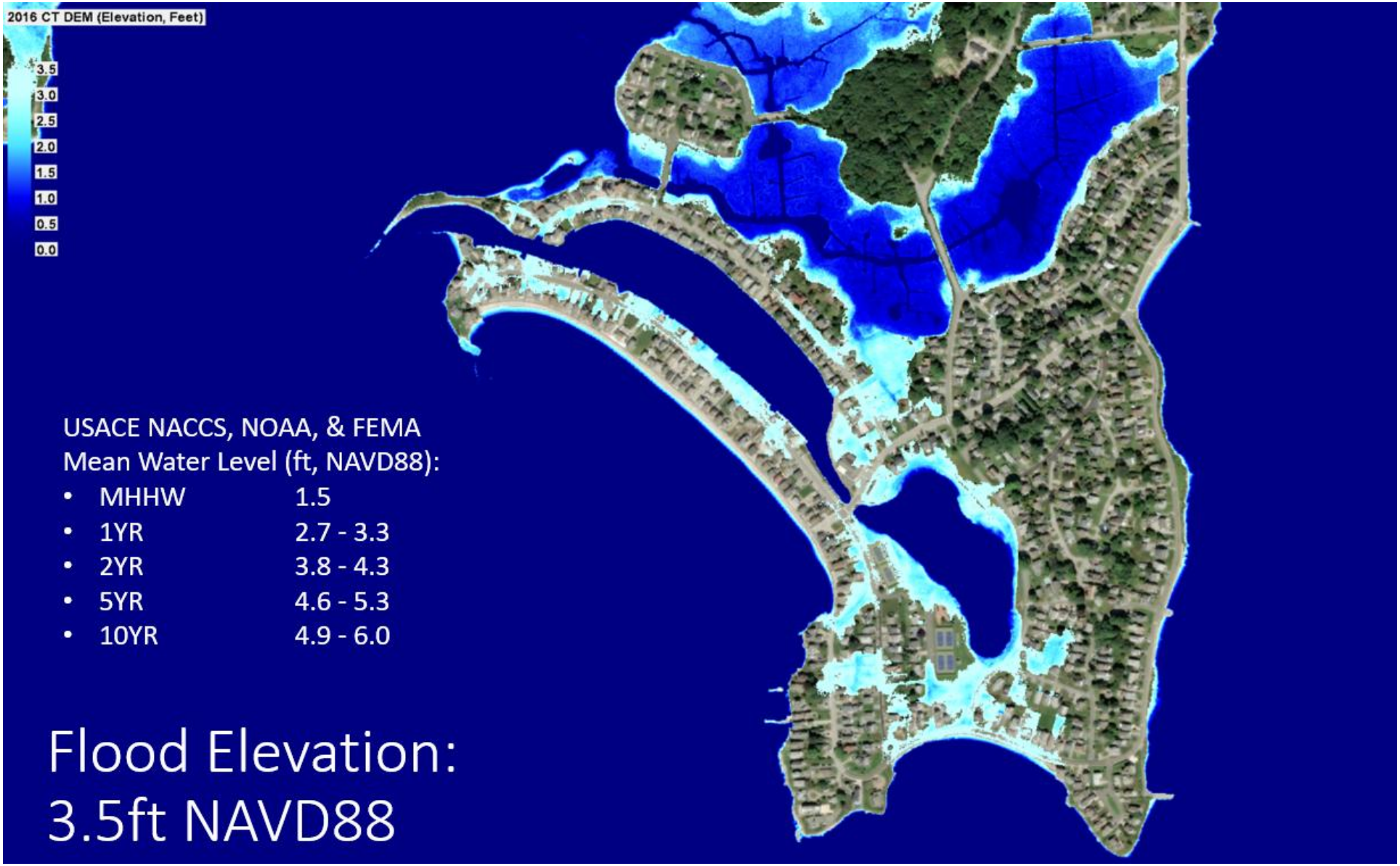


Figure 16: Modeled Flooding of GLP with a Stillwater Elevation of 3.5 Feet, NAVD88

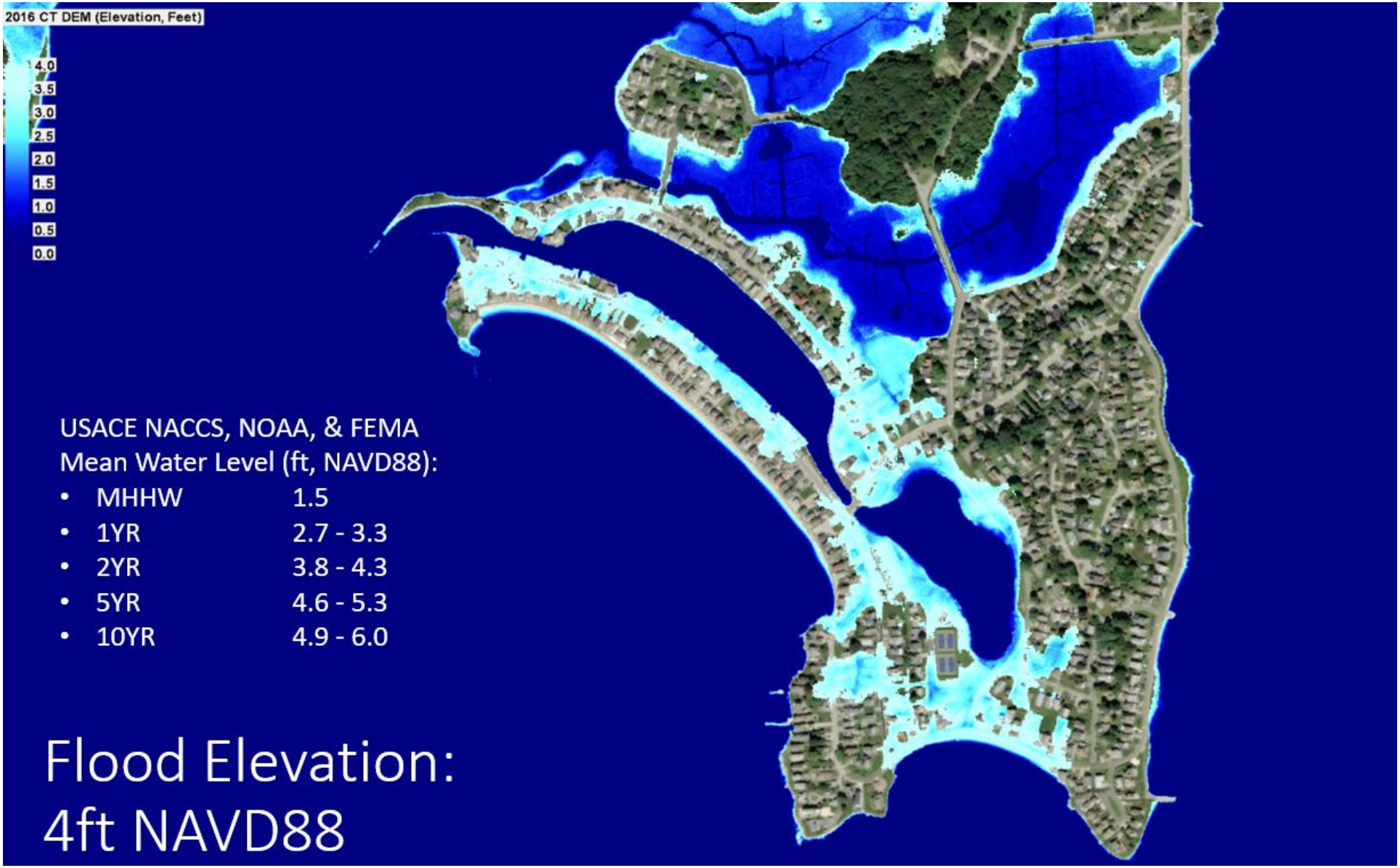


Figure 17: Modeled Flooding of GLP with a Stillwater Elevation of 4.0 Feet, NAVD88

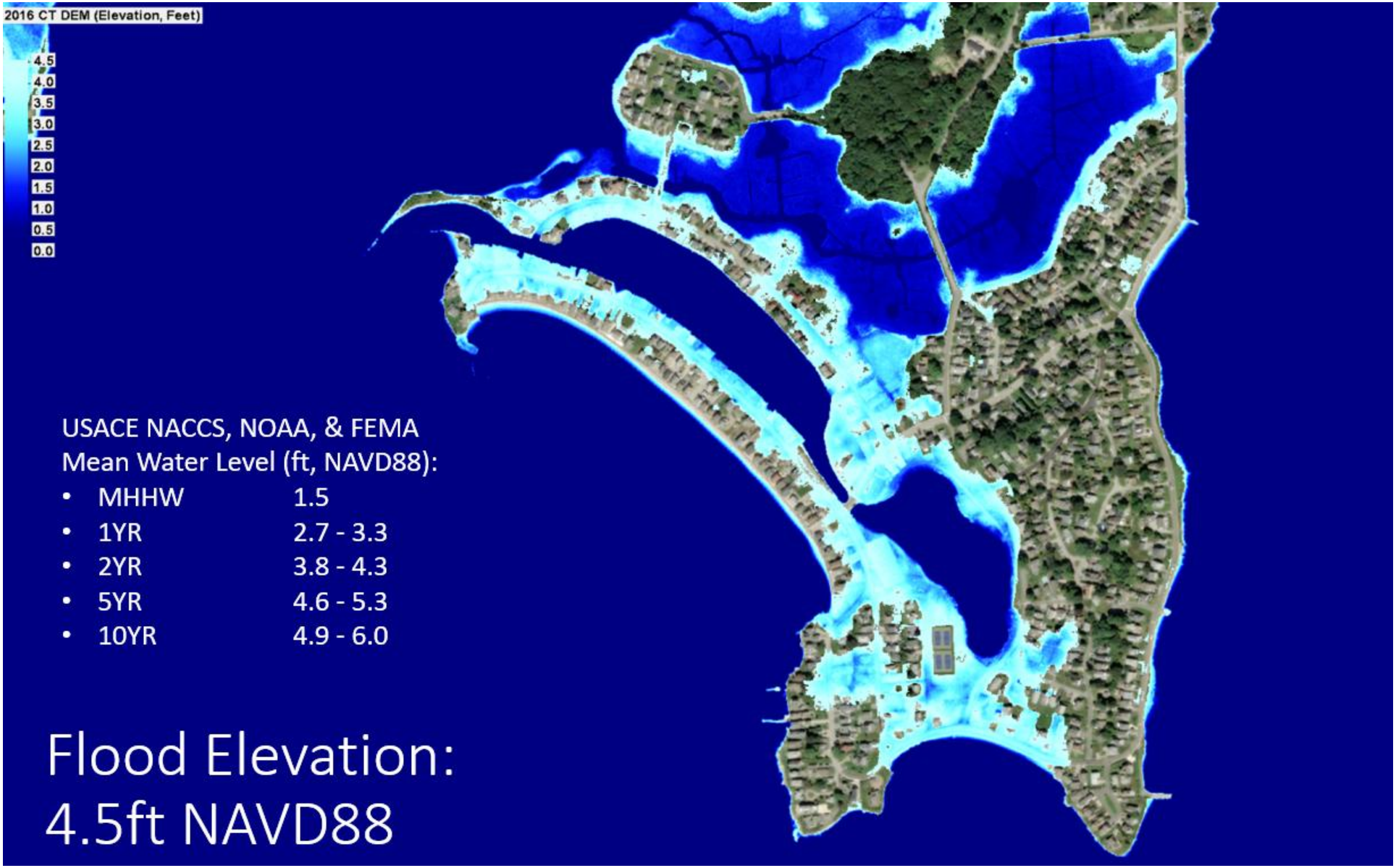


Figure 18: Modeled Flooding of GLP with a Stillwater Elevation of 4.5 Feet, NAVD88

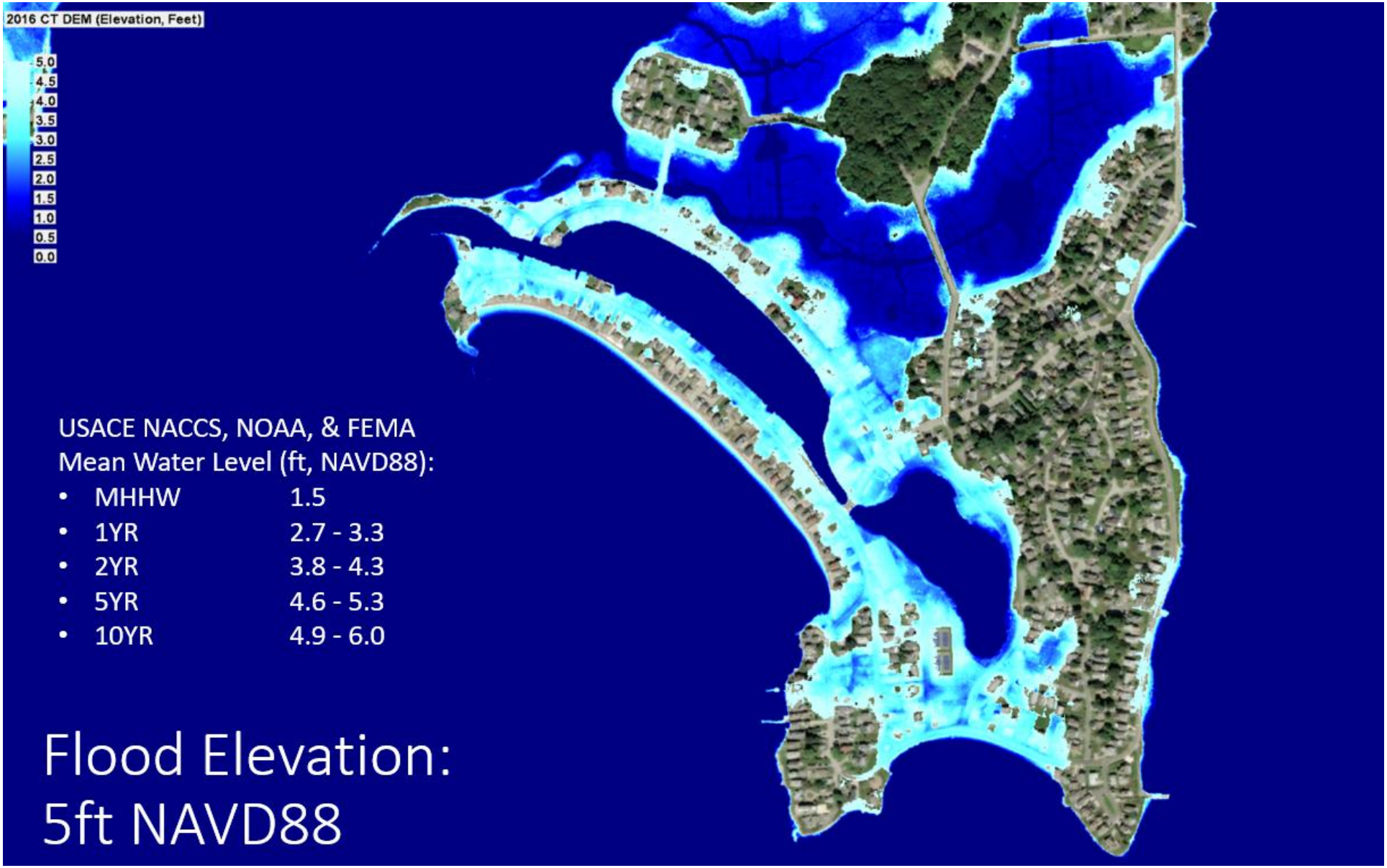


Figure 19: Modeled Flooding of GLP with a Stillwater Elevation of 5.0 Feet, NAVD88

3.0 PROJECT RESULTS

3.1 TASK A: FORM AND COORDINATE WITH STAKEHOLDER GROUPS

Subtask A.1: Project Initiation

GZA completed a kick-off meeting with the project team and reviewed the project goals and needs and attended meetings with UCONN, SRC representatives, and GLP to discuss the stakeholder group make-up and identify key stakeholder contacts on May 7, 2024.

Subtask A.2: Progress Meetings (Approximately 100% Complete)

GZA met with GLP stakeholder representatives typically biweekly, since the project kickoff. Stakeholder representatives included:

- Glenn Lussier – GLP Public Works Director
- Joe Orchardo – GLP Long Range Planning Director

3.2 TASK B: ESTABLISH GOALS AND VISION

GZA, through discussion with GLP representatives, understands that GLP has developed five "pillars" of resilience that affect the planned development of resilience improvements. These include:

1. Stormwater System Analysis and Improvements;
2. Public Safety Location and Readiness;
3. Shoreline Protection and Wave Attenuation;
4. Building Elevation in Line with Current and Future Floodplains;
5. Marsh Evaluation and Restoration.

These pillars aligned well with the previously completed GLPA Resilience Study completed by GZA. GZA carried forward conceptual project identification and conceptual design with the goal of addressing one or more pillars.

Additionally, based on the results of our existing conditions evaluation described in Section 2, GLP is highly exposed to flooding. For example, much of the GLP peninsula would be under several feet of water during the 100-year base flood. Flood protection alternatives given the degree of flood exposure would, by inspection, require large-scale intervention and potentially large, regional civil works beyond the scope of this project and the budget of GLP. As a result, GZA and GLP agreed to focus on projects geared towards allowing GLP to bounce back faster after floods. This resulted in focusing more on frequent events, projected mid-century high tide events, and drainage improvements to allow for the area to attain a dry condition more quickly after a flood. The focus toward mitigation of nuisance flooding is expected to effect a quality of life improvement based on present-day conditions and anticipated mid-century hydrology and hydraulics.

Several preliminary alternatives were developed based on our discussions with GLP representatives, our site visits, and our experience with similar projects, including:

1. Upper Lagoon Raised Walking Path/ Marsh Migration Area
    a. This concept would raise the low-lying land around the upper lagoon, approximately along the current walking path and prevent flooding pathways from occurring in the surrounding areas. This concept would not only reduce the flooding frequency around the upper lagoon, but allow for the marsh vegetation to have an area to retreat to as sea levels rise. This option would likely be expensive, require extensive permitting, and potentially damage currently vegetated areas.
2. Upper Lagoon Tide Gate
    a. This concept consists of the installation of a tide gate in the opening beneath the Beach Road bridge and would allow for restricted flow into the Upper Lagoon during flooding scenarios. The tide gate would allow for increased flood storage capacity in the Upper Lagoon but would be bypassed by overland flooding once the storm stillwater elevation could pass over the adjacent roadway.
3. West Shore Ave. Stormwater Improvements (Back-flow Preventors)
    a. Back-flow preventors or check valves are installed in line of the stormwater outfalls and only allow flow in one direction, stopping water from infiltrating from the coast and coming out of the low-lying catch basins and flooding roadways. While they are a relatively simple solution, to perform correctly regular maintenance including debris removal and biofouling checks are recommended.
4. West Shore Ave. Roadway Flooding Action (Storage/ pump)
    a. To reduce roadway flooding and standing water post storm events, sub-surface storage can be placed, along with a pump to remove the water. This alternative concept is suggested to be located at the West end of West Shore Ave where standing water and roadway flooding can be an issue. This concept would be located mostly below grade and have minor visual changes, but may be limited in its storage capacity with the high groundwater in the area.
5. Sports Field Roadway Berm
    a. This concept proposes installing a low berm at field end of the roadway/ driveway leading to the sports field to close off the flooding pathway from the marsh behind the sports field to Atlantic Ave. This concept is recommended to include bioswales along the sides of the driveway and is relatively low scale, natural solution, and can mitigate roadway flooding. This concept would likely require support from individual property owners and fill on some of these private lands.

GZA and GLP representatives reviewed the preliminary alternatives during our biweekly meetings. Based on guidance from the GLP stakeholders and the parameters of the QAPP and contracted scope of work, GZA and GLP selected stormwater and flooding analyses and improvements as part of this phase of work.

Project selection and concept designs are presented in Section 3.4.

3.3 TASK C: QAPP DEVELOPMENT

Following the grant requirements and EPA funding requirements, GZA has developed a QAPP for the project work. The QAPP development consisted of organizing data collection needs and measures and the project team to see the organization and quality of the work. The QAPP submittal went through EPA review and requests for minor revisions and was ultimately approved and received approval on November 6, 2024.

3.4 TASK D: DEVELOP A SUMMARY REPORT OF SERVICES PROVIDED - CONCEPTUAL DESIGN

Subtask D.1: Data Collection

In preparation of site visits, GZA reviewed existing information for the site(s), including Town GIS data, bathy-topo data, and other publicly available data from CT DOT and CT Department of Energy and Environmental Protection (DEEP), discussed in previous sections. This allowed for a streamlined site visit, allowing focus on key areas such as catch basins and the Upper Lagoon. GZA utilized a handheld GPS unit (Leica) to obtain spot measurements while in the field and periodically inspected the points to ensure desired horizontal and vertical accuracy. The field team also used measuring tapes, photographs, and field notes to best document the site conditions. See Section 2.2 for additional information.

Subtask D.2: Conceptual Design(s)

The conceptual design process included discussing the number of potential projects and project locations and vetting with GLP stakeholders. These locations and concepts were confirmed during site visits and subsequent virtual meetings where tables and figures were shared through presentation slides. Each conceptual design was formally developed and reviewed by the GLP stakeholders along with an assessment of the following, provided by GZA.

- Assessment using the PERSISTS (see below) criteria;
- Order-of-magnitude opinion of cost;
- Recommended future studies;
- Anticipated responsible parties;
- Permits likely to be required; and
- Potential funding sources.

The PERSISTS criteria was developed by the Connecticut Institute for Resilience and Climate Adaptation (2020) Resilient Connecticut Planning Framework. PERSISTS helps to move projects from the inception phase to implementation by providing specific criteria that helps project feasibility assessment and project prioritization. The PERSISTS acronym is broken down below with a synopsis of each based on a helpful guide developed by the Long Island Sound Resilience Resource Hub (https://www.lisresilience.org/a-guide-to-resilience-planning/):

P: Permittable. How likely is the project to get necessary permits and permissions and what is the anticipated difficulty in getting there?

E: Engaged. How does the project consider input from the community and impact to the community and neighboring communities?

R: Realistic. Can the project be realistically implemented based on community support, funding available, and the project scale?

S: Safe. Does the project maintain or enhance the wellbeing of the community?

I: Innovative. Has the process considered innovative approaches and nature-based solutions?

S: Scientific. Does the project incorporate the best available science?

T: Transferrable. Does the project serve as a model for other communities?

S: Sustainable. How does the project enhance the community and ecosystems today and in the future?

The PERSISTS acronym is not presented in order of importance; each of the eight criteria is of equal importance inherently, though certain criteria may not apply to every project or every site.

Overall, the PERSISTS criteria showed that many of the criteria rank similarly due to project location, the low-lying nature of the area, the community involved, and the space and design constraints (**Table 4**). Because of this, each of the concepts considered ranked similarly on Equitable, Realistic, Scientific, and Transferable criteria.

GZA found that there was room for innovation and sustainable designs to be incorporated into some projects, such as a marsh migration area in the raised walking path concept. This raised area would not only provide safety and benefits to the population that live in GLP, but also to the wetlands species around the lagoon and give them a place to move as sea levels rise. The exercise of reviewing these criteria helped the team to consider all impacts of each concept and how they might be incorporated into the larger picture of resiliency in the community.

To continue from the PERSISTS criteria, GZA reviewed 1) Order-of-magnitude Cost; 2) Recommended Future Studies; 3) Anticipated Responsible Parties; 4) Permits Likely; and 5) Potential Funding Sources for each of the concept designs (Table 5). GLP is a low-lying area with complicated stormwater and coastal systems that are recommended to be evaluated prior to final design. GZA recommended that most concepts have further Hydrologic and Hydraulic (H&H) Modeling before advancing to later stages of design. H&H modeling can help size stormwater infrastructure appropriately and assist in setting elevations of structures and earthen fill such that improvements do not have unintended consequences or make flooding problems worse in other areas. Based on GZA's history of work within the State of Connecticut and completing similar projects in the area, GLP may anticipate permitting with entities such as CT DEEP, the USACE and the Town of Groton. It is also recommended that GLP complete a pre-application meeting prior to final design of each project to make permitting more efficient and incorporate early feedback from permitting agencies into project design.

Potential funding sources for the projects discussed at this conceptual design phase include:

1) CT DEEP Climate Resilience Fund for Design and Permitting;

2) FEMA Flood Mitigation Assistance (FMA) 2026;

3) FEMA Hazard Mitigation Grant Program (HMGP) 2026;

4) Long Island Sound Futures Fund (NFWF/EPA /QAPP) with a 50% Match, Design/Planning Projects: $50,000 to $500,000 (2025 Notice of Funding Opportunity (NOFO) closed May 29, 2025 with funds awarded in November);

5) CT DEEP Matching Fund Grant Program for FEMA/NOAA/EPA Grants; and

6) National Coastal Resilience Fund (NCRF).

Historically, the CT DEEP Climate Resilience Fund would be a good choice for the community and type of work involved, however there is currently a break in funds. The NCRF fund primarily invests in nature-based solutions that protect coastal communities from coastal hazards. GZA recommends completing up-to-date research on funding opportunities as they may change after this report is finalized.

Two conceptual designs were selected by the GLP stakeholders to move forward to 30% design evaluations: the West Shore Ave Stormwater Improvements (backflow preventors) and Upper Lagoon Raised Walking Path concepts.

The West Shore Ave Stormwater Improvements (backflow preventors - Figure 2A in **Appendix D**, concept design drawings) are recommended to be installed in line of the 12" stormwater outfalls outlet pipes, just seaward of the last catch basin. These would only allow flow in one direction (towards the harbor/ ocean) and stop water from infiltrating from the coast and coming out of the low-lying catch basins and flooding roadways. The installation location at the catch basins allows for regular maintenance to be performed more easily and reduces potential failures in the system from things that would more likely occur at the seaward end, such as debris and biofouling.

The Upper Lagoon Raised Walking Path concept (Figure 1A in **Appendix D**, the concept design drawings) would raise the low-lying land around the upper lagoon, approximately to 3.5 ft, NAVD88. This grade raise would be located along the current walking path and prevent flooding pathways from the Upper Lagoon to the surrounding areas. This concept would not only reduce the flooding frequency around the Upper Lagoon but allow for the marsh vegetation to have elevated areas to retreat to as sea levels rise. The concept shows a low fill elevation (compared to the existing ground) and a relatively shallow slope, with a maximum of a 3ft horizontal to a 1 vertical, still allowing the raised area to be easily traversed. This option would tie into the higher existing ground elevations surrounding the lagoon and include the installation of backflow preventors in existing outfalls. Overall, it is likely to be expensive and require extensive permitting, however at the proper elevation this would reduce flooding of the surrounding areas which will become much more frequent as sea levels rise.

Table 4: PERSISTS (Permittable, Equitable, Realistic, Safe, Innovative, Scientific, Transferrable, Sustainable) Criteria Concept Review – Approximate Values

PERSISTS	Potential Benefit Compared to Others	Potential Drawback Compared to Others	1a. Upper Lagoon Raised Walking Path	1b. Upper Lagoon Tide Gate	2a. W. Shore Ave Stormwater Improvements (Back-flow)	2b. W Shore Ave Roadway Flooding Action (Storage/ pump)	3. Sports Field Road Berm
Permittable	Are there historic or ecological sensitivities to consider in the project area?		Yes, marsh	Yes, marsh/ benthic	No	No	Yes, marsh
	What Federal, State, and local permits would be required and is it likely the project can get all necessary permits?		DEEP; USACE; Town of Groton	DEEP; USACE; Town of Groton	DEEP	DEEP	DEEP; USACE; Town of Groton
	How long is the permitting process likely to take?		2+ Years	2+ Years	0.5-1 Year	1 Year	1 Year
Equitable	Does the alternative reduce risk and/or provide benefits to vulnerable populations?		No	No	No	No	No
	Have community members been involved in developing the strategy or project?		Yes	Yes	Yes	Yes	Yes
	Does the alternative increase or decrease environmental burdens for the community; or increase environmental justice?		No Change	No Change	No Change	No Change	No Change
Realistic	Is the project approach reasonably proportionate to the identified problem? (This indicates a realistic pathway for funding)		Yes	Yes	Yes	Yes	Yes
	Are there state or federal grants available to help with implementation?		Yes	Yes	Yes	Yes	Yes
	Is there potential for local or state match funding for implementation?		Yes	Yes	Yes	Yes	Yes
Safe	Does the project reduce risks to people, infrastructure or critical community lifelines?		Yes	Yes	Yes	Yes	Yes
	Does the project potentially decrease or increase emergency response needs in the area?		No Change	No Change	Decrease	Decrease	No Change
	Does the project improve mobility without increasing evacuation needs?		Yes	Yes	Yes	Yes	Yes
Innovative	Is there an opportunity to apply a new approach to planning, design, engagement, or financing that has been successful in other places?		Yes	Yes	No	Yes	Yes
	Is there an opportunity to incorporate nature-based solutions and improve ecological function as part of the adaptation strategy?		Yes	No	No	Yes	Yes
Scientific	Does the project utilize the best available local climate science from CIRCA and/or Governor's Council on Climate Change (GC3) Science and Technology Working Group?		Yes	Yes	Yes	Yes	Yes
Transferable	Do the benefits of implementing the project extend beyond the local community?		No	No	No	No	No
	Does the project create a model for local, state, or Federal funding in CT?		No	No	No	No	No
Sustainable	Is there strong support from political leadership, municipal staff, and the local community to implement the strategy or project?		Yes	Yes	Yes	Yes	Yes
	Is there potential significant state support for the project (state agency involvement, state or regional priority, etc.?		No	No	No	No	No
	Would ecosystem services and ecological functions be improved or impaired?		Yes	No	No	No	Improved
	Does the project increase or decrease the potential for carbon emissions?		No	Increase	No	Increase	Decrease

Table 5: Decision Criteria: Cost; Recommended Future Studies; Anticipated Responsible Parties; Permits Likely; and Potential Funding Sources

Alternative	Order of Magnitude Construction Cost*	Recommended Future Studies	Anticipated Parties Responsible for Implementation	Permits Likely Required	Potential Funding Sources	Initial Rank
1a- Upper Lagoon Raised Walking Path (~2,300 lft)	Berm cost: $262k ($114/lft) Sidewalk: $138k ($60/lft) **Total: $400k**	Yes – H&H modeling	Contractor	DEEP; USACE; Wetlands and Watercourses Permit	**1)** CT DEEP Climate Resilience Fund for Design and Permitting (best choice- no match- but not sure when it will come out in 2026) **2)** FEMA Building Resilient Infrastructure and Communities (BRIC) 2026 **3)** FEMA Flood Mitigation Assistance (FMA) 2026 **4)** FEMA Hazard Mitigation Grant Program (HMGP) 2026 **5)** Long Island Sound Futures Fund (NFWF/EPA /QAPP) 50% Match Design/Planning Projects: $50,000 to $500,000 (2025 NOFO was open in May, but funds awarded in November) **6)** CT DEEP Matching Fund Grant Program for FEMA/NOAA/EPA Grants **7)** National Coastal Resilience Fund (NCRF)	2
1b - Upper Lagoon Tide Gate	**$500-800k**	Yes – H&H modeling	Contractor	DEEP; USACE; Wetlands and Watercourses Permit		4
2a - W. Shore Ave Stormwater Improvements (black-flow preventors)	**$10k/each**	Flush out/ check for blockage	Community/ Contractor	Construction General Permit		1
2b - W Shore Ave Roadway Flooding Action (Storage/ pump)	**$500k-$1M**	Yes – H&H modeling	Contractor	Construction General Permit		5
3 - Sports Field Road Berm and Bioswale	Berm: $20k ($114//lft) Bio-Swale: $6k ($58/lft) ($400 maintenance/yr) **Total: $30k**	Yes – H&H modeling	Contractor	DEEP; USACE; Wetlands and Watercourses Permit		3

*These values are approximate and subject to change given many factors including time/ date of construction, materials cost, and contractor availability

3.5 TASK E: SUBMIT ALL FINAL PRODUCTS DEVLEOPED THROUGH SERVICES

This task is completed at the end of the project, with the submittal of this Final Summary Report and the reports previously submit (1-year update report, the 6-month update report, and the QAPP). Conceptual designs have also been completed and delivered to the client.

4.0 CONCLUSIONS/ RECOMMENDED FUTURE ACTIONS

GZA has completed project initiation, established the overall goals and visions with GLP and stakeholders, QAPP development and approval, site visit tasks, and conceptual designs. Next steps involve future phases and contracts with the GLP Stakeholders and include hydraulics and hydrology modeling to appropriately understand stormwater processes and solutions, as well as the advancement of selected conceptual designs to 30% design.

GZA's work has the following key findings for this conceptual design phase:

- Project goals were refined to focus on the ability of GLP to "bounce back" from floods more quickly;
- Key focus areas include low-lying roadways and other low-lying areas around the Upper Lagoon and West Shore Avenue that act as flood pathways that could result in frequent high-tide flooding of GLP, particularly as projected during mid-century conditions;
- The conceptual designs developed are intended to improve the quality of daily life for GLP residents, but due to the low elevations throughout Groton Long Point, they cannot protect the area from flooding during large coastal floods (approximately 10-year recurrence interval and greater). Such large floods would require a larger-scale, regional type of flood protection project beyond the scope of this project;
- Concept designs have been completed and are included in the body of this report; and
- Future design phases (e.g., 30%, 60%, permitting, etc.) are recommended to advance these design concepts.

An updated schedule showing project completion has been included as **Appendix B**.

Appendix A - Limitations

USE OF REPORT

1. GeoEnvironmental, Inc. (GZA) prepared this Report on behalf of, and for the exclusive use of the Groton Long Point Association for the stated purpose(s) and location(s) identified in the Report. Use of this Report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

STANDARD OF CARE

2. Our findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Report and/or proposal and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this Report may be found at the subject location(s).
3. The interpretations and conclusions presented in the Report were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of the described services. The work described in this Report was carried out in accordance with the agreed upon Terms and Conditions of Engagement.
4. GZA's elevation, hydrologic, and hydraulic evaluation was performed in accordance with generally accepted practices of qualified professionals performing the same type of services at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made. The findings are dependent on numerous assumptions and uncertainties inherent in the assessment process. The findings of the evaluation are not an absolute characterization of actual risks, but rather serve to highlight potential sources of risk at the site(s).
5. The study included review of flood elevations developed for the current climate.
6. Unless specifically stated otherwise, the evaluations performed by GZA and associated results and conclusions are based upon evaluation of historic data, trends, references, and guidance with respect to the current climate and sea level conditions. Future climate change may result in alterations to inputs which influence flooding at the site (*e.g.*, rainfall totals, storm intensities, mean sea level, *etc*.). Such changes may have implications on the estimated flood elevations, flood frequencies and/or other parameters contained in this Report.

RELIANCE ON INFORMATION FROM OTHERS

7. In conducting our work, GZA has relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Any inconsistencies in this information which we have noted are discussed in the Report.

COMPLIANCE WITH CODES AND REGULATIONS

8. We used reasonable care in identifying and interpreting applicable codes and regulations necessary to execute our scope of work. These codes and regulations are subject to various, and possibly contradictory, interpretations. Interpretations with codes and regulations by other parties are beyond our control.

COST ESTIMATES

9. Unless otherwise stated, our cost estimates are for comparative, or general planning purposes. These estimates may involve approximate quantity evaluations and may not be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over the labor and material costs required to plan and execute the anticipated work, our estimates were made using our experience and readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

ADDITIONAL INFORMATION

10. In the event that the Client or others authorized to use this Report obtain information on conditions at the site(s) not contained in this Report, such information shall be brought to GZA's attention forthwith. GZA will evaluate such information and, on the basis of this evaluation, may modify the opinions stated in this Report.

ADDITIONAL SERVICES

11. GZA recommends that we be retained to provide services during any future investigations, design, implementation activities, construction, and/or property development/ redevelopment at the Site. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

Appendix B - Schedule

Updated Schedule

	2024								2025						
Task	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**% Complete**
Task A.1: Project Initiation															100%
Task A.2: Progress Meetings															100%
Task B: Establish Goals and Vision															100%
Task C: QAPP Development															100%
Subtask D.1: Data Collection															100%
Subtask D.2: Conceptual Design(s)															100%
Task E: Submit All Final Products															100%

*Percent of each task completed at the time of the 1-year report submittal

Appendix C – Quality Assurance Project Plan (QAPP)

Quality Assurance Project Plan for Concept Design for Priority Projects Identified in the Groton Long Point Association Resiliency Plan LI-00A01412 - Connecticut Sea Grant, Long Island Sound Study Project QA # 24221

Prepared by
GZA GeoEnvironmental, Inc. in coordination with the Groton Long Point Association, Connecticut

Prepared for
EPA Region 1 (New England)
5 Post Office Square - Suite 100
Boston, MA 02109-3912
1-888-372-7341

Approvals Signature (required prior to project start):

_____ Date: 10/24/24
Joseph Orchardo
Groton Long Point Association
Director of Long Range Planning – Public Works

_____ Date: 10/24/2024
Glenn Lussier
Groton Long Point Association
Director – Public Works

_____ Date: October 21, 2024
David M. Leone, P.E., CFM
Project Lead, GZA GeoEnvironmental, Inc.
Associate Principal

_____ Date: _October 21, 2024_____
Wayne Cobleigh, CPSM
QA Officer, GZA GeoEnvironmental, Inc.
Associate Principal

_____ Date: _____
Carly Boyd
U.S. Environmental Protection Agency
EPA QA Reviewer

_____ Date: _____
Nicole Tachiki
U.S. Environmental Protection Agency
Project Officer

SARAH SCHECHTER
_____ Date: 10/25/2024
Sarah Schechter
SRC, EP, Project Manager

Table of Contents

1.0 PROJECT MANAGEMENT

1.1 Title and Approval Page (EPA QA/R-5 A1) - See page 1.

1.2 Table of Contents (EPA QA/R-5 A2) - See pages 2 - 4.

1.3 Distribution List (EPA QA/R-5 A3)

Name: Joseph Orchardo
Title: Director of Long Term Planning
Organization: Groton Long Point Association
Contact Information: 860-536-4736; jrorchardo@gmail.com

Name: Glenn Lussier
Title: Director – Public Works
Organization: Groton Long Point Association
Contact Information: 860-536-4736; glenn.lussier@gmail.com

Name: David M. Leone, P.E., CFM
Title: Project Lead, Associate Principal
Organization: GZA GeoEnvironmental, Inc.
Contact Information: 781-603-9879; davidm.leone@gza.com

Name: Wayne Cobleigh, CPSM
Title: QA Officer, Associate Principal
Organization: GZA GeoEnvironmental, Inc.
Contact Information: 860-250-6790; wayne.cobleigh@gza.com

Name: Michael Gardner
Title: Project Manager
Organization: GZA GeoEnvironmental, Inc.
Contact Information: 781-327-9323; michael.gardner@gza.com

Name: Carly Boyd
Title: EPA QA Reviewer
Organization: U.S. Environmental Protection Agency
Contact Information:

Name: Nicole Tachiki
Title: Project Officer
Organization: U.S. Environmental Protection Agency
Contact Information:

Name: Sarah Schechter
Title: Long Island Sound Study SRC Eastern Connecticut Extension Professional
Organization: Connecticut Sea Grant and University of Connecticut
Contact Information: 860-405-9215; sarah.schechter@uconn.edu

1.4 Project Organization (EPA QA/R-5 A4)

This study is being performed by GZA GeoEnvironmental, Inc. (GZA) in concert with the Groton Long Point Association (GLPA). The Project Team includes the key representatives from GLPA and GZA that will receive copies of this Quality Assurance Project Plan (QAPP), and any approved revisions of this plan. See Figure 1-1. Organization Chart for an overview of the project roles for each Project Team member. Once approved, this QAPP will be available to any interested party by requesting a copy from the project management.

1.5 Problem Definition/Background (EPA QA/R-5 A5)

Groton Long Point (GLP) is situated in the southeast region of Connecticut. GLP is located on a peninsula, bordered on the west by Mumford Cove and on the south and east by Fishers Island Sound and on the north by Groton Long Point Road. The GLP study area is approximately 0.5 square miles, containing residential development, sandy beaches, salt and freshwater marshes, and wooded areas featuring nature trails. A harbor has been created in the lagoon protected by a sandy spit; the upper portion of the lagoon forms a sheltered pond. GLP is accessible by car via the Palmer Cove bridge and causeway, or by foot or bicycle through Haley Farm and Mumford Cove Association (see **Figure 2-1**).

This project proposes to develop conceptual designs for priority projects identified in the Groton Long Point Association Resiliency Plan, which GZA originally developed in 2023, to help the Groton Long Point Association plan for and create a more resilient Groton Long Point. The project's conceptual design development is an important next step in the process of mitigating the vulnerabilities of Groton Long Point to natural hazards in a systemic manner and will provide input and support for a comprehensive approach to prioritize resiliency projects.

1.6 Project/Task Description and Schedule (EPA QA/R-5 A6)

The objective of this project is to develop conceptual designs for priority projects (up to four projects / sites) identified in the GLP Resiliency Plan to mitigate the risk posed by stormwater, coastal flood hazards, and climate change interactions to GLP area located in the Town of Groton. The objective of this document is to identify the quality assurance components that are necessary to implement the project activities. This objective will be achieved by using accepted methodology (e.g., Federal Emergency Management Agency (FEMA), State of Connecticut, U.S. Army Corps of Engineers) to collect, measure, analyze, and interpret physical asset and natural hazard data that will be used as input to the conceptual design of mitigation measures. Some examples of where guidance will be pulled from are the following: Guidance for FEMA's Risk Mapping, Assessment and Planning, USACE's Comprehensive Evaluation of Projects with Respect to Sea-Level Change, and USACE Coastal Risk Reduction and Resilience.

GLP has previously developed a Resiliency Plan to assess or mitigate the risks associated with natural hazards. This project will advance one or more of the following natural hazard mitigation measures to a conceptual design phase:

- Shoreline stabilization through nature-based structures such as living shorelines,
- Stormwater management improvements (pilot project scale),

- Sustainable erosion protection and beach restoration.

GZA will have responsibility for completing the concept design based on the action items listed above. GZA has extensive project experience focused on climate resilience and adaptation planning, natural hazard mitigation planning, and resiliency assessments. GZA completed the GLP Resiliency Plan in 2023. GZA has completed numerous projects focused on these services in the state of Connecticut.

This project will not directly lead to built structures that require permits or compliance with comprehensive management plans. **Additional design phases and engineering analyses are necessary prior to permitting and construction.** The concept designs will incorporate the sea level rise scenario adopted by the state of Connecticut as required by the Connecticut General Statutes (CGS) Section 25-68o(b).

Project objectives will be achieved by using the following approach for collection of data. This will include review of previous plans, existing mapping, and other available existing resources from authoritative sources (e.g., the Town of Groton, Southeastern Connecticut Council of Governments (SCCOG), the State of Connecticut, Connecticut Institute for Resilience and Climate Adaptation (CIRCA), federal government agencies such as the National Oceanic and Atmospheric Administration, FEMA, U.S. Army Corps of Engineers (USACE)).

GZA will apply this approach to the categories of data collections in the following chronological order:

- Secondary Data Collection: secondary data will be collected by reviewing published geospatial, natural hazard, and modeling data. Most secondary data collection has been completed as part of the 2023 Resiliency Plan effort (covered in QAPP for NFWF Project No. 73368, November 2022).
- Primary Data Collection: primary data will be collected on-the-ground.

Note that no input from the general public will be formally collected as part of this effort. Public input was obtained in the earlier planning phase of work to identify priority projects that were advanced to this concept level design phase of work. A technical advisory committee consisting of GLP board and resilience committee personnel, the Town of Groton resilience manager, and Connecticut Sea Grant representatives will be formed to provide input through a series of virtual meetings.

Data to be collected in each of these categories are described below in chronological order, and data quality objectives for the Project are described in Section 1.3.

Estimated Project Schedule

Task	Start Date	Approximate Duration (days)	End Date
Progress Meetings (Monthly)	July 2024	335	June 20225
QAPP Development	July 2024	167	December 2024
Six-Month Summary Report	11/04/2024	46	12/20/2024
Secondary Data Collection	11/04/2024	52	12/26/2024
Primary Data Collection	1/06/2025	82	03/29/2025

One-Year Summary Report	12/20/2024	168	06/06/2025
Final Summary Report	06/06/2025	21	06/27/2025
Conceptual Design(s)	12/20/2024	168	06/06/2025

Secondary Data Collection

Most data collected for this project will be secondary data. The secondary data falls into the two general categories of (1) infrastructure/asset data and (2) natural hazard data. Most secondary data has already been collected as noted above. This effort will include checking the secondary data below for updates since the completion of the 2023 Resiliency Plan. **Table 1** includes the constituents to be evaluated.

Secondary data will be used to provide the starting basis for the conceptual design work. Upon collection of the secondary data, the GZA Project Team will utilize the infrastructure/asset data, natural hazard data and the modeling assessment data outlined in **Table 2** to develop specific conceptual design alternatives. For example, existing waterfront structures data, building data, topographic data, in combination with sea level rise data from CIRCA and FEMA flood data as outlined in **Table 2** will be used to identify specific alternatives for concept design of additional shoreline protection features.

GZA will utilize existing publicly available modeling assessment data and will not be conducting additional modeling for this project.

Primary Data Collection

Primary on-the-ground data (e.g., inventory of resources and infrastructure) will be collected in future project phases to supplement existing data sources (secondary data, discussed below). The GZA Project Team will collect project data. The GZA Project Team consists of a principal-in-charge, project manager, QA/QC consultant reviewer (QA Officer), senior resiliency planner, vulnerability assessment lead, permitting and regulatory compliance lead, geospatial team lead, resiliency funding lead, stormwater planning lead, and staff engineers and planners. Volunteers will not be involved in technical data collection activities.

The on-the-ground data inventory will be developed using site visits that will be determined based on the criteria outlined in Section 1.3, including photographic documentation and visual assessments. This data will be collected in the study area within the geographical area of the grant.

The overall project timeline is May 2024 through June 2025. Required measurements including a field survey and inventory of buildings and community assets will begin upon approval of this QAPP and continue through June 2025 (weather permitting)**.** GZA will conduct site visits and inventory of GLP stormwater assets for up to a total of five 8-hour days. The data collection will be performed by two members from GZA's Project Team. Physical data will be collected through traditional manual methods, including visual observation, photo documentation, use of a tape measure, and survey equipment as described in Section 2.2. The data (or constituents) to be collected during the site visits will include those listed in **Table 2**.

Analytical Tools

Limited analytical tools may be used to aid in the conceptual design process. This is anticipated to include widely used software programs including Microsoft Excel, AutoCAD, or Esri ArcGIS. Application of analytical tools will be conducted primarily using secondary data but may be supplemented by primary data where secondary data is missing.

1.7 Quality Objectives and Criteria for Measurement Data (EPA QA/R-5 A7)

This project's conceptual design development is an important next step in the process of mitigating vulnerabilities of Groton Long Point in a systemic manner and will provide input and support for a comprehensive approach to prioritize resiliency projects. Conceptual designs may include enhanced roadway crossings, shoreline stabilization through both soft and hardened structures and living shorelines, stormwater management improvements, erosion protection, managed retreat (e.g., potential relocation of emergency services buildings), ecological restoration, and sustainable beach nourishment. These solutions will work in conjunction with the themes listed in the 2020 Long Island Sound Study (LISS) Comprehensive Conservation and Management Plan Implementation Actions and the PERSISTS (Permittable, Equitable, Realistic, Safe, Innovative, Scientific, Transferrable, Sustainable) criteria (along with stakeholder feedback) will be used to rank and prioritize projects.

1.7.1 Objectives and Project Decisions

The quality objectives for the project are accuracy, precision, completeness, representativeness, and comparability, including the performance and acceptance criteria to achieve these objectives. Data Quality Objectives (DQOs) for each category of data collection are described below.

1.7.2 Action Limits/Levels

Analytical parameters for this project will be based on field analyses. GPS and publicly available survey data accuracy will be provided. See **Table 1-1** for details.

Secondary Data Collection

We will select secondary data from authoritative government sources using the geographically specific data available for the infrastructure and assets, natural hazards and modeling assessment data based on the parameters (i.e., constituents and units) outlined in **Table 1.** However, specific parameters will be available from different data sources. For the infrastructure and asset data, the Project Team will inventory the Town of Groton GIS first. Next the Project Team will inventory, and reference state data sources as outlined in Table 2 such as the CT DEEP or CT DOT. The outcome of the asset data assessment will be selection of asset data for use in the later concept design phase, including usage in base plan drawings.

Similarly for natural hazard data, we will first utilize and reference the flood elevations (in feet) and flood inundation areas in GLP from FEMA's Flood Insurance Rate Maps (FIRMs) and Flood Insurance Study (FIS) for present-day flood hazards. The projected flood elevations (in feet) and flood inundation areas in

GLP based on the CIRCA findings and guidance on changes in climate hazards due to climate change will then be checked. Finally, we will evaluate the flood elevation (in feet) data from federal sources such as the USACE, FEMA, and NOAA to add other findings and guidance regarding changes in flood hazards due to newer data or climate change interactions.

For natural hazard data, GZA will assess water surface elevations for the current (2024) 100 and 500-year recurrence interval floods, as well as water surface elevations for those events in 2050. The flood elevations for each data source outlined in Table 2 are in the NAVD88 vertical datum. This will allow the project team to compare the flood hazard data over time using the flood elevations in feet using a consistent vertical datum in the conceptual design of mitigation measures.

We will use the most recent publicly available data sources. Data sources referenced in **Table 1** include the most recent data sources at the time of preparing this QAPP and is considered to be the best available information. The most recent FEMA flood hazard data is based on a 2012 hydraulic and hydrologic study of the GLP and surrounding area as presented in the FEMA Flood Insurance Study (FIS). For climate projections, data will be analyzed from present day (2022) through 2050 based on CIRCA's recommendation**,** and GZA will follow State of Connecticut guidance and use climate projections from CIRCA for 2050. Natural hazard data may represent varying time scales (i.e., present day or 2050) and geography. Asset data will not vary. Each of the natural hazard data sources are listed in **Table 1** and include the most recent source dates for the CIRCA (i.e., 2019), NOAA (2022), and USACE (2015) sea level rise projection data.

Note that new data may become available during this project that results from a change in guidance based on a new FEMA or NOAA study that includes more up to date sea level rise data projections compared to the projections from CIRCA. If new data does become available, the project team will coordinate with GLP to determine if the project schedule will support integrating such data on a case-by-case basis.

Sources of secondary data will be considered reliable if they meet at least one of the following acceptance criteria:

- The data are from a peer-reviewed, industry-specific source
- The source is state or federal government
- The information or data are from a group deemed credible by CT DEEP and/or CIRCA as outlined in the Connecticut state guidance.

In addition to meeting the criteria above, the secondary data will be reviewed by GZA based on our experience performing similar work and engineering judgment.

Primary Data Collection

Data quality assurance is a function of the experience of the project team and the quality control process integrated into GZA activities. The GZA project team members conducted similar studies, including a similar field survey for a study in Downtown Westport, CT as part of the Downtown Westport Resiliency and Recovery Plan, completed in 2018. Quality objectives in this context include:

- Accuracy: Field staff will proofread data entry. GZA's project team also includes an independent QA/QC role who is not involved in project day-to-day activities and will provide review of project deliverables.
- Precision: The same field staff and the same equipment will be used throughout the work. Measurements will be obtained using the same standard operating procedure.
- Completeness: Data will be checked by field staff and independently reviewed by a QA/QC Consultant/Reviewer (QA Officer) assigned by GZA for independent review of data QA/QC. Data will be compared and cross-checked with available secondary data as noted above.
- Representativeness: Field data generation will be documented in the project final report. The data source will be checked that it represents the geographic location it is intended to cover through comparison to other publicly available, secondary data and based on the experience of the project team.
- Comparability: Units of field data generated will be consistent (e.g., inches; feet in elevation; etc.). Data collected will be checked by field staff and the project team.

Upon approval of the QAPP, GZA in coordination with GLP will make the final decisions on which sites are suitable for primary data collection given finite project resources. Criteria for site selection includes: a) the results of the secondary data collection described above, including the asset type and hazard exposure; b) the size of the system being considered for data collection (small systems are anticipated, consistent with "pilot project" type concept design activities); c) initial site reconnaissance; and d) the experiential data from GLP based on their experience maintaining their systems and living in the study area.

Analytical Tools

Analytical tools will be applied by personnel qualified by their educational experience, professional experience performing similar work, and experience with the specific tool. Analytical tools will undergo review by technical and project staff other than the original tool developer or modeler. The responsibilities of the reviewer are to confirm that the technical approach and procedures used are logical and appropriate, that the documentation of input/output data is complete and clear, that the calculations are accurate through either line by line checking of input/output data or through use of a confirmatory secondary calculation. Independent QA/QC will also be performed by a technical reviewer not directly involved with the project data collection effort.

See Table 1-1. Analytical Parameters and Target Limits

1.7.3 Measurement Performance Criteria/Acceptance Criteria

See Table 2-4. Quality Control Requirements for Analyses
See Table 2.5. Quality Control Requirements for Field Measurements
See Table 2-7. Photographic Field Log Example
See Table 2-8. Field Log Example

The Quality Assurance Objectives (QAOs) define a tolerable level of potential decision error for data collected on a project. They help to define the DQOs and clarify the project objectives further. The QAOs

are then used as comparison criteria during data quality review by the Project Manager and Primary Field Sampler to determine if the minimum requirements have been met and the data may be used as planned.

GPS units will be checked for calibration by GZA staff prior to deploying the unit and accuracy is dependent upon various factors including, the number of satellites tracked, observation time, and the number of units in use.

Field Assessments

For the measurement of primary data constituents, the Project Team will collect data for each site using a topographic survey instrument based on standard operating procedure (see **Appendix A-2**), supplemented by manual measurements with a measuring tape / ruler. The Project Team will double-check data collected before leaving the area.

Prior to conducting the field work, staff will review the standard operating procure to obtain consistency and accuracy in data collection methods. Field work will be conducted by professional, trained staff with similar project experience. The data (or constituents) to be collected during the site visits will include those listed in **Table 2** in **Section 1.2**. All measurements will be made by a team of two Project Team Members from GZA. All numbers will be recorded on a field data sheet and double-checked for accuracy before leaving each site. The Project Team Lead, Project Manager and QA Officer will review the data collected for the sites and will cross check the data with GLP and other secondary data.

The quality assurance objectives are listed in **Table 3** and outline the range of information that would be acceptable for use on the project**.**

Note that survey measurements do not need to be exact for enabling the selection of the type of natural hazard protection for shorelines or stormwater infrastructure at a concept design level. Subsurface measurements that are not accessible to the survey instrument will be collected using a retractable measuring tape, with increments no coarser than one-tenth of a foot.

Secondary Data

As discussed in Section 1.3, all secondary data to be evaluated for the project will meet one of the following criteria:

- The data are from a peer-reviewed, government, industry-specific source;
- The source is published; or
- The information or data are from a group deemed credible by CT DEEP and/or CIRCA as outlined in the Connecticut state guidance.

The Project Team Lead, Project Manager, and QA Officer will review (1) the metadata of each secondary data source to confirm that the data meets the above criteria and (2) the QC procedures used by the authoritative source that produced the data. The source/ author data will be recorded and the metadata will be stored with each secondary data source.

Analytical Tools

The Project Team Lead, Project Manager and QA Officer will review analytical tool input/output and related documentation for overall reasonableness. GZA does not anticipate widespread use of computer modeling software as part of this project, but limited use of certain specialized software may be employed to assist with conceptual design. As the project objective is to complete a conceptual design, which is subject to refinement and change in the future, any analytical tool output should be considered approximate guidance for conceptual design activities, as opposed to exact design criteria.

1.8 Special Training Requirements/Certification (EPA QA/R-5 A8)

No specialized training or certifications are required for the work to be performed under the current scope.

1.9 Documents and Records (EPA QA/R-5 A9)

1.9.1 QA Project Plan Distribution

The Project Manager is responsible for ensuring that members of the GZA Project Team have a current version of the QAPP. All records generated by this project will be stored by GZA. Copies of this QAPP will be distributed to all parties involved with the project, including signatories, field personnel, and the stakeholder and secondary data acquisition team. Any future changes or amendments to the QAPP will be held and distributed in the same fashion. Copies of previous versions of the QAPP will be clearly marked as "superseded by Revision #" so as not to create confusion.
Data and assumptions used to develop analytical tools will be recorded and documented in the draft and final reports. GZA will document and save the results of output data and data used.

1.9.2 Field Documentation and Records

At project completion, the field team will provide copies of the field data sheets (or relevant pages of field logs) as a representative sample subset submittal of analysis as discussed in Section 4.1. At a minimum, information must be provided to Connecticut Sea Grant staff.

Electronic data generated in the field will be stored in its native file format. Field survey information will be presented in AutoCAD or GIS format. Electronic files generated will also be available to GLP.

The records of all project information and data used to complete the activities of the project will be retained for at least seven years from the date of sampling, measurement, report, or application.

1.9.3 Laboratory Documentation and Records

This section does not apply to this project. No laboratory analyses are included in this project scope.

1.9.4 Quarterly and/or Final Reports

During the project, GLP Leads may require periodic reporting, as noted below. **Table 4** summarizes the types of data to be reported and the method in which that information will be delivered to GLP Leads.

All results meeting data quality objectives and results having satisfactory explanations for deviations from objectives will be reported in the QA Summary Report. Results will be reported to GLP Leads at project completion as noted above. Reports may be submitted electronically along with the final programmatic report. Final reports and electronic files will also be available to the EPA Project Officer.

2.0 DATA GENERATION AND ACQUISITION

2.1 Sampling Design (Experimental Design) (EPA QA/R-5 B1)

No sampling is a part of the project.

2.2 Sampling Methods (EPA QA/R-5 B2)

The GZA project team will conduct a weather check before the field assessment to assure that conditions are suitable for data collection. The team will hold a brief meeting at the beginning of the field assessment to review the objectives for data collection. Digital cameras, phones and/or tablets, and survey equipment will be checked and charged, and extra batteries will be provided in preparation for the field survey. All supplies will be prepared and organized before the scheduled survey date. This includes organizing the field binders/packets and ensuring that enough field forms and other materials are provided for the GZA project team. The Project Manager and Primary Field Sampler from the GZA project team will participate in the field assessment. They may be accompanied by GLP Leads and up to two additional field support staff from GZA.
See **Figure 2-1** for a Site Map.

Digital photographs will be taken in the field to support the documentation process. The location of each photograph will be noted, and each photograph will be given a photo ID number.

Secondary Data

The Primary Field Sampler will conduct the secondary data collection. Secondary data will be collected by downloading data from sources that meet the acceptance criteria described in Section 1.3. Data will be stored in a file geodatabase. The constituent, data source, and web service will be tracked in an Excel spreadsheet. The Project Manager and Project Team Lead will then review the secondary data collection.

2.3 Sample Handling and Custody (EPA QA/R-5 B3)

Physical samples will not be collected as a result of this project.

2.4 Analytical Methods (EPA QA/R-5 B4)

No additional data collection is required for the use of analytical tools. Primary and secondary data

described above will be used as input to analytical tools. It is noted that the project objective is to develop conceptual designs which are inherently subject to change during future design phases, as more detailed data collection efforts are completed in the future.

The table below includes a proposed schedule for the data collection activities for the project (e.g., data collection will occur during this time period; actual activity duration, particularly primary data collection, will be shorter).

TASK	Start Date	Duration (days)	End Date
Secondary Data Collection	11/04/2024	52	12/26/2024
Primary Data Collection	1/06/2025	82	03/29/2025

2.4.1 Field Measurements Methods

GZA personnel will visit selected proposed project sites in GLP to gain familiarity with the project area, perform visual reconnaissance, a site survey using GPS, and document conditions pertinent to the advancement of concept designs.

2.4.2 Field Analyses Methods

2.4.2.1 Screening
Some visual site analyses will be performed to select future focus areas, potential future sampling and/or analysis activities, such as sediment sampling. No specific test kits will be involved.

2.4.2.2 Definitive
No special on-site analyses or tests that may provide data of equivalent quality as off-site laboratory analysis will be performed during site visits.

Field Assessment

Cameras and cell phones used to take pictures during the field assessment do not require calibration. Additionally, tape measures used to make simple measurements do not require calibration. To assure accurate measurements from tape measures, constituents will be spot checked by measurement by two different members of the project team and compared before the measurement is recorded. Survey equipment will be used per the standard operating procedure.

All site visit activities will be adequately and consistently documented to ensure defensibility of any data used for decision-making, as described in Section 1.3 and to support data interpretation. Pertinent field information, including (as applicable), the information from the stormwater survey will be recorded on the field data sheets. Photo locations will be documented in a sketch based on GIS mapping data along with the data sheets for each site.

The Project Manager will be responsible for ensuring that the field data collection team adheres to proper

documentation procedures. Field datasheets will be maintained for all data and information collected during each site visit. Field datasheets will be in hard copy during the field assessment. Data sheets will be electronically transcribed, scanned and stored as an electronic copy by the Primary Field Sampler after the field assessment.

Secondary Data

Secondary data identified in **Table 1** will be downloaded and stored in a file geodatabase (if applicable) on GZA computers for data analysis. The Primary Field Sampler will organize data into the database. The Primary Field Sampler will also document analysis results during the data analytics and vulnerability assessment process. In some cases, related existing data will not be used if there is more relevant data available. Secondary data source selection will be followed as outlined in Section 1.3. All secondary data will be stored in electronic format. Geospatial data will be maintained in a file geodatabase, along with associated metadata. Reports containing information on climate projections and natural hazard data will be stored as PDFs on GZA computers.

2.4.3 Laboratory Analyses Methods (Off-Site)

No Laboratory Analyses will be required for this project.

2.5 Quality Control Requirements (EPA QA/R-5 B5)

See Table 2-4. Quality Control Requirements for Analyses
See Table 2-5. Quality Control Requirements for Field Measurements

The overall QA objective for this project is to develop and implement procedures for data collection and reporting that will provide results that are scientifically defensible. Specific procedures for reporting of data, internal QC, audits, preventive maintenance of field equipment, and corrective action are described in the other sections of this QAPP.

2.5.1 Field Sampling Quality Control

No field samples will be required for this project.

2.5.2 Field Measurement/Analysis Quality Control

2.5.2.1 Field Measurement QC

Internal QC is achieved by review of the data collection data sheets and/or records by the project manager to ensure that results are within the specified QC objectives discussed in sections 1. The internal QC components of a data collection and analyses program will ensure that the data of known quality are produced and documented.

GZA will establish a control point of a known National Geodetic Survey (NGS) benchmark in the vicinity of the survey area. This can be used to adjust field values if warranted.

2.5.2.2 Field Analysis QC (Screening and Definitive)

Several quality control steps have been described throughout earlier parts of this QAPP. The following summarizes quality control checks for field surveys:

- The GZA project team will hold an internal meeting with field personnel to review survey and field data quality objectives.
- The GZA project team will use existing standard field survey forms to document sites.
- At the end of the training/survey day, the technical leader reviews the field sheets to ensure forms are complete. The binder, and associated photos, are turned in or sent to the project manager/data coordinator when surveying is complete. Electronic data gathered by mobile devices transmitted to GZA networks will also be reviewed.
- The project manager reviews the forms for apparent accuracy and completeness.

For existing data, the GZA Project Team Lead, Project Manager, and QA Officer will review the metadata of each secondary data source to ensure that the data meets the above criteria. The source/ author data will be recorded, and the metadata will be stored with each secondary data source.

2.5.3 Laboratory Analysis Quality Control

No Laboratory Analyses will be required for this project.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance (EPA QA/R-5 B6)

See Table 2-6. Field Equipment/Instrument Calibration, Maintenance, Testing, and Inspection.

Equipment used for data collection must be cleaned and maintained in accordance with proper field practices. All equipment will be cleaned before and after the site visit. The Field/ Survey Engineer is responsible for the oversite of equipment maintenance and inspection.

All instrument and equipment testing will be performed according to manufacturer recommendations. Please see appendices for GPS equipment manuals. All equipment will be tested once before the site visit. Digital cameras, phones and/or tablets are checked and charged, and extra batteries are provided in preparation for the field survey. All supplies will be prepared and organized before the scheduled survey date. This includes organizing the field binders/packets and ensuring that enough field forms and other materials are provided for the GZA project team. Organizers ensure there are enough cameras/phones for the project team and that units are charged and in working order. During the site survey, GPS survey points will be inspected periodically to ensure that desired horizontal and vertical accuracies are maintained.

2.6.1 Field Measurement Instruments/Equipment

Field measurement equipment will consist of GPS survey units, measuring tapes, field binders, packets, and forms and cameras/phones.

2.6.2 Field Instruments/Equipment (Screening and Definitive)

- Field Book
- Pencil or pen
- GPS equipment (Leica): either the survey grade GS-18t/CS-35 (see GS-18 manual in Appendix A, the CS-35 manual is not available for public distribution) using Captivate collection software or GG-04/Android tablet (mapping grade) using Zeno Mobile collection software. Both units utilize Real Time Kinematic correction (RTK) via internal cellular connection.
- Survey pole
- Measuring tape

2.6.3 Laboratory Analysis Instruments/Equipment (Off-Site)

No Laboratory Analyses will be required for this project.

2.7 Instrument/Equipment Calibration and Frequency (EPA QA/R-5 B7)

Field measurement equipment will not need a task-specific calibration. The proposed equipment software has a Customer Care Plan (CCP) that provides updates to the software as it is made available via push notifications to the units. Any calibrations or repairs to the units are done in the event we cannot resolve issues.

2.7.1 Field Measurement Instruments/Equipment

The Leica GS18 Survey Equipment and Panasonic Model No. FZ-G1 series computer tablet equipment operating manuals are attached for GZA Field Staff to review for proper transporting, cleaning, and operating the survey equipment.

2.7.2 Field Instruments/Equipment (Screening and Definitive)

Most commonly, issues are User error related to inexperienced operators accidentally changing settings in the unit software, which will be avoided through pre and in field QA/ QC processes and utilizing previously trained and qualified survey engineers.

See Table 2-6. Field Equipment/Instrument Calibration, Maintenance, Testing, and Inspection

2.7.3 Laboratory Analysis Instruments/Equipment (Off-Site)

No Laboratory Analyses will be required for this project.

2.8 Inspection/Acceptance Requirements for Supplies and Consumables (EPA QA/R-5 B8)

This section is not applicable to this project, because no supplies and consumables are planned to be used.

2.8.1 Field Sampling Supplies and Consumables

Not applicable, see text above.

2.8.2 Field Measurement/Analyses (Screening and Definitive) Supplies and Consumables

Not applicable, see text above.

2.8.3 Laboratory Analyses (Off-Site) Supplies and Consumables

Not applicable, see text above.

2.9 Data Acquisition Requirements (Non-Direct Measurements) (EPA QA/R-5 B9)

Please refer to section 1.6 Project/Task Description and Schedule, Secondary Data Collection.

2.10 Data Management (EPA QA/R-5 B10)

Collected field data will be stored as hand-written and/ or electronic notes, including GPS point data that will be stored on a local tablet/ iPad and immediately uploaded to the ESRI online network. Collected data can be used in CAD, GIS, or report format. The GG-04 can export project data to .kmz format, for viewing in Google Earth. Any data errors will be determined in-field during the collection and troubleshot during that time through referencing nearby known datums or software updates.

The responsible individuals for the data management tasking are as follows:

Field/ Survey Engineer: Experienced GZA representative responsible for the collection of survey points, field equipment checks, and download of survey points to GZA's network.

Project Manager (PM): GZA representative who manages the project from proposal to completion and is the point of contact for routine project matters. The PM also oversees data from all support staff.

Principal-in-Charge (PIC): GZA representative that assumes the financial and technical responsibility for the project. The PIC will also provide a higher-level review and oversight of data.

QA/QC Consultant / Reviewer (C/R): GZA representative assigned to the project is qualified to provide an independent quality assurance (QA Officer) review of the work. The C/R is involved in an advisory, and quality control review capacity at key milestones of the work but not involved in the day-to-day execution, thereby providing independent quality assurance of GZA's work.

3.0 ASSESSMENT AND OVERSIGHT

3.1 Assessments/Oversight and Response Actions (EPA QA/R-5 C1)

Assessments to be performed during the project include a field survey and inventory of buildings and community assets to begin upon approval of this QAPP and continue through June 2025. (weather permitting). GZA will conduct site visits and inventory of GLPA stormwater assets for up to a total of five 8-hour days. The data collection will be performed by two members from GZA's Project Team. Physical data will be collected through traditional manual methods, including visual observation, photo documentation, use of a tape measure, and survey equipment as described in Section 2.6.

Each catch basin/manhole will be assigned an ID. At each catch basin/manhole our survey field team will take elevations and coordinates with survey grade accuracy from our Leica GS18 instruments. A digital survey file will be maintained (i.e., there will not be a physical field data sheet). Photographs of the structure will also be taken and marked with the structure's ID. After field data collection and survey shot validation, survey data will be processed and incorporated into our cad design system, and matched to the asset's ID. When agreed to design services are complete, all linework and pictures with attributed ID's will be delivered.

Every project at GZA has a Principal-in-Charge and a Project Manager who have extensive experience in their area of practice. In addition, GZA uses the concept of independent "Consultant-Reviewer" (C-R) to review all proposals, reports with recommendations, specifications, and design plans. The C-R must also be a Principal of the firm with extensive experience in providing similar services and licensed in that particular area of practice.

Reports with recommendations are first reviewed by the Project Manager. The Principal-in-Charge then reviews the report and recommendations. The report is then submitted to the C-R for review. The final report copy is saved in the appropriate project folder and draft copies are deleted. Reports that are revised in response to client comment are saved according to the appropriate revision number. All reports are signed by the Principal and C-R.

3.2 Reports to Management (EPA QA/R-5 C2)

Project status updates will be provided to the project team for review (PM, PIC, CR) upon any significant milestones, including completion of field work and project scope tasks. Updates will be provided by email or memorandum/ report, depending on the task size and detail required. Any comments from the QA/QC lead or project team will be incorporated into the tasking.

See section 2.10 for details on management for report review.

4.0 DATA REVIEW AND USABILITY

4.1 Data Review, Verification, and Validation Requirements (EPA QA/R-5 D1)

Copies of data collection sheets, original preliminary and final reports, and electronic media reports will be kept for review by GZA. The field crew will retain original field data sheets.

Field data sheets are checked and signed in the field by the Project Manager. They will identify any results

where information is incorrect, missing, or inadequate. Such data will be marked as unacceptable by the PM and the field crew and will not be entered into the electronic data base and/or otherwise used for project analysis, reporting or other purpose. The check will be completed at the end of each day of fieldwork, as there will not be an opportunity to repeat fieldwork.

The data generated will be converted to a standard database format maintained by GZA and available for CTSG staff review when requested. This review is for QA/QC purposes only and will not be used for any other purpose. All project information will remain confidential. See Section 3.1 for additional information on this data reporting requirement.

After data entry or data transfer procedures are completed for each sample event, data will be inspected for data transcription errors by the Project Manager and Project Team Lead. Errors are determined by following the acceptance criteria outlined in Section 1. If data is found to have errors, it will not be included in the analysis. After the final QA checks for errors are completed, the data will be added to the project database by the Primary Field Sampler.

4.2 Verification and Validation Methods (EPA QA/R-5 D2)

Secondary data from publicly available sources will be verified using ground-truthing during site visits through visual and GPS points. GPS survey points will be validated post survey and in real-time reviewing GPS accuracy results during data gathering.

Data must be consistently assessed and documented to determine whether project QAOs discussed in Section 1.7.3 have been met, quantitatively assess data quality, and identify potential limitations on data use. Assessment and compliance with quality control procedures will be undertaken during the data collection phase of the project. Quality control procedures are described in Section 1.

4.3 Reconciliation with User Requirements (EPA QA/R-5 D3)

Survey point results will be reviewed for accuracy both during the field visit and in post processing. These points will then be used to supplement exiting available data of the proposed project areas, identifying key features and elevations.

If any survey points display outside of the surveyed area or fall outside of acceptable accuracy limits, they will be deleted from the survey dataset. Data accuracy limitations at the time of survey will be noted and relayed in reporting.

5.0 REFERENCES

1. State of Maine, 2020. Maine Lake and Stream Watershed Survey Generic Quality Assurance Project Plan. Maine Department of Environmental Protection.

2. U.S. Environmental Protection Agency (USEPA), 1996. The Volunteer Monitor's Guide to Quality Assurance Project Plans. Office of Wetlands, Oceans and Watersheds; USEPA document #841-B-96-003; Washington, D.C., 59 pp.

FIGURES:

Figure 1-1. Organization Chart

Name	Title/Organization	Phone Number/E-mail
Michael Gardner	Project Manager, GZA	Responsible for coordinating all activities conducted on this project including schedule adherence, QAPP preparation, budgeting, and oversight of all scope-related activities. Scope-related activities include assigning project tasks to personnel, data collection, data analysis, interpretation, communication, and interim and final reporting. Michael will also coordinate all program/project needs related to project personnel and convene periodic project-planning meetings.
Wayne Cobleigh	QA Officer, GZA	Responsible for reviewing primary, secondary, and survey data to ensure that the data meets the data quality objectives; overall project conclusions; and recommendations. Responsible for overseeing the development of and review project deliverables to ensure that the deliverables meet the criteria outlined in the QAPP and CTSG grant. Responsible for compliance with GZA company policy 04-0001 Quality Organization Management and Responsibilities. The QA Officer has an independent line of communication to senior management.
Alexander Roper	Water Resource Engineer, GZA	Responsible for conducting primary and secondary data collection and completing the vulnerability assessment.
Liam Hanley	Coastal Engineer, GZA	Responsible for assisting with primary and secondary data collection and completing the vulnerability assessment.
David M. Leone	Associate Principal, GZA	Responsible for overseeing coordinating all activities conducted on this project including schedule adherence, budgeting, and oversight of all scope-related activities. Dave is also responsible for reviewing primary, secondary, and workshop data to ensure that it meets data quality objectives.
Glenn Lussier	Project Manager and Director – Public Works, GLPA	Responsible for supporting the GLPA Leads development of and review project deliverables to ensure that the deliverables meet the criteria outlined in the QAPP and CTSG grant.
Joseph Orchardo	Project Manager and Director of Long Term	Responsible for supporting the GLPA Leads development of and review project deliverables to

	Planning - GLPA	ensure that the deliverables meet the criteria outlined in the QAPP and CTSG grant
Nicole Tachiki	US EPA Project Officer	Responsible for monitoring the project's activities, progress reports, project period, and project budget; providing technical assistance to the recipient; ensuring completion of EPA's programmatic terms and conditions; and maintaining documentation.
Carly Boyd	US EPA QA Reviewer	Responsible for ensuring the quality and integrity of data and assessments by reviewing data collection, analysis, and reporting processes to ensure compliance with EPA standards.

GZA organizational structure for lines of communication will be the following. Staff level to coordinate with the Project Manager, and project Manager to coordinate with the Principal-in-Charge. The QA Officer and Reviewer is used as an independent review process of the project information and deliverables.

Figure 2-1. Site Map

TABLES:

Table 1: Secondary Data Constituents to be Evaluated for Concept Design

CATEGORY	CONSTITUENT	UNIT	DATA REFERENCE
Infrastructure/ Asset Data			
	Roadways	Miles of roadway	Connecticut Department of Transportation, 2022. CTDOT Open Data. https://connecticut-ctdot.opendata.arcgis.com/
	Bridges	# of bridges	Connecticut Department of Transportation, 2022. CTDOT Open Data. https://connecticut-ctdot.opendata.arcgis.com/
	Stormwater Infrastructure	Miles of pipe, # of outfalls, # of catch basins; # of manholes	Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-ct.gov/apps/GrotonGISViewer/#
	Sanitary Infrastructure	Miles of pipe, # of pumps, # of manholes	Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-ct.gov/apps/GrotonGISViewer/#
	Waterfront Structures	# of structures	CT DEEP, 2022. Connecticut Department of Energy and Environmental Protection. GIS Open Data Website https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/
	Essential Facilities	# of facilities	U.S. Department of Homeland Security, 2022. Homeland Infrastructure Foundation-Level Data. https://hifld geoplatform.opendata.arcgis.com/
	Buildings	# of buildings	Microsoft, 2018. U.S. Building Footprints. https://www.microsoft.com/en-

CATEGORY	CONSTITUENT	UNIT	DATA REFERENCE
			us/maps/building-footprints; and Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-ct.gov/apps/GrotonGISViewer/#
	Wetlands	Acres of wetland	Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-ct.gov/apps/GrotonGISViewer/#
	Water Basin	Acres within a designated water basin (e.g., Mystic River and Southeast Shoreline)	Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-ct.gov/apps/GrotonGISViewer/#
	Geology	Acres of Surficial Materials (e.g., glacial till, salt marsh, sand)	Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-ct.gov/apps/GrotonGISViewer/#
	Soils	Acres of soil type	Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-ct.gov/apps/GrotonGISViewer/#
	Erosion Susceptibility	Acres within a designated erosion susceptibility area (e.g., surficial materials susceptible to erosion, soils susceptible to erosion)	Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-ct.gov/apps/GrotonGISViewer/#
	Wildlife	Acres of natural diversity areas	Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-ct.gov/apps/GrotonGISViewer/#
	Topography	Feet, elevation	Town of Groton, CT, 2022. GIS Viewer. https://maps.groton-

CATEGORY	CONSTITUENT	UNIT	DATA REFERENCE
			ct.gov/apps/GrotonGISViewer/# and/or CT DEEP, 2016. Connecticut Department of Energy and Environmental Protection. 2016 Orthophotography and Lidar Download. https://cteco.uconn.edu/data/download/flight2016/index.htm
	Open Space	Acres of open space	CT DEEP, 2022. Connecticut Department of Energy and Environmental Protection. GIS Open Data Website https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/
Natural Hazard Data			
	Coastal Flooding	Elevation (ft)	FEMA, 2013. https://hazards-fema.maps.arcgis.com/apps/webappviewer/index.html?id=8b0adb51996444d4879338b5529aa9cd
	Coastal Flooding	Elevation (ft)	CIRCA, 2021. Connecticut Institute for Resilience & Climate Adaptation (CIRCA). Connecticut Sea Level Rise and Storm Surge Viewer. https://circa.uconn.edu/sea-level-rise-and-storm-surge-viewer/
	Sea Level Rise	Elevation (ft)	CIRCA, 2019. Connecticut Institute for Resilience & Climate Adaptation (CIRCA). Sea Level Rise in CT. https://circa.uconn.edu/publications/
	Sea Level Rise	Elevation (ft)	NOAA et al. 2022. NOAA Sea Level Rise

CATEGORY	CONSTITUENT	UNIT	DATA REFERENCE
			Projections. https://climate.sec.usace.army.mil/slat/
	Sea Level Rise	Elevation (ft)	USACE, 2015. U.S. Army Corps of Engineers North Atlantic Coast Comprehensive Study: Resilient adaptation to increasing risk. https://cdm16021.contentdm.oclc.org/digital/collection/p16021coll10/id/9411
	Intense Precipitation	Inches of Precipitation	NOAA, 2019. Atlas 14, Precipitation-Frequency Atlas of the United States Volume 10 Version 3.0: Northeastern States https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=ct
	Intense Precipitation	Inches of precipitation	CIRCA, 2019. Connecticut Physical Climate Science Assessment Report. https://circa.uconn.edu/publications/

Table 2: Primary Data Constituents to be Evaluated

CONSTITUENT	UNIT
Stormwater catch basins and manholes	Inlet or cover dimensions (inches or feet) Inlet elevation (feet, NAVD88) Depth (feet and inches) Pipe inlets and outlets (number) Other apparent conditions (e.g., sediment depth from catch basin cover in feet, other qualitative material condition if visible)
Stormwater pipes and outfalls	Pipe diameter (inches)

CONSTITUENT	UNIT
	Pipe invert elevation (feet relative to ground surface) Pipe material (visual observation) Headwall or outfall type (visual observation)

Table 3: Quality Assurance Objectives for Individual Measurements

Parameter	Method	Accuracy	Precision	Completeness
Elevations	Survey instrument	100%	+/- 0.1 foot	100%
Material Type	Visual Observation	100%	80%	80%
Number and Location	Visual Observation	100%	100%	100%
Depth and Below Ground Elevations	Visual Observation and using a tape measure to determine dimensions.	100%	+/-0.1 foot	100%

Table 4: QA Summary Reporting Data

Data	Data Description	Reporting Method	Frequency
Primary Data	Raw data from field assessment. Stormwater infrastructure survey data.	Metrics uploaded to CTSG online system.	At CTSG Request during the closeout procedure
Secondary (Geospatial) Data	ArcGIS polygon maps, latitude/longitude info.	Uploaded via CTSG online system map page	At CTSG Request during the closeout procedure
Analytical Tools	Native electronic files	Transmitted via CTSG or GZA file transfer systems	At CTSG Request during the closeout procedure

Table 1-1. Analytical Parameters and Target Limits

Matrix/Media:

Analytical Parameter[1]	Project Action Limit/Level (applicable units)
GPS Accuracy	Under 1 foot horizontal and vertical accuracy
Available LiDAR/ Survey Accuracy	Under 10 foot accuracy

[1] Analytical parameters includes field analyses.

Table 2-4. Quality Control Requirements for Analyses

(<<Matrix>> for Analyses of <<Type of Analyses>>)

Analytical Method/SOP:

QC Sample:	Data Quality Indicator (DQI)	Frequency/ Number	Method/SOP QC Acceptance Limits	Acceptance Criteria/ Measurement Performance Criteria[1]	Corrective Action
LABORATORY ANALYSIS:					
Not Applicable					
FIELD ANALYSIS:					
GPS Unit	Horizontal and vertical accuracy per point	One value per point for horizontal and vertical accuracy	Review point data both in field and during post processing of data	Under 1 foot horizontal and vertical accuracy	If accuracy is poor there are several actions that can be taken, including: use of a base station; check for clear skies; try another GPS Unit; use an offline map for point gathering in the field.

[1] Information supports the acceptance criteria/measurement performance criteria introduced in Section 1.7.3.

Table 2-5. Quality Control Requirements for Field Measurements

(<<Matrix>> for Field Measurements of <<Type of Parameters>>)

Field Parameter:

QC Sample:	Data Quality Indicator (DQI)	Frequency/ Number	Method/SOP QC Acceptance Limits	Acceptance Criteria/ Measurement Performance Criteria[1]	Corrective Action
GPS Point Accuracy – Leica GPS System (Leica GS18 or CS35)					
GPS Unit	Horizontal and vertical accuracy per point	One value per point for horizontal and vertical accuracy	Review point data both in field and during post processing of data	Under 1 foot horizontal and vertical accuracy	If accuracy is poor there are several actions that can be taken, including: use of a base station; check for clear skies; try another GPS Unit; use an offline map for point gathering in the field.

[1] Information supports the acceptance criteria/measurement performance criteria introduced in Section 1.7.3.

Table 2-6. Field Equipment/Instrument Calibration, Maintenance, Testing, and Inspection

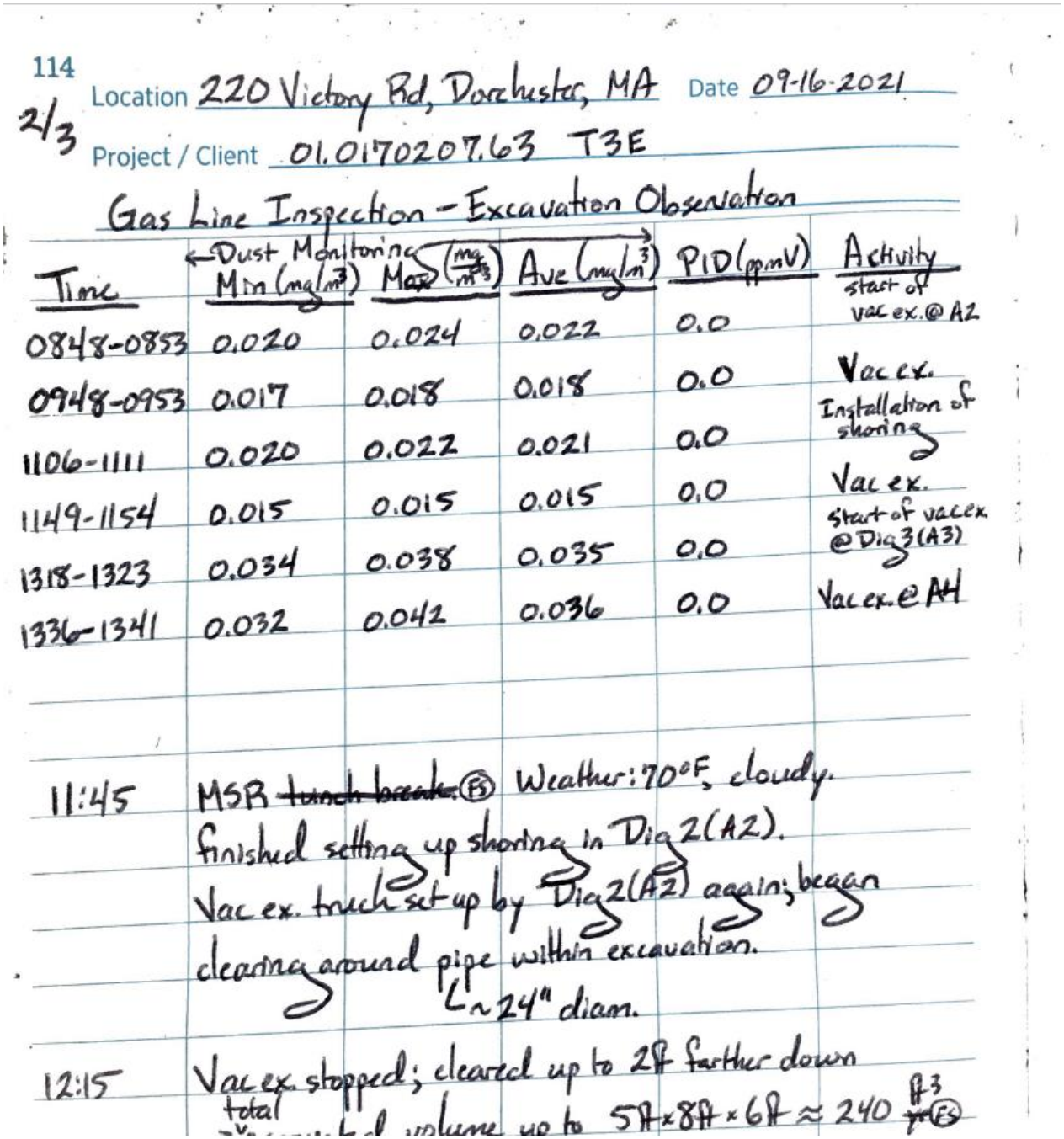
Analytical Parameter	Field Equipment/ Instrument	Calibration Activity	Maintenance Activity	Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
GPS accuracy	GS-18t/CS-35 Leica	Customer Care Plan (CCP) that provides updates to the software as it is made available via push notifications to the units		utilize Real Time Kinematic (RTK) correction via internal cellular connection	Reviewed during the Start and End of the Field visit	Horizontal and vertical accuracies within desired tolerances	Establish a control point of a known NGS benchmark in the vicinity of the survey area

Table 2-7. Photographic Field Log Example

GZA GeoEnvironmental, Inc.		PHOTOGRAPHIC LOG
Client Name:	Site Location:	Project No.:

Photo No.: 3	Date:	
Direction Photo Taken: Photographer:		
Description:		

Table 2-8. Field Log Example



114
2/3

Location 220 Victory Rd, Dorchester, MA Date 09-16-2021

Project / Client 01.0170207.63 T3E

Gas Line Inspection – Excavation Observation

Time	← Dust Monitoring Min (mg/m³)	Max (mg/m³)	Ave (mg/m³)	PID (ppmV)	Activity
0848-0853	0.020	0.024	0.022	0.0	start of vac ex. @ A2
0948-0953	0.017	0.018	0.018	0.0	Vac ex.
1106-1111	0.020	0.022	0.021	0.0	Installation of shoring
1149-1154	0.015	0.015	0.015	0.0	Vac ex.
1318-1323	0.034	0.038	0.035	0.0	start of vacex @ Dig 3 (A3)
1336-1341	0.032	0.042	0.036	0.0	Vac ex. @ A4

11:45 MSB ~~lunch break~~ (FS) Weather: 70°F, cloudy. finished setting up shoring in Dig 2 (A2). Vac ex. truck set up by Dig 2 (A2) again; began clearing around pipe within excavation. L ~ 24" diam.

12:15 Vac ex. stopped; cleared up to 2ft further down total volume up to 5ft × 8ft × 6ft ≈ 240 ft³ (FS)

APPENDICES

APPENDIX A.

A-1. Equipment/Instrument Manuals
A-2. Standard Operating Procedures

APPENDIX A

Appendix A-1.
Equipment/Instrument Manuals

Leica GS18

User Manual
Version 2.0
English

- when it has to be **right**

Leica Geosystems

PART OF HEXAGON

Introduction

Purchase

Congratulations on the purchase of the Leica GS18.

This manual contains important safety directions as well as instructions for setting up the product and operating it. Refer to 1 Safety Directions for further information.

Read carefully through the User Manual before you switch on the product.

☞

The content of this document is subject to change without prior notice. Ensure that the product is used in accordance with the latest version of this document.

Updated versions are available for download at the following Internet address:

https://myworld.leica-geosystems.com > **myDownloads**.

Product identification

The model and serial number of your product are indicated on the type plate.

Always refer to this information when you need to contact your agency or Leica Geosystems authorised service centre.

Trademarks

- *Bluetooth*® is a registered trademark of Bluetooth SIG, Inc.

All other trademarks are the property of their respective owners.

Validity of this manual

This manual applies to all models of the Leica GS18 GNSS instrument. Where there are differences between the various instruments they are clearly described.

Available documentation

Name	Description/Format		
GS18 Quick Guide	Provides an overview of the product together with technical data and safety directions. Intended as a quick reference guide.	✓	✓
GS18 User Manual	All instructions required in order to operate the product to a basic level are contained in the User Manual. Provides an overview of the product together with technical data and safety directions.	-	✓

Name	Description/Format		
Captivate Technical Reference Manual	Overall comprehensive guide to the product and apps. Included are detailed descriptions of special software/hardware settings and software/hardware functions intended for technical specialists.	-	✓

Refer to the following resources for documentation/software:

- the Leica Captivate USB documentation card
- https://myworld.leica-geosystems.com

myWorld@Leica Geosystems (**https://myworld.leica-geosystems.com**) offers a wide range of services, information and training material.

With direct access to myWorld, you are able to access all relevant services whenever it is convenient for you.

Service	Description
myProducts	Add all products that you and your company own and explore your world of Leica Geosystems: View detailed information on your products and update your products with the latest software and keep up-to-date with the latest documentation.
myService	View the current service status and full service history of your products in Leica Geosystems service centres. Access detailed information on the services performed and download your latest calibration certificates and service reports.
mySupport	Create new support requests for your products that will be answered by your local Leica Geosystems Support Team. View the complete history of your support requests and view detailed information on each request in case you want to refer to previous support requests.
myTraining	Enhance your product knowledge with Leica Geosystems Campus - Information, Knowledge, Training. Study the latest online training material on your products and register for seminars or courses in your country.
myTrustedServices	Add your subscriptions and manage users for Leica Geosystems Trusted Services, the secure software services, that assist you to optimise your workflow and increase your efficiency.

Table of Contents

1 Safety Directions

1.1 General Introduction

Description

The following directions enable the person responsible for the product, and the person who actually uses the equipment, to anticipate and avoid operational hazards.

The person responsible for the product must ensure that all users understand these directions and adhere to them.

About warning messages

Warning messages are an essential part of the safety concept of the instrument. They appear wherever hazards or hazardous situations can occur.

Warning messages...

- make the user alert about direct and indirect hazards concerning the use of the product.
- contain general rules of behaviour.

For the users' safety, all safety instructions and safety messages shall be strictly observed and followed! Therefore, the manual must always be available to all persons performing any tasks described here.

DANGER, **WARNING**, **CAUTION** and **NOTICE** are standardised signal words for identifying levels of hazards and risks related to personal injury and property damage. For your safety, it is important to read and fully understand the following table with the different signal words and their definitions! Supplementary safety information symbols may be placed within a warning message as well as supplementary text.

Type	Description
⚠ **DANGER**	Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
⚠ **WARNING**	Indicates a potentially hazardous situation or an unintended use which, if not avoided, could result in death or serious injury.
⚠ **CAUTION**	Indicates a potentially hazardous situation or an unintended use which, if not avoided, may result in minor or moderate injury.
NOTICE	Indicates a potentially hazardous situation or an unintended use which, if not avoided, may result in appreciable material, financial and environmental damage.
☞	Important paragraphs which must be adhered to in practice as they enable the product to be used in a technically correct and efficient manner.

1.2 Definition of Use

Intended use

- Computing with software
- Recording measurements
- Carrying out measurement tasks using various GNSS measuring techniques
- Recording GNSS and point related data
- Remote control of product
- Data communication with external appliances
- Measuring raw data and computing coordinates using carrier phase and code signal from GNSS satellites (GNSS systems)
- Capturing image groups and computing 3D coordinates of points using images

Reasonably foreseeable misuse

- Use of the product without instruction
- Use outside of the intended use and limits
- Disabling safety systems
- Removal of hazard notices
- Opening the product using tools, for example screwdriver, unless this is permitted for certain functions
- Modification or conversion of the product
- Use after misappropriation
- Use of products with recognisable damage or defects
- Use with accessories from other manufacturers without the prior explicit approval of Leica Geosystems
- Inadequate safeguards at the working site
- Controlling of machines, moving objects or similar monitoring application without additional control and safety installations

1.3 Limits of Use

Environment

Suitable for use in an atmosphere appropriate for permanent human habitation: not suitable for use in aggressive or explosive environments.

⚠WARNING

Working in hazardous areas, or close to electrical installations or similar situations

Life Risk.

Precautions:

- ▸ Local safety authorities and safety experts must be contacted by the person responsible for the product before working in such conditions.

1.4 Responsibilities

Manufacturer of the product

Leica Geosystems AG, CH-9435 Heerbrugg, hereinafter referred to as Leica Geosystems, is responsible for supplying the product, including the User Manual and original accessories, in a safe condition.

Person responsible for the product

The person responsible for the product has the following duties:

- To understand the safety instructions on the product and the instructions in the User Manual
- To ensure that it is used in accordance with the instructions
- To be familiar with local regulations relating to safety and accident prevention
- To inform Leica Geosystems immediately if the product and the application become unsafe
- To ensure that the national laws, regulations and conditions for the operation of the product are respected
- To ensure that the radio modem is not operated without the permission of the local authorities on frequencies and/or output power levels other than those specifically reserved and intended for use without a specific permit. The internal and external radio modems have been designed to operate on frequency ranges and output power ranges, the exact use of which differs from one region and/or country to another.

1.5 Hazards of Use

⚠ DANGER

Risk of electrocution

Because of the risk of electrocution, it is dangerous to use poles, levelling staffs and extensions in the vicinity of electrical installations such as power cables or electrical railways.

Precautions:

- ▸ Keep at a safe distance from electrical installations. If it is essential to work in this environment, first contact the safety authorities responsible for the electrical installations and follow their instructions.

⚠ WARNING

Distraction/loss of attention

During dynamic applications, for example stakeout procedures, there is a danger of accidents occurring if the user does not pay attention to the environmental conditions around, for example obstacles, excavations or traffic.

Precautions:

- ▸ The person responsible for the product must make all users fully aware of the existing dangers.

⚠WARNING

Inadequate securing of the working site

This can lead to dangerous situations, for example in traffic, on building sites and at industrial installations.

Precautions:

- Always ensure that the working site is adequately secured.
- Adhere to the regulations governing safety, accident prevention and road traffic.

⚠CAUTION

Not properly secured accessories

If the accessories used with the product are not properly secured and the product is subjected to mechanical shock, for example blows or falling, the product may be damaged or people can sustain injury.

Precautions:

- When setting up the product, make sure that the accessories are correctly adapted, fitted, secured, and locked in position.
- Avoid subjecting the product to mechanical stress.

⚠WARNING

Lightning strike

If the product is used with accessories, for example masts, staffs, poles, you may increase the risk of being struck by lightning.

Precautions:

- Do not use the product in a thunderstorm.

⚠ DANGER

Risk of being struck by lightning

If the product is used with accessories, for example on masts, staffs, poles, you may increase the risk of being struck by lightning. Danger from high voltages also exists near power lines. Lightning, voltage peaks, or the touching of power lines can cause damage, injury and death.

Precautions:

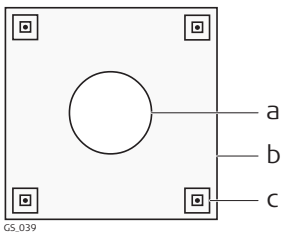
- Do not use the product in a thunderstorm as you can increase the risk of being struck by lightning.
- Be sure to remain at a safe distance from electrical installations. Do not use the product directly under or close to power lines. If it is essential to work in such an environment contact the safety authorities responsible for electrical installations and follow their instructions.
- If the product has to be permanently mounted in an exposed location, it is advisable to provide a lightning conductor system. A suggestion on how to design a lightning conductor for the product is given below. Always follow the regulations in force in your country regarding grounding antennas and masts. These installations must be carried out by an authorised specialist.
- To prevent damages due to indirect lightning strikes (voltage spikes) cables, for example for antenna, power source or modem should be protected with appropriate protection elements, like a lightning arrester. These installations must be carried out by an authorised specialist.
- If there is a risk of a thunderstorm, or if the equipment is to remain unused and unattended for a long period, protect your product additionally by unplugging all systems components and disconnecting all connecting cables and supply cables, for example, instrument - antenna.

Lightning conductors

Suggestion for design of a lightning conductor for a GNSS system:

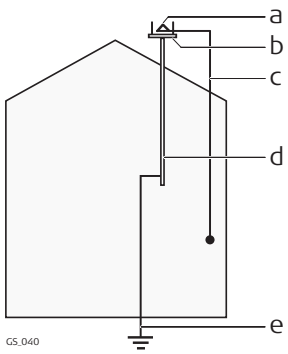
1. On non-metallic structures
   Protection by air terminals is recommended. An air terminal is a pointed solid or tubular rod of conducting material with proper mounting and connection to a conductor. The position of four air terminals can be uniformly distributed around the antenna at a distance equal to the height of the air terminal.
   The air terminal diameter should be 12 mm for copper or 15 mm for aluminium. The height of the air terminals should be 25 cm to 50 cm. All air terminals should be connected to the down conductors. The diameter of the air terminal should be kept to a minimum to reduce GNSS signal shading.
2. On metallic structures
   Protection is as described for non-metallic structures, but the air terminals can be connected directly to the conducting structure without the need for down conductors.

Air terminal arrangement, plan view



a Antenna
b Support structure
c Air terminal

Grounding the instrument/antenna



a Antenna
b Lightning conductor array
c Antenna/instrument connection
d Metallic mast
e Connection to earth

For the AC/DC power supply:

⚠WARNING

Electric shock due to use under wet and severe conditions

If unit becomes wet it may cause you to receive an electric shock.

Precautions:

- ▸ If the product becomes humid, it must not be used!
- ▸ Use the product only in dry environments, for example in buildings or vehicles.

- ▸ Protect the product against humidity.

For the AC/DC power supply:

⚠WARNING

Unauthorised opening of the product

Either of the following actions may cause you to receive an electric shock:

- Touching live components
- Using the product after incorrect attempts were made to carry out repairs.

Precautions:

- ▸ Do not open the product!
- ▸ Only Leica Geosystems authorised service centres are entitled to repair these products.

⚠WARNING

Inappropriate mechanical influences to batteries

During the transport, shipping or disposal of batteries it is possible for inappropriate mechanical influences to constitute a fire hazard.

Precautions:

- Before shipping the product or disposing it, discharge the batteries by the product until they are flat.
- When transporting or shipping batteries, the person in charge of the product must ensure that the applicable national and international rules and regulations are observed.
- Before transportation or shipping, contact your local passenger or freight transport company.

⚠WARNING

Exposure of batteries to high mechanical stress, high ambient temperatures or immersion into fluids

This can cause leakage, fire or explosion of the batteries.

Precautions:

- Protect the batteries from mechanical influences and high ambient temperatures. Do not drop or immerse batteries into fluids.

⚠WARNING

Short circuit of battery terminals

If battery terminals are short circuited e.g. by coming in contact with jewellery, keys, metallised paper or other metals, the battery can overheat and cause injury or fire, for example by storing or transporting in pockets.

Precautions:

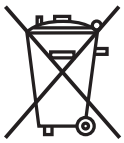
- Make sure that the battery terminals do not come into contact with metallic objects.

⚠WARNING

If the product is improperly disposed of, the following can happen:

- If polymer parts are burnt, poisonous gases are produced which may impair health.
- If batteries are damaged or are heated strongly, they can explode and cause poisoning, burning, corrosion or environmental contamination.
- By disposing of the product irresponsibly you may enable unauthorised persons to use it in contravention of the regulations, exposing themselves and third parties to the risk of severe injury and rendering the environment liable to contamination.
- The product includes parts of Beryllium inside. Any modification of some internal parts can release dust or fragments, creating health hazard.

Precautions:

▸ 

The product must not be disposed with household waste. Dispose of the product appropriately in accordance with the national regulations in force in your country. Always prevent access to the product by unauthorised personnel.

Product-specific treatment and waste management information can be received from your Leica Geosystems distributor.

⚠WARNING

Improperly repaired equipment

Risk of injuries to users and equipment destruction due to lack of repair knowledge.

Precautions:

▸ Only authorised Leica Geosystems Service Centres are entitled to repair these products.

1.6 Electromagnetic Compatibility (EMC)

Description

The term Electromagnetic Compatibility is taken to mean the capability of the product to function smoothly in an environment where electromagnetic radiation and electrostatic discharges are present, and without causing electromagnetic disturbances to other equipment.

⚠WARNING

Electromagnetic radiation

Electromagnetic radiation can cause disturbances in other equipment.

Precautions:

▸ Although the product meets the strict regulations and standards which are in force in this respect, Leica Geosystems cannot completely exclude the possibility that other equipment may be disturbed.

⚠CAUTION

Use of the product with accessories from other manufacturers. For example field computers, personal computers or other electronic equipment, non-standard cables or external batteries

This may cause disturbances in other equipment.

Precautions:

- Use only the equipment and accessories recommended by Leica Geosystems.
- When combined with the product, they meet the strict requirements stipulated by the guidelines and standards.
- When using computers, two-way radios or other electronic equipment, pay attention to the information about electromagnetic compatibility provided by the manufacturer.

⚠CAUTION

Intense electromagnetic radiation. For example, near radio transmitters, transponders, two-way radios or diesel generators

Although the product meets the strict regulations and standards which are in force in this respect, Leica Geosystems cannot completely exclude the possibility that function of the product may be disturbed in such an electromagnetic environment.

Precautions:

- Check the plausibility of results obtained under these conditions.

⚠CAUTION

Electromagnetic radiation due to improper connection of cables

If the product is operated with connecting cables attached at only one of their two ends, for example external supply cables, interface cables, the permitted level of electromagnetic radiation may be exceeded and the correct functioning of other products may be impaired.

Precautions:

- While the product is in use, connecting cables, for example product to external battery, product to computer, must be connected at both ends.

⚠WARNING

Use of product with radio or digital cellular phone devices

Electromagnetic fields can cause disturbances in other equipment, in installations, in medical devices, for example pacemakers or hearing aids and in aircrafts. Electromagnetic fields can also affect humans and animals.

Precautions:

- Although the product meets the strict regulations and standards which are in force in this respect, Leica Geosystems cannot completely exclude the possibility that other equipment can be disturbed or that humans or animals can be affected.
- Do not operate the product with radio or digital cellular phone devices in the vicinity of filling stations or chemical installations, or in other areas where an explosion hazard exists.
- Do not operate the product with radio or digital cellular phone devices near to medical equipment.
- Do not operate the product with radio or digital cellular phone devices in aircrafts.
- Do not operate the product with radio or digital cellular phone devices for long periods with the product immediately next to your body.

1.7 FCC Statement, Applicable in U.S.

☞ The greyed paragraph below is only applicable for products without radio.

⚠WARNING

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules.

These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

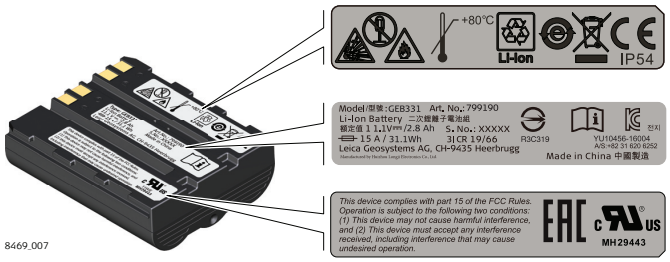
- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

⚠CAUTION

Changes or modifications not expressly approved by Leica Geosystems for compliance could void the user's authority to operate the equipment.

Labelling GS18

Labelling GEB331



1.8 ISED Statements (EN/FR), Applicable in Canada

⚠WARNING

This Class (B) digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe (B) est conforme à la norme NMB-003 du Canada.

Canada Compliance Statement

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

Canada Déclaration de Conformité

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1. L'appareil ne doit pas produire de brouillage;
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

2 Description of the System

2.1 System Components

Main components

Component	Description
Instrument	To calculate a position from the computed ranges to all visible GNSS (Global Navigation Satellite System) satellites. To estimate a tilt compensated pole tip position by combining the GNSS position with attitude information from an Inertial Measurement Unit (IMU). To capture image groups with the camera and to use those captured images to calculate the 3D coordinates of points.
Web server	Web-based tool to preprogram the GNSS instrument.
Antenna	To receive the satellite signals from the GNSS satellites.
Leica Infinity	The office software including a series of help programs which support working with Leica instruments.

Instrument

Instrument	Description
GS18	GPS, GLONASS, BeiDou and GalileoGNSS receiver, multi-frequency, SBAS (EGNOS, WAAS, MSAS, GAGAN), code and phase, real-time capable, integrated Inertial Measurement Unit.

2.2 System Concept

2.2.1 Software Concept

Description

All instruments use the same software concept.

Software for all GS GNSS instruments

Software type	Description
GS firmware (GS_xx.fw)	This software covers all functions of the instrument. The Web server application is integrated into the firmware and cannot be deleted. The English language is integrated into the firmware and cannot be deleted.
Language software (WEB_LANG.sxx)	Numerous languages are available for the Web server application. The English language is the default language. One language is chosen as the active language.

Software upload

☞ Uploading GS firmware can take some time. Ensure that the battery is at least 75% full before beginning the upload, and do not remove the battery during the upload process.

Software for	Description
All GS models	The software can be uploaded using the Leica Web server application or myWorld@Leica Geosystems. ☞ Ensure that a Leica SD card is inserted into the GS instrument before starting the upload. Refer to 4.3 Working with the SD Card.

2.2.2 Power Concept

General

Use the batteries, chargers and accessories recommended by Leica Geosystems to ensure the correct functionality of the instrument.

Power options

Power for the instrument can be supplied either internally or externally.

Model	Power supply
Internally	One battery (GEB331) fits into the instrument.
Externally	GEB371 battery connected via a cable, or Car battery connected via a converter cable supplied by Leica Geosystems, or 10.5 V-28 V DC power supply via a converter cable supplied by Leica Geosystems, or 110 V/240 V AC to 12 V DC power supply unit, supplied by Leica Geosystems.

☞ For permanent operations use **U**ninterruptible **P**ower **S**upply units as a back-up in a main power failure.

2.2.3 Data Storage Concept

Description

Data (Leica GNSS raw data and RINEX data) can be recorded on the SD card.

Memory device

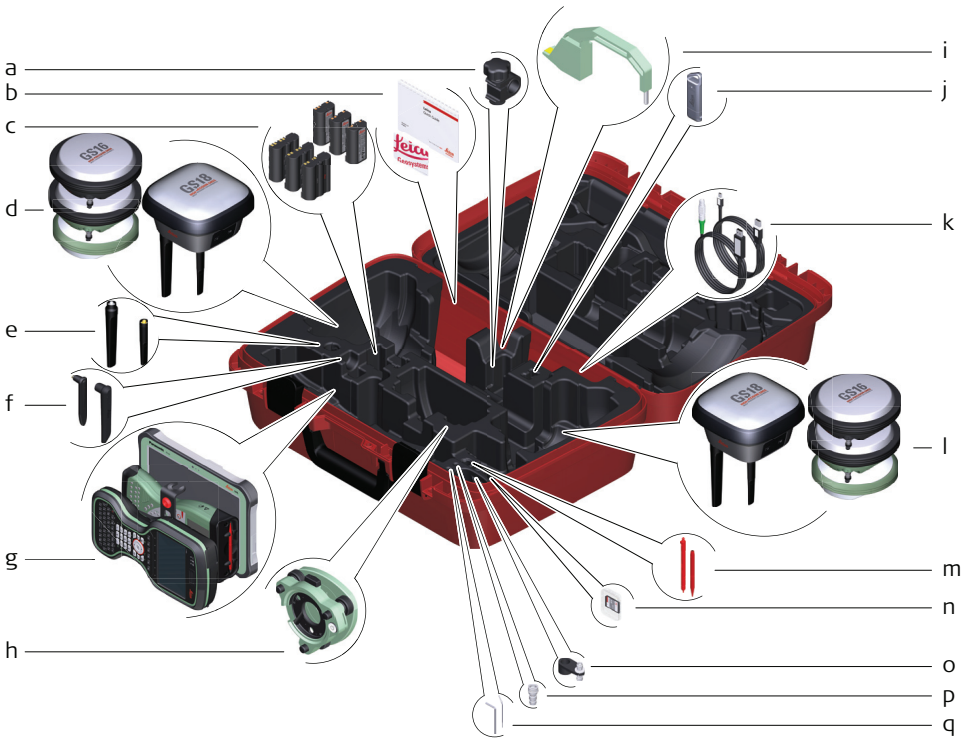
SD card: The GS18 GNSS instrument has an SD card slot fitted as standard. An SD card can be inserted and removed.
Available capacity: 1 GB, 8 GB.

☞ While other SD cards can be used, Leica Geosystems recommends to only use Leica industrial grade SD cards and is not responsible for data loss or any other error that can occur while using a non-Leica card.

☞ Unplugging connecting cables, removing the data storage device or interrupting the power supply during the measurement can cause loss of data. Only remove the data storage device, unplug connecting cables or interrupt the power supply when the GS GNSS instrument is switched off.

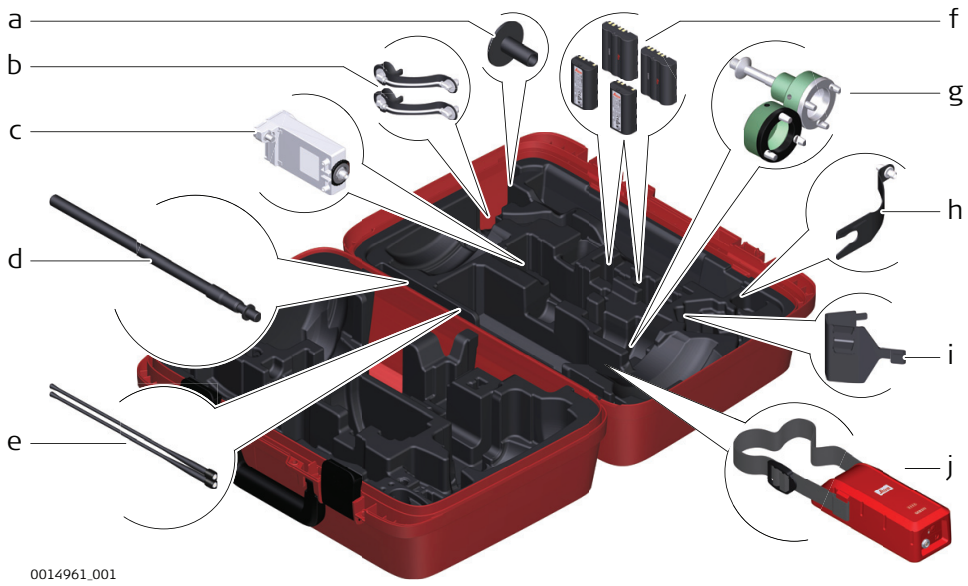
☞ SD cards can directly be used in an OMNI drive as supplied by Leica Geosystems. Other PC card drives can require an adaptor.

Container for GS instrument and accessories 1/2



a GHT63 clamp
b Manuals and USB documentation card
c GEB212 or GEB331 batteries
d Antenna
e GAT18, GAT27 or GAT28 mobile antenna
f GAT21, GAT25 or GAT26 radio antenna
g Field controller with holder or CS35 tablet
h Tribrach
i Height hook
j USB stick
k Cables
l Antenna
m Stylus
n SD cards
o GAD34 arm 3 cm
p TNC QN-adapter
q Allen key and adjustment tool

Container for GS instrument and accessories 2/2



a GHT36 base for telescopic rod
b Antenna arm
c GFU RTK modem
d GAD32 telescopic rod
e GAT1 or GAT2 radio antennas
f GEB212 or GEB331 batteries
g GRT146 or GRT247 carrier
h GAD33 arm
i GHT58 tripod bracket for GFU
j External battery

Container for GS instrument and accessories

a Field controller with holder
b Antenna
c CRP15, quick release adaptor for quick mounting and demounting the GS18 to the pole without screwing
d GAT25, GAT26, GAT27 or GAT28 antenna
e Stylus
f GHT63 clamp
g USB stick
h GAT1 or GAT2 radio antennas
i Antenna arm
j microSD card including adapter or SD card
k Manual & USB documentation card
l GEB212 or GEB331 batteries

2.4 Instrument Components

The instrument can be preprogrammed using the Web server application running from the instrument on a web browser of a Windows device. Connect the instrument to a computer using a cable. Turn on the instrument by holding down the Power key for 2 s. A green blinking light at the connectivity and the storage LED indicates that the instrument powers up.

GS18 components

a SMB-connector for external UHF antenna, only for models with UHF radio
b SMB-connector for external LTE antenna
c LEDs, ON/OFF button and Function button
d Battery compartment with SD card and micro SIM card slot
e LEMO port, serial, USB and external power
f Antenna Reference Plane (ARP)

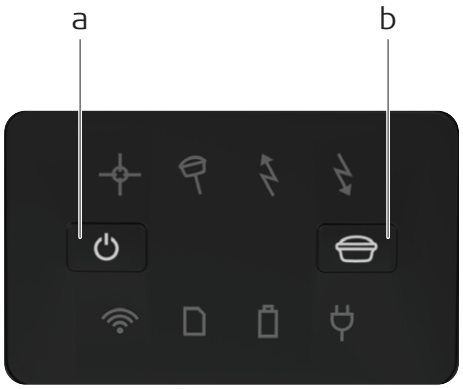
a Camera (GS18 I)

☞ A Bluetooth port is included inside all GS GNSS instruments enabling connectivity to the field controller.

3 User Interface

3.1 Keyboard

Keyboard GS18



a ON/OFF button
b Function button

ON/OFF button

Button	Function
ON/OFF	If GS18 already off: Turns on GS18 when held for 2 s. ☞ While the GS18 is booting the Connectivity and Storage LED are flashing green. The Battery and or Power LEDs shine green or red depending on the power source and the battery status.
	If GS18 already on: Turns off GS18 when held for 2 s. ☞ The Position LED shines orange. The Tilt and the Storage LEDs shine red. RTK Base and RTK Rover LEDs shine green. The Connectivity LED shines blue or green, depending on the connectivity. The Battery and Power LEDs shine green or red depending on the battery status.

Function button

☞ All functions following described assume the GS18 is already on.

Button	Function
Function	Press and hold button for <1 s. If the GS18 is in: • base mode: The GS18 switches to be in rover mode. • rover mode and in static mode: No action. • rover mode and in kinematic mode: The GS18 switches to be in base mode.
	Press and hold button for 3 s. If the GS18 is in:

Button	Function
	• base mode and a position is available, RTK OUT is configured: The RTK base LED flashes green for 2 s. The GS18 takes the next available position and updates the coordinates of the currently stored RTK base position. • base mode and no position is available, no RTK OUT is configured: No action. • rover mode: No action.
	Press and hold button for 5 s. If the GS18 is in: • base mode: No action. • rover mode and RTK IN via Internet is configured: The RTK rover LED flashes green for 2 s. The GS18 will connect to the RTK base station or the Ntrip server configured. • rover mode and RTK IN active and data being received via Internet: The RTK rover LED flashes green for 2 s. The GS18 will stop the RTK stream and disconnect to the RTK base station or (Ntrip) server. • rover mode but RTK in not configured: No action.

Button combinations

Button		Function
ON/OFF		Press and hold both buttons, release after 1 s.
Function		The current almanacs stored on the GNSS instrument are deleted and new almanacs are downloaded. The Position LED flashes orange quickly three times. Press and hold buttons for 5 s. The Memory LED flashes red quickly three times. If inserted, the SD card of the GNSS instrument is formatted. The Memory LED continues to flash red as the SD card is formatted.
		Press and hold buttons for 10 s. The System RAM on the GNSS instrument is formatted. Settings of all installed software will be deleted. After the formatting the System RAM, the GNSS instrument is turned off. Following LEDs flash simultaneously three times: • Position LED: Orange • Tilt LED: Red • RTK Base and RTK Rover LEDs: Green
		Press and hold buttons for 15 s.

Button	Function
	The System RAM on the GNSS instrument is formatted. Settings of all installed software will be deleted. The registry of the GNSS instrument is deleted. Windows CE and communication settings will be reset to factory defaults. After deleting the registry, the GNSS instrument is turned off. Following LEDs flash simultaneously three times: • Position LED: Orange • Tilt and Storage LED: Red • Connectivity LED: Blue • All other LEDs: Green
	Press and hold buttons for >15 s. The GNSS instrument switches back to last operation mode.

3.2 Operating Principles

Operating the instrument

The GS18 GNSS instrument is operated either by pressing its buttons (ON/OFF button, function button) or by the field controller.

Operation by buttons

The GS18 GNSS instrument is operated by pressing its buttons. Refer to 3.1 Keyboard for a detailed description of the buttons and their function.

Operation by field controller

The GS18 GNSS instrument is operated by the field controller using the Captivate software. Refer to the User Manual of the field controller for a detailed description of the keys and their function.

Turn on GS18

To turn on the instrument press and hold the Power button for 2 s.

Turn off GS18

To turn off the instrument:
- press and hold the ON/OFF button for 2 s
- confirm to power down the instrument when exiting the software on the field controller

4 Operation

4.1 Equipment Setup

4.1.1 Setting up as a Post-Processing Base

Use

The equipment setup described is used for static operations over markers.

Description

The instrument can be programmed with the field controller before use which can then be omitted from the setup.

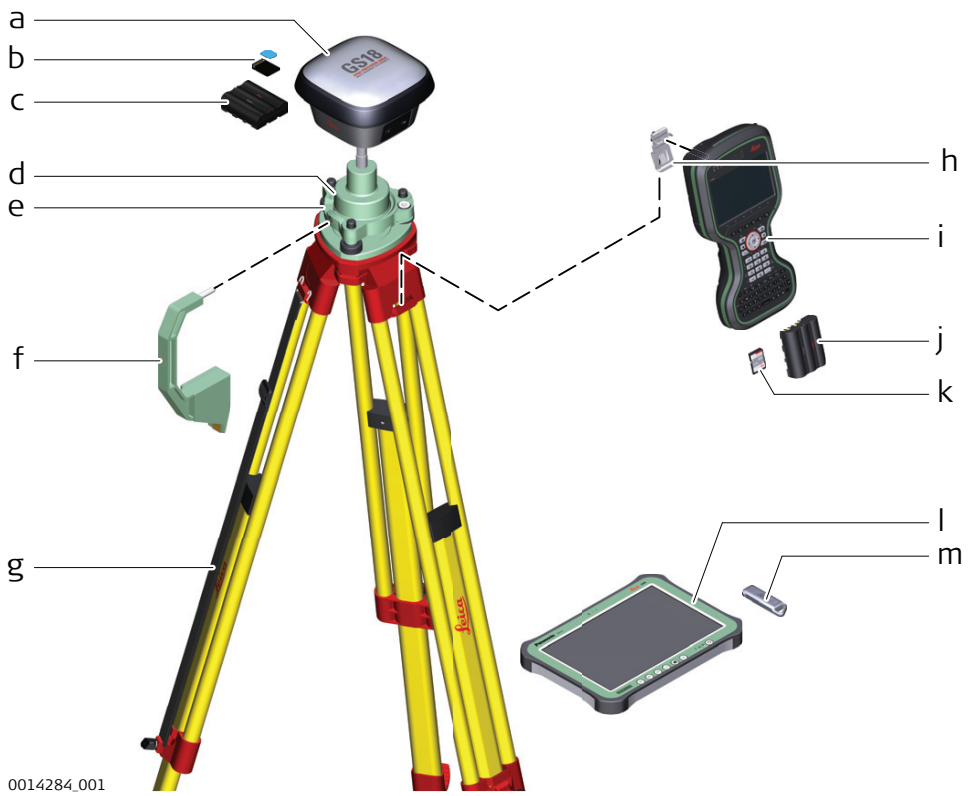
☞

- The antenna is mounted directly using screw fitting. If using stub and adapter, procedures can vary slightly.
- When using the adapter and carrier, ensure that the antenna and the adapter assembly slide down the full length of the carrier stub. An incorrectly mounted antenna will have a direct effect on the results.

☞

Use an external battery such as GEB371 to ensure operation for a full day.

Equipment setup



a GS instrument
b SD card
c GEB331 battery
d GRT146 carrier
e Tribrach
f Height hook
g Tripod
h Utility hook
i CS20 field controller
j GEB331 battery
k SD card
l CS35 tablet
m USB stick

Equipment setup step-by-step

1.	Set up the tripod.
2.	Mount and level the tribrach on the tripod.
3.	Ensure that the tribrach is over the marker.
4.	Place and lock the carrier in the tribrach.
5.	Insert the data storage device and the batteries into the GS.
6.	Screw the GS onto the carrier.
7.	Check that the tribrach is still level.
8.	Insert the data storage device and the battery into the field controller.
9.	Switch on the field controller and connect it to the instrument if necessary.
10.	To hang the field controller on the tripod leg, use the hook on the hand strap or use the utility hook. Refer to the User Manual of the field controller.
11.	Insert the height hook into the carrier.
12.	Measure the antenna height using the height hook.
13.	Press the ON/OFF button on the instrument for at least 2 s to switch on the instrument.

4.1.2 Setting up as a Real-Time Base

Use

The equipment setup described is used for real-time base stations with the need of optimal radio coverage. Raw observation data can also be collected for post-processing.

Description

The GS18 instrument can be programmed with the field controller before use which can then be omitted from the setup.

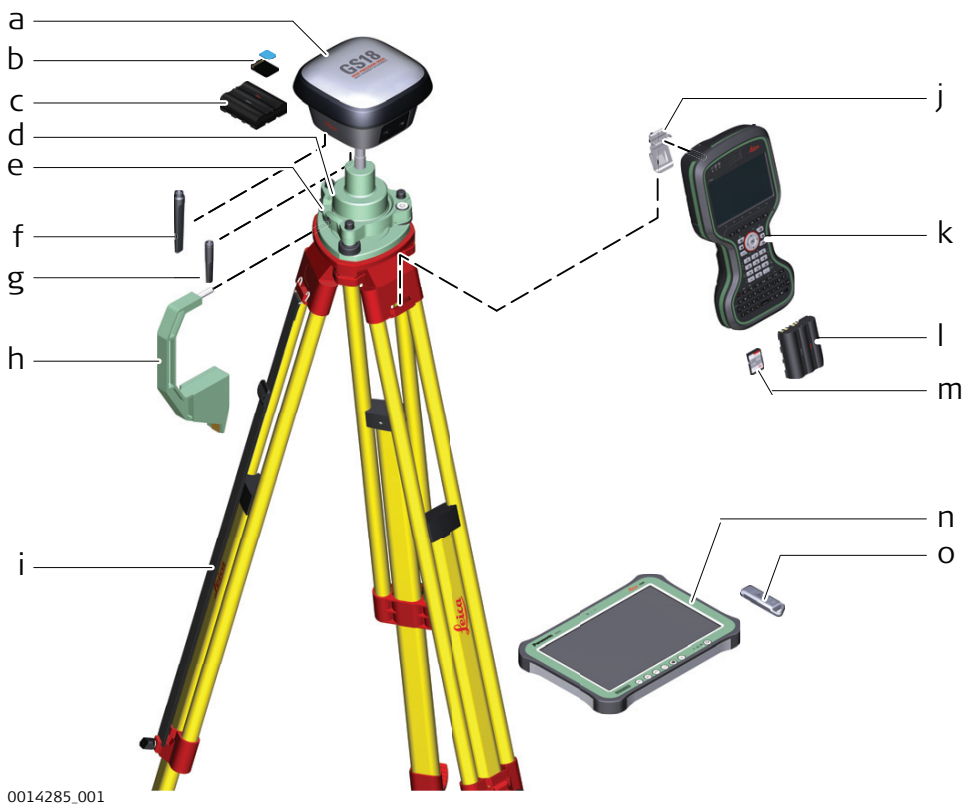
The connection between GS18 and the field controller is made via Bluetooth.

The radio antenna (GAT28) is directly mounted downwards facing at the GNSS antenna. Alternatively, the radio antenna (GAT1/GAT2) can be mounted on the antenna arm (CA41) which clips to the GNSS antenna.

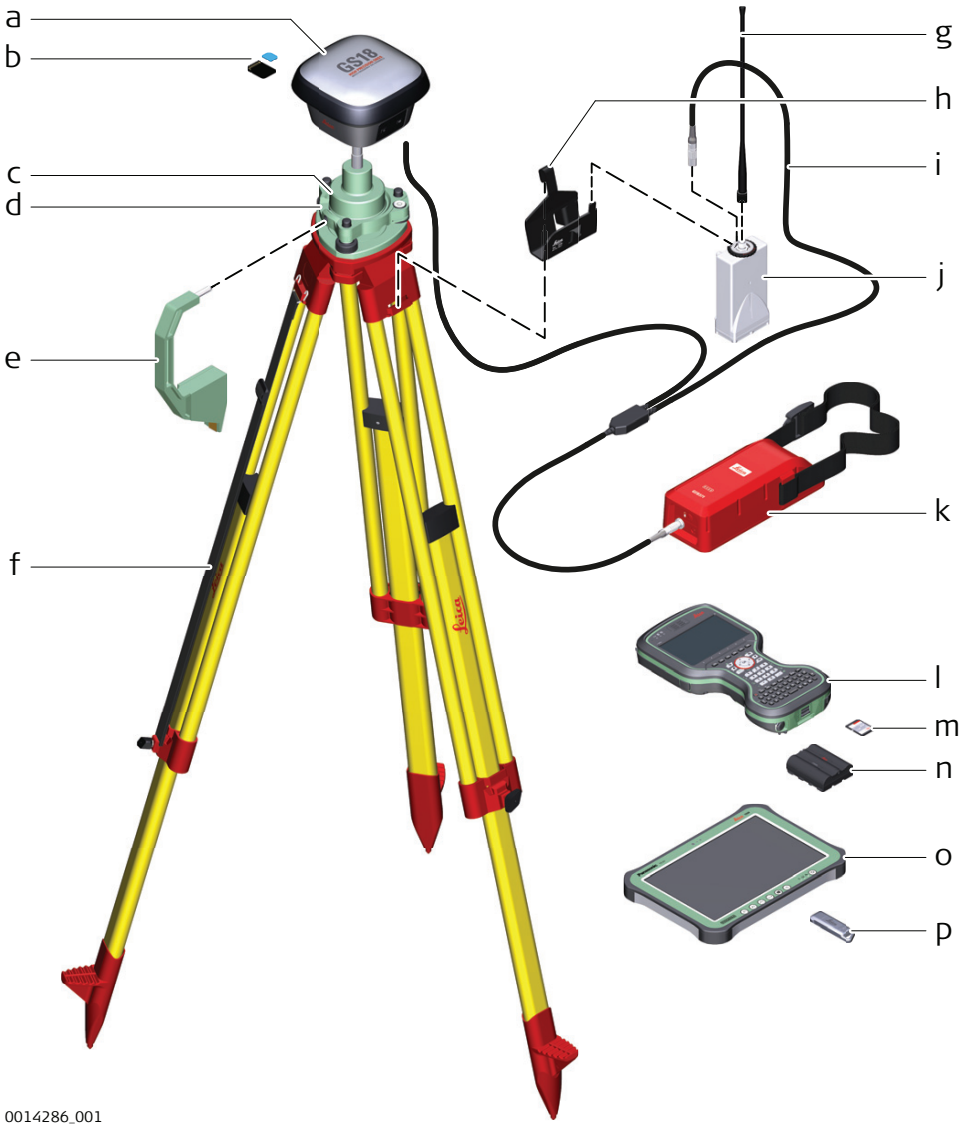
- The GNSS antenna is mounted directly using screw fitting. If using stub and adapter, procedures can vary slightly.
- When using the adapter and carrier, ensure that the antenna and the adapter assembly slide down the full length of the carrier stub. An incorrectly mounted antenna will have a direct effect on the results.
- Standard radio is used throughout the instructions. Digital cellular phones can also be used but the setup can differ slightly.

Use an external battery such as GEB371 to ensure operation for a full day.

Equipment setup - GS18 cellular or GS18 UHF



a GS instrument with integrated cellular modem or UHF (transmit) modem
b SD card and micro SIM card
c GEB331 battery
d GRT146 carrier
e Tribrach
f GAT28 radio antenna, for UHF use only
g GAT27 LTE antenna
h Height hook
i Tripod
j Utility hook
k CS20 field controller
l GEB331 battery
m SD card
n CS35 tablet
o USB stick



a GS instrument
b SD card and micro SIM card
c GRT146 carrier
d Tribrach
e Height hook
f Tripod
g GAT1/GAT2 radio antenna
h GHT58 tripod bracket
i GEV264 Y-cable
j GFU radio modem
k GEB371 external battery
l CS20 field controller
m SD card
n GEB331 battery
o CS35 field controller
p USB stick

Equipment setup step-by-step

1.	Set up the tripod.	
2.	Mount and level the tribrach on the tripod.	
3.	Ensure that the tribrach is over the marker.	
4.	Place and lock the carrier in the tribrach.	
	GS18	**GS** with external RTK device
5.	Insert the data storage device and the batteries into the GS18.	
6.	Screw the GS18 onto the carrier.	
7.	Check that the tribrach is still level.	
8.	-	Hang the external battery onto a tripod leg.
9.	-	Hang the tripod bracket onto a tripod leg and attach the radio housing onto the tripod bracket.
10.	Connect the UHF or LTE antenna to the GS18.	Connect the GEV264 cable to the GS18, to the external battery and to the radio housing.
11.	Insert the data storage device and the battery into the field controller.	
12.	Connect the field controller to the instrument if necessary.	
13.	To hang the field controller on the tripod leg, use the hook on the hand strap or use the utility hook. Refer to the User Manual of the field controller.	
14.	Insert the height hook into the carrier.	
15.	Measure the antenna height using the height hook.	
16.	Press the ON/OFF button on the instrument for at least 2 s to switch on the instrument.	

4.1.3 Setting up as a Real-Time Rover

Use

The equipment setup is used for real-time rover with extended periods of use in the field.

Description

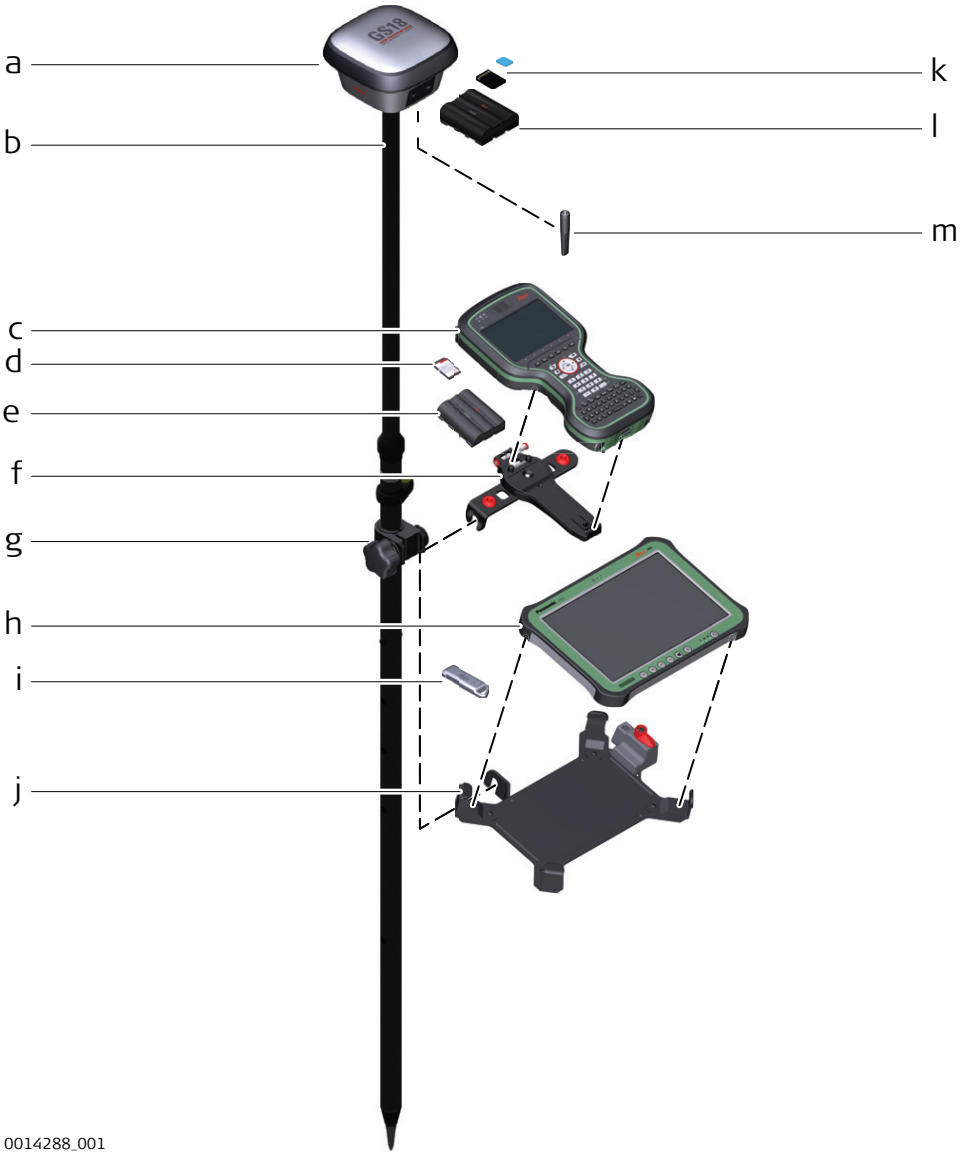
Connections are made to the GNSS antenna, radio antenna and field controller.

The field controller is fixed to the pole with the GHT63. Connection between the GS18 instrument and the field controller is made through Bluetooth.

☞

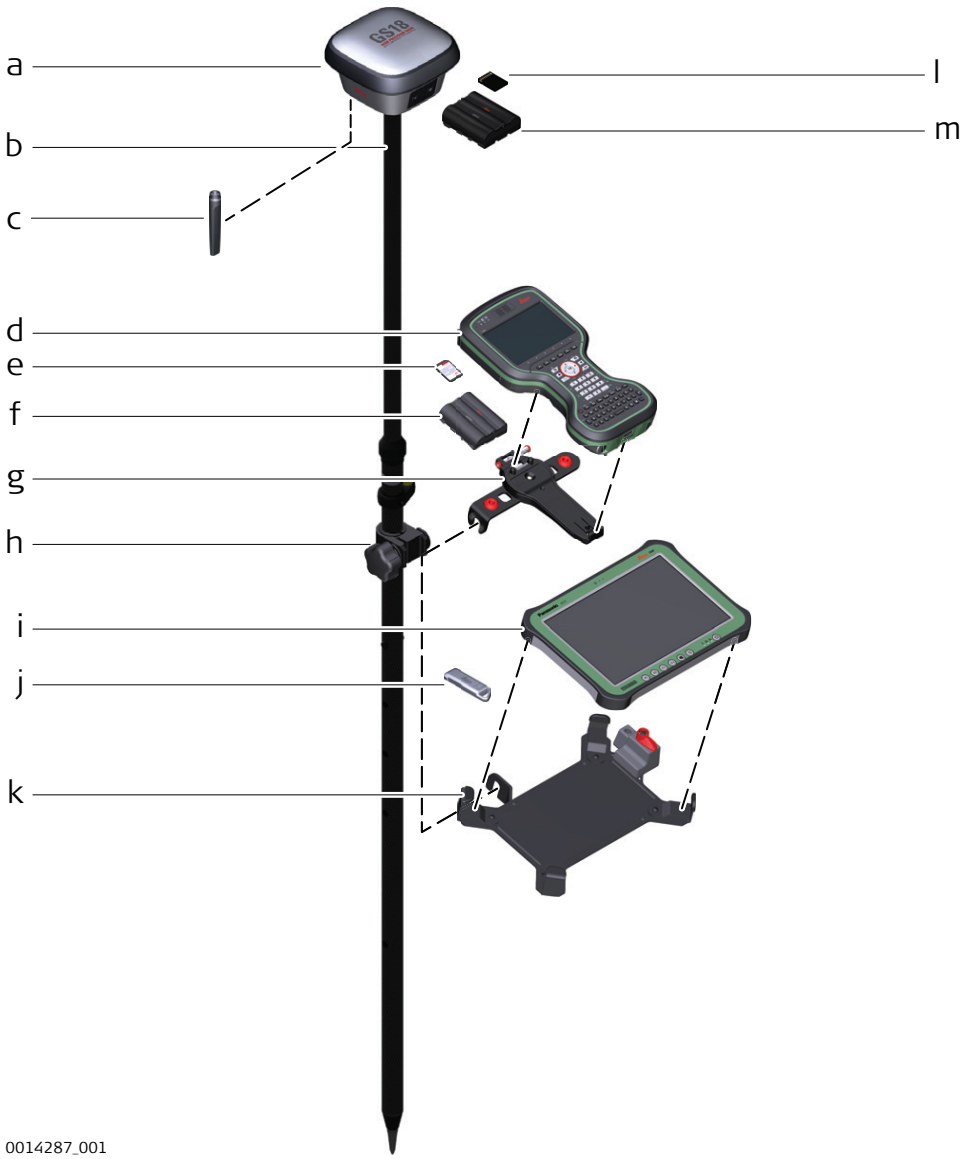
- The antenna is mounted directly using screw fitting. If using stub and adapter, procedures can vary slightly.
- When using the pole with stub, ensure that the antenna and the screw-to-stub adapter slide down the full length of the stub before tightening the locking ring. An incorrectly mounted antenna will have a direct effect on the results.
- Carbon fibre poles are used since they are recommended for automatic tilt compensated measurements. For applications without tilt compensation, they can be replaced with their aluminium equivalent without any changes to these instructions.
- Standard radio is used throughout the instructions. Digital cellular phones can also be used but the setup can differ slightly.

Equipment setup - GS18 LTE



a GS instrument
b GLS30 carbon fibre pole
c CS20 field controller
d SD card for CS20
e GEB331 battery
f GHT66 holder
g GHT63 pole clamp
h CS35 tablet
i USB stick
j GHT78 holder
k SD card and micro SIM card for GS18
l GEB331 battery
m GAT27 LTE external antenna

Equipment setup - GS18 UHF



a GS instrument with integrated UHF radio modem
b GLS30 carbon fibre pole
c GAT28 radio antenna
d CS20 field controller
e SD card for CS20
f GEB331 battery
g GHT66 holder
h GHT63 pole clamp
i CS35 tablet
j USB stick
k GHT78 holder
l SD card for GS18
m GEB331 battery

Equipment setup step-by-step

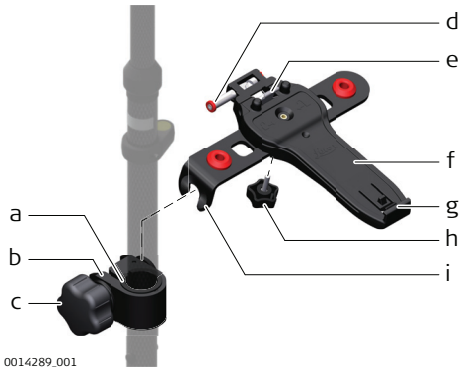
1.	Attach the GHT66 for CS20 holder to the pole.
2.	Insert the data storage device and the battery into the field controller.
3.	Clip the field controller into the holder and lock it by pushing the locking pin into the locked position.
4.	Press ON/OFF button on the field controller to switch on.
5.	Insert the data storage device and the batteries into the GS18.
6.	Press ON/OFF button on the GS18 to switch on.
7.	Screw the GS18 to the top of the pole.
8.	The field controller and GS18 are connected via Bluetooth.

4.1.4 Fixing the Field Controller to a Holder and Pole

☞ This chapter is valid for all holders.

Components of the GHT66 Holder

The GHT66 holder consists of the following components:



GHT63 clamp

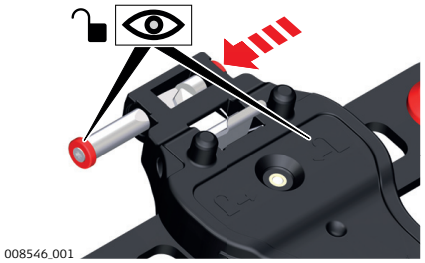
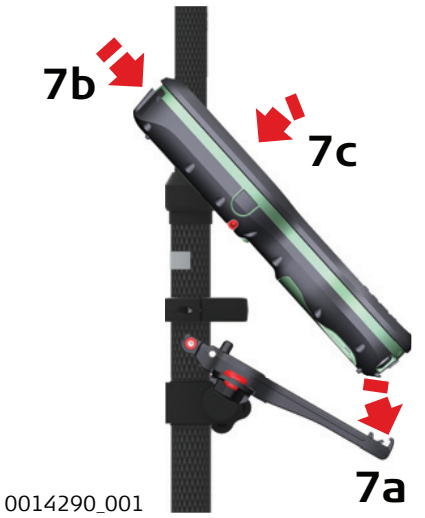
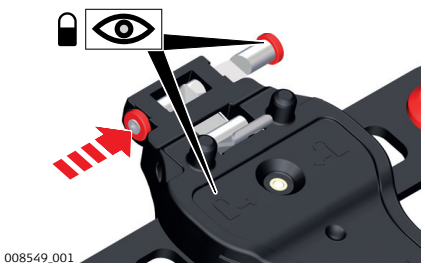
a Plastic sleeve
b Pole clamp
c Clamp bolt

GHT66 holder

d Locking pin
e Top clip
f Mounting plate
g Bottom clip
h Tightening screw
i Mounting arm

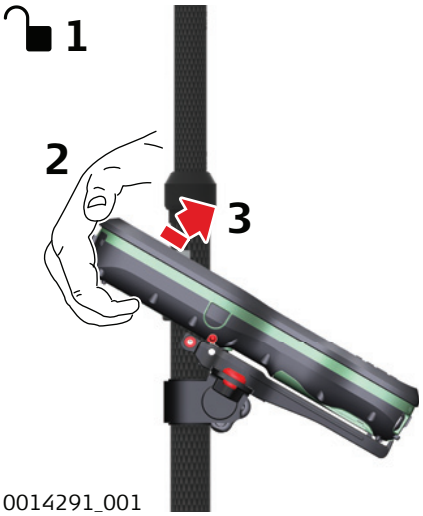
Fixing the field controller and GHT66 to a pole step-by-step

☞	For an aluminium pole, fit the plastic sleeve to the pole clamp.
1.	Insert the pole into the clamp hole.
2.	Attach the holder to the clamp using the clamp bolt.

3.	Adjust the angle and the height of the holder on the pole to a comfortable position.	
4.	Tighten the clamp with the clamp bolt.	
5.	Before placing the CS field controller onto the mounting plate, ensure that the locking pin is put into the unlocked position. To unlock the locking pin, push the locking pin to the left.	
6.	Hold the CS field controller above the holder and lower the end of the CS field controller into the mounting plate.	
7.	Apply slight pressure in a downward direction and then lower the top part of the CS field controller until the unit is clicked into the holder. The guides of the mounting plate aid in this action.	
8.	After the CS field controller is placed onto the mounting plate, ensure that the locking pin is put into the locked position. To lock the locking pin, push the locking pin to the right.	

Detaching the field controller from a pole step-by-step

1. Unlock the locking pin by pushing the locking pin to the left of the mounting plate.
2. Place your palm over the top of the field controller.
3. While in this position, lift the top of the field controller from the holder.



4.1.5 Connecting to a Personal Computer

Description

Leica USB drivers support Windows 7, Windows 8 (8.1) and Windows 10 operating systems.

Cables

Leica USB drivers support:

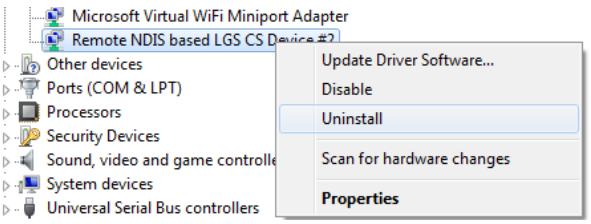
Name	Description
GEV234	USB data cable, 1.65 m, connects CS to GS or CS to PC (USB)
GEV261	Y-cable, 1.8 m, connects instrument to PC – battery

Uninstalling the previous drivers

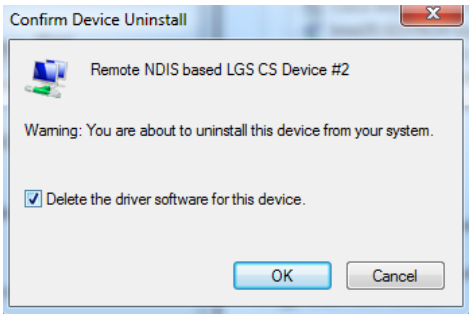
Skip the following steps if you have never installed Leica USB drivers before.

If older drivers were previously installed on the PC, follow the instructions to uninstall the drivers prior the installation of the new drivers.

1. Connect your instrument to the PC via cable.
2. On your PC, select to **Control Panel** > **Device Manager**.
3. In **Network Adapters**, right-click on **Remote NDIS based LGS...**.
4. Click on **Uninstall**.



5. Set **Delete the driver...** as checked. Press **OK**.



Install Leica USB drivers

1. Start the PC.

2. Run the **Setup_Leica_USB_XXbit.exe** to install the drivers necessary for Leica devices. Depending on the version (32bit or 64bit) of the operating system on your PC, you have to select between the three setup files following:
   - Setup_Leica_USB_32bit.exe
   - Setup_Leica_USB_64bit.exe
   - Setup_Leica_USB_64bit_itanium.exe

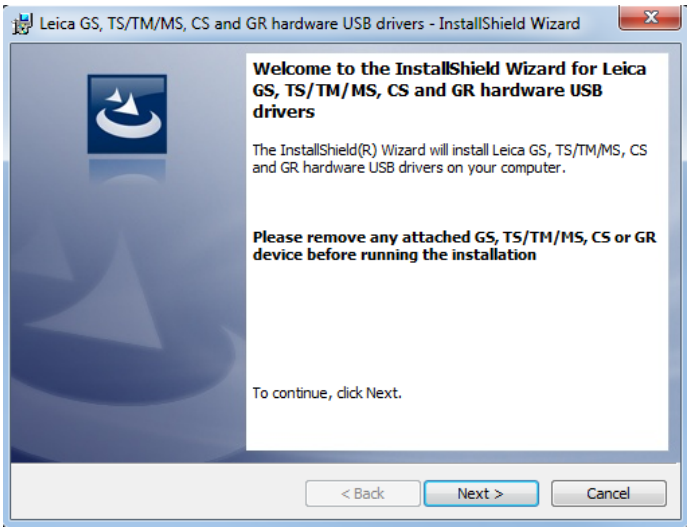
   ☞ To check the version of your operating system, go to **Control Panel** > **System** > **System type**.

   ☞ The setup requires administrative privileges.

   ☞ The setup has to be run only once for all Leica devices.

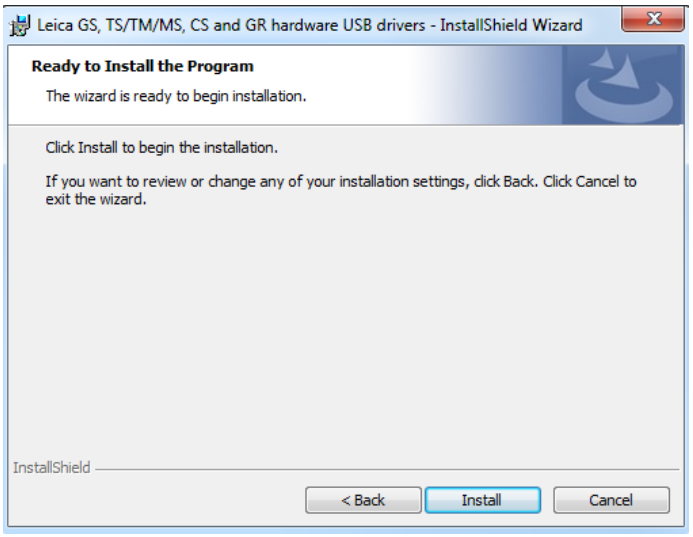
3. The **Welcome to InstallShield Wizard for Leica GS, TS/TM/MS, CS and GR USB drivers** window appears.

   ☞ Ensure that all Leica devices are disconnected from your PC before you continue!



4. Click **Next>**.

5. The **Ready to Install the Program** window appears.



6.	Click **Install**. The drivers will be installed on your PC.
7.	The **InstallShield Wizard Completed** window appears.
8.	Click **Finish** to exit the wizard.

Connect to PC via USB cable step-by-step

1.	Start the PC.
2.	Plug the cable into the instrument.
3.	Turn on the instrument.
4.	Plug the cable into the USB port of the PC.
5.	Press the Windows Start button at the bottom left corner of the screen.
6.	Type the IP address of the device into the search field. • \\192.168.254.1\ for field controller
7.	Press **Enter**. A file browser opens. You can now browse within the folders on the instrument.

4.1.6 Connecting to the Web Server

Description

The Web server is a web-based tool to view the status of and configure the GNSS instruments. The Web server application is integrated into the GS firmware and cannot be deleted.

Accessing the Web server via cable step-by-step

	Action
1.	Start the PC and turn on the GS instrument. ☞ Instead of connecting to your PC, you can connect your GS instrument to the field controller.
2.	Connect the GS instrument with the GEV234 cable to the PC. Refer to 4.1.5 Connecting to a Personal Computer.

Action	
3.	Double-Click the **Configure GS connection** shortcut from the desktop of your PC. The GS network adapter is configured with IP address: 192.168.254.1. A DOS window appears when the configuration was successful. Press any key to exit the DOS window. The **Configure GS connection** shortcut disappears from the desktop.
4.	Start the web browser of your PC.
5.	Type in **http://192.168.254.2** and press enter to access the web server of GS instrument.

Accessing the Web server via Bluetooth step-by-step

To access the Web server the tasks following have to be done:

- Configure the PC's Bluetooth device
- Establish a Bluetooth connection between PC and GS
- Accessing the Web server

Configuring the PC's Bluetooth device

Action	
1.	Start your PC.
2.	Activate the Bluetooth device of your PC.
3.	Go **Start⇒Settings⇒Network Connections**.
4.	Double-click **Bluetooth** from the **LAN or High-Speed Internet** device list. The **Bluetooth Properties** windows is started.
5.	In the **General** page, select **Internet Protocol (TCP/IP)** from the list and click **Properties**. The **Internet Protocol (TCP/IP) properties** windows is started.
☞	This procedure has to be done only once.

Establishing a Bluetooth connection between PC and GS instrument

Action	
1.	Start the PC and turn on the GS instrument. ☞ Instead of connecting to your PC, you can connect your GS instrument to the field controller. In this case, turn on the field controller, start Captivate and establish a Bluetooth connection to the GS instrument.
2.	Run the Bluetooth software and start the **Bluetooth Setup Wizard**.
3.	Click **Next**. The **Bluetooth Device Selection** will be started and an automatic search will be done.
4.	Select the shown GS instrument and click **Next**. The Bluetooth Security Setup is started.
5.	Type in **0000** as **Bluetooth security code** and click **Pair Now**. The pairing procedure will be done and the Bluetooth Service Selection is started.
6.	Highlight **Personal Ad-hoc Network** and check the checkbox for Personal Ad-hoc Network. ☞ Do not select **Serial Port** as service.

Action	
7.	Click **Next**. The **Bluetooth Setup Wizard Completion Page** is started.
8.	Type in a name for your GS instrument and click **Finish** to complete the **Bluetooth Setup Wizard**.
☞	This procedure has to be repeated for every GS instrument you want to connect to.

Accessing the Web server

Action	
1.	Start the web browser on your PC/field controller. ☞ Ensure that your GS instrument is still running and the Bluetooth connection between PC/field controller and GS is established.

2.	Type in **192.168.253.2**. The Web server is started. You will see the home functions following:
	• **Go to Work!**
	  • To select and start the Wake-up application.
	• **Current Status**
	  • To access GNSS information of the GS as well as the instrument firmware.
	• **Instrument**
	  • To access configuration settings for the GS.
	• **User**
	  • To upload and activate firmware, licence keys and languages.

4.2 Batteries

4.2.1 Operating Principles

First-time use/ charging batteries

- The battery must be charged before using it for the first time because it is delivered with an energy content as low as possible.
- The permissible temperature range for charging is from 0 °C to +40 °C/+32 °F to +104 °F. For optimal charging, we recommend charging the batteries at a low ambient temperature of +10 °C to +20 °C/+50 °F to +68 °F if possible.
- It is normal for the battery to become warm during charging. Using the chargers recommended by Leica Geosystems, it is not possible to charge the battery once the temperature is too high.
- For new batteries or batteries that have been stored for a long time (> three months), it is effectual to make only one charge/discharge cycle.
- For Li-Ion batteries, a single discharging and charging cycle is sufficient. We recommend carrying out the process when the battery capacity indicated on the charger or on a Leica Geosystems product deviates significantly from the actual battery capacity available.

Operation/discharging

- The batteries can be operated from −20 °C to +55 °C/−4 °F to +131 °F.
- Low operating temperatures reduce the capacity that can be drawn; high operating temperatures reduce the service life of the battery.

4.2.2 Battery for GS18

☞ The SIM card size must be a micro SIM (3FF) .

The SIM card must be inserted in the correct way as depicted on the GS18 housing.

Using a SIM card adapter might damage the SIM card tray of the GS18.

Change battery step-by-step

1.	Push the slide fastener of the battery compartment in the direction of the arrow with the open-lock symbol. Remove the cover.
2.	To remove the battery, push the retaining clip upwards. This releases the battery from its fixed position.
3.	Remove the battery.
4.	To insert the battery, slide the battery into the battery compartment with the battery contacts facing downwards. Push the battery into the compartment so that it locks into position.
5.	Insert the cover of the battery compartment into the compartment.
6.	Push the slide fastener in the direction of the arrow with the close-lock symbol.

4.3 Working with the SD Card

☞
- Keep the card dry.
- Use it only within the specified temperature range.
- Do not bend the card.
- Protect the card from direct impacts.

☞ Failure to follow these instructions could result in data loss and/or permanent damage to the card.

Insert a SD card and micro SIM card step-by-step

☞	Removing the SD card or micro SIM card while the GS18 is turned on can cause loss of data. Only remove the SD card or micro SIM card or unplug connecting cables when the GS18 is switched off.
☞	The SD card and micro SIM card are inserted into a slot inside the battery compartment of the instrument.
1.	Push the slide fastener of the battery compartment in the direction of the arrow with the open-lock symbol.
2.	Remove the cover from the battery compartment.
3.	Slide the SD card and micro SIM card with the logo facing upwards firmly into the slot until it clicks into position.
4.	Insert the cover of the battery compartment into the compartment.
5.	Push the slide fastener in the direction of the arrow with the close-lock symbol.

4.4 Working with the Tilt Compensation

Description

The pole can be held in a slanting position over the point to be measured without checking the circular bubble on the pole.

Measurements are reliable and accurate even if the pole is not levelled as the tilt values are calculated by an Inertial Measurement Unit. Tilt values contain information about the 3D position of the pole.

The measurements are immune to magnetic disturbances as there is no magnetometer used.

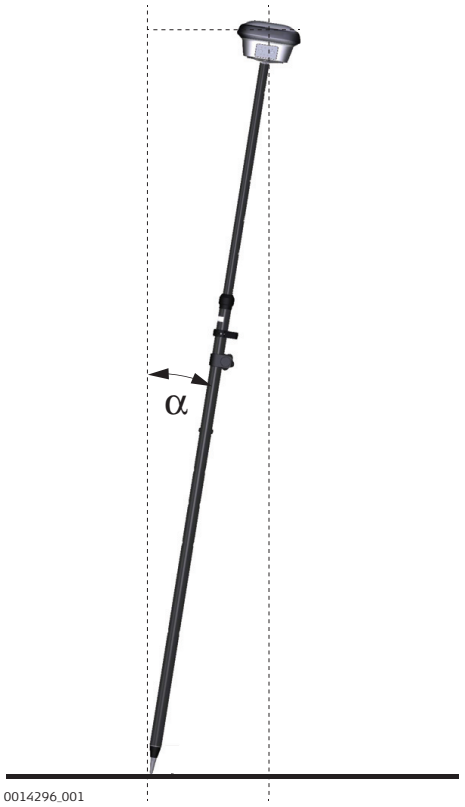
Tilt compensation also works with Navigated and Code solutions. High accuracy positions are recommended to speed up the tilt compensation initialization.

Tilt compensation is turned off when RINEX logging is on.

When measuring a point, the pole tip must be stable on the point while the pole should be in slight movement. Tilt compensation is indicated by an icon and the Tilt LED and is maintained by natural pole movement, for example while moving to the next point to be measured.

Advantages:
- No need to level the pole
- Faster surveying procedure

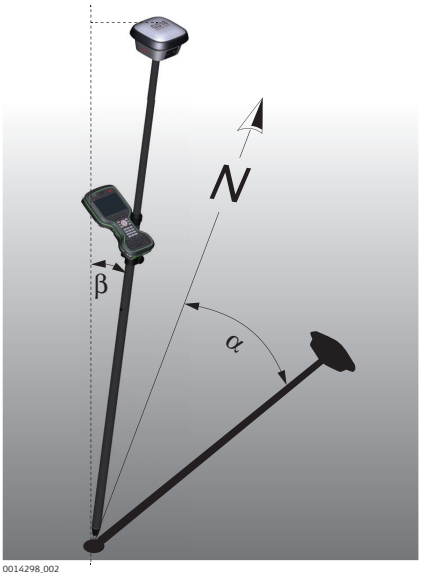
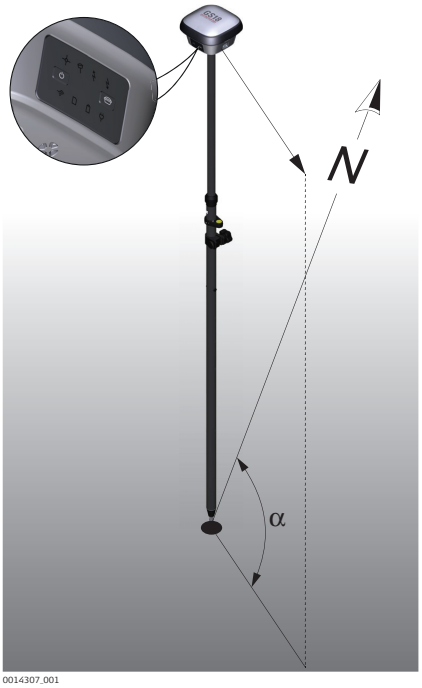
Diagram

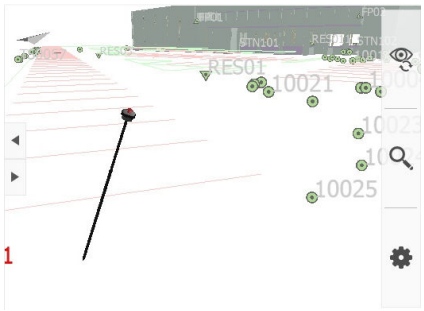
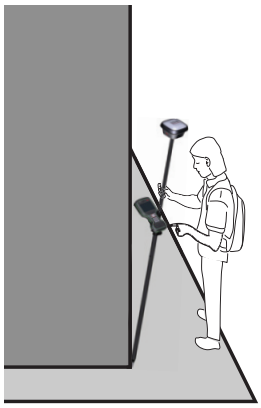
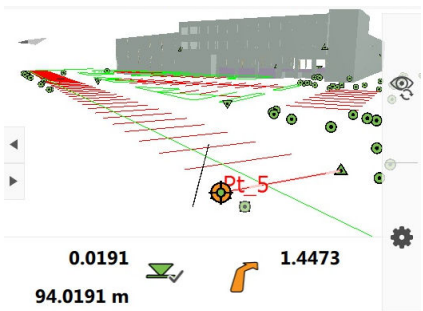


α **Tilt**

Tilt compensation step-by-step

Action		Result
☞	A GS18 must be configured as real-time rover and connected to a CS20 or CS35.	
1.	**Leica Captivate - Home**: **Settings\GS Sensor\Tilt compensation**	
2.	**Tilt Compensation** **Use tilt compensation**: Check box checked. Set **Use tilt compensator to**: **Compensate & store tilt**.	
3.	**OK**	
☞	Move the antenna for initialisation. Walking to the survey mark is sufficient. A message and a voice promt indicate that the tilt compensation is being applied.	

Action	Result
☞ The LEDs on the GS18 and the green background of the position icon on the CS20 or CS35 indicate when a tilt compensated measurement is possible. Refer to 4.6 LED Indicators on GS18.	
4. **For an overview of the current position in the survey area** Click the GS position icon. Select **Current position**.	
5. **Current GS position**, **Tiltpage** The fields are updated according to the setting for **GS position update rate** in **Screen, Audio & Text Input**.	 0014298_002 α **Tilt** β **Direction of tilt**  0014307_001 α **GS heading**

Action	Result
6. **For an overview of the current position in the survey area** Use the 3D viewer with dxf data or a background image:	
7. **Measure points** **Leica Captivate - Home**: **Measure** The position of the tilted GS18 is shown in the 3D viewer. **Measure** **Stop** **Store** Application example:	  0014297_001
8. **Stake points** **Leica Captivate - Home**: **Stake points** The position of the tilted GS18 is shown in the 3D viewer.	
9. Stake out the point. The values are valid for the tip of the pole.	

4.5 Working with the GS imaging App

Description

The camera can be used to capture images of an object of interest.

In respect to the user, the camera needs to be directed toward the left or the right side, so that it always faces the object of interest while walking along it.

To assure a good visual overlap of the images, the system captures the images with a rate of 2 Hz.

In order to get the best accuracy of point coordinates computed from the images, the images within one sequence should be captured along a U-shaped trajectory.

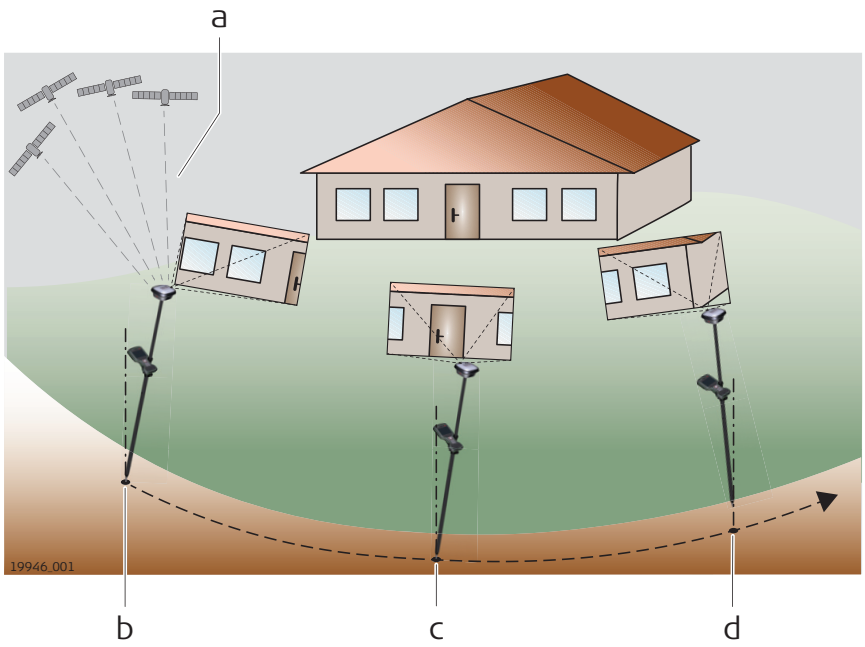
The images captured within one sequence will be stored as an image group.

The coordinates of any characteristic point captured in the images can be computed right away. One point needs to be picked manually in one image. The algorithm will automatically find the picked point in other images from the image group. The algorithm will select and use the images that are the most optimal for the calculation of the 3D position of the point.

Advantages:

- No need to measure each point individually with the pole tip of the GS sensor
- No need to physically access the points
- Capture images of the areas with weak or no satellite signal

Diagram



a GNSS signal
b Position of captured image i
c Position of captured image i+1
d Position of captured image i+2

Capturing an image group step-by-step

☞ GS18 I is ready to capture an image group when all of the following conditions are fullfilled:

- The GS18 I must be configured as real-time rover and connected to a CS20 LTE or CS35 via cable or WLAN.
- The live video stream is visible.
- The tilt compensation is initialised.
- The 3D coordinate quality value is better than 10 cm.

Action		Result
1.	**Leica Captivate - Home**: **GS imaging\Capture image group**	
2.	**Start** Walk along the object of interest while the camera is directed toward the left or the right side in respect to the user. **Stop** Wait until the image processing has been finished. **Store**	
	Capturing time The value indicates how much time has passed since the capturing of images was started. The capturing time is limited to 60 seconds.	The capturing time increases constantly during the capturing. After 60 seconds, the capturing stops automatically.
	Number of images The value indicates the number of images that were captured within the image group	The number of images will be shown after the capturing is stopped.
3.	**Image group quality** The value indicates the expected quality of a point measurement inside the image group	The quality will be shown after the capturing is stopped.

Measuring in images step-by-step

Action		Result
☞	At least one image group must be stored within the active job.	
1.	**Leica Captivate - Home**: **GS imaging\Measure in images**.	
2.	Select an image group.	
3.	Pick a characteristic point in the image. The picked point will be marked with the symbol ✛ in the image.	

Action		Result
☞	The snapping tool option can be used to automatically snap the point to the closest corner point.	
4.	**Measure**	
	For editing a measurement	
☞	If an image was used for the calculation of the 3D coordinates of the picked point, the symbol will appear in the selected image.	
☞	If an image was not used for the calculation of the 3D coordinates of the picked point, the symbol will appear in the selected image. The symbol marks the approximate position of the measured point in the selected image.	
5.	To remove an image from the measurement, select the image with **Previous** or **Next** and press **Remove**.	The coordinates and its CQ values will be re-calculated automatically after the image has been removed from the measurement.
6.	To add an image to the measurement, select the image with **Previous** or **Next**. Pick the point in this image and press **Add**. The image will be added to the measurements.	The coordinates and its CQ values will be re-calculated automatically after the image has been added to the measurement.
7.	**Store** When the point is stored, the point symbol appears in all images of the image group.	

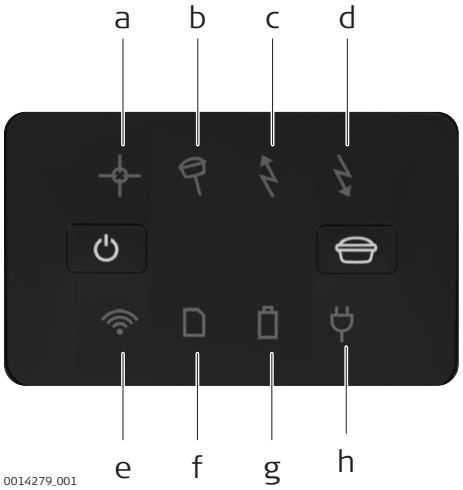
4.6 LED Indicators on GS18

LED indicators

Description

The GS18 instrument has **L**ight **E**mitting **D**iode indicators. They indicate the basic instrument status.

Diagram



a Position LED
b Tilt LED
c RTK Base LED
d RTK Rover LED
e Connectivity LED
f Storage LED
g Battery LED
h Power LED

Description of the LEDs

LED	LED Status	Status of the Instrument
Position LED	off	No satellites are tracked or GS18 is switched off.
	flashing orange	Satellites are tracked, a position is not yet available.
	orange	A navigated position is available.
	flashing green	A code-only position is available. SmartLink is converging. SBAS correction is used.
	green	A fixed RTK position is available, including xRTK. SmartLink has converged.
Tilt LED	off	GS18 is not powered. Tilt functionality is unavailable or switched off.
	green	Tilt compensation is activated, compensation values are stored. Tilt compensation is being applied.
	red	Tilt compensation is activated, but currently not being applied
	flashing red	Undefined problem with tilt compensation
RTK Base LED	off	GS18 is in RTK rover mode or GS18 is switched off.
	green	GS18 is in base mode, no RTK data is transmitted

LED	LED Status	Status of the Instrument
	flashing green	GS18 is in base mode, RTK data is transmitted to the selected port. Rate according to RTK base setting.
RTK Rover LED	off	GS18 is in RTK base mode or GS18 is switched off.
	green	GS18 is in rover mode, no RTK data is received via selected port.
	flashing green	GS18 is in rover mode, RTK data is received via selected port. Rate according to received correction data.
Connectivity LED	off	GS18 is not powered or module is not ready.
	green	Bluetooth is in data mode and ready for connecting.
	blue	Bluetooth has connected.
Storage LED	off	No SD card is inserted or GS18 is switched off.
	green	SD card is inserted but no raw data is being logged.
	flashing green	Raw data is being logged. More than 50 MB of memory space is available on the SD card.
	red	Less than 50 MB of memory space is available on the SD card.
	flashing red	Raw data is being logged but less than 50 MB of memory space left on the SD card.
	fast flashing red	SD card is full or no SD card is inserted while raw data logging is configured. No raw data can be logged.
Battery LED	off	Battery is not connected, flat or GS18 is switched off.
	green	Power is 21% - 100%.
	flashing green	Battery is inserted. External power is connected.
	red	Power is 20% - 11%. The remaining time for which enough power is available depends on the type of survey, the temperature and the age of the battery.
	flashing red	Battery is inserted with less than 20% power remaining. External power is connected.
	fast flashing red	Power is low (<10%).
Power LED	off	External battery is not connected or flat or no external power supply is connected or GS18 is switched off.
	green	External power is 21% - 100%.
	red	External power is 20% - 11%.

LED	LED Status	Status of the Instrument
	flashing red	External power is low (<10%).

4.7 Guidelines for Correct Results with GNSS Surveys

Undisturbed satellite signal reception

Successful GNSS surveys require undisturbed satellite signal reception, especially at the instrument which serves as a base. Set up the instrument in locations which are free of obstructions such as trees, buildings or mountains.

Steady instrument for static surveys

For static surveys, the instrument must be kept perfectly steady throughout the whole occupation of a point. Place the instrument on a tripod or pillar.

Centred and levelled instrument

Centre and level the instrument precisely over the marker.

Tilt compensation for kinematic surveys

For stakeout and surveys with instantaneous point measurement, auto points or point measurements with short occupation time, tilt compensation is applied. The pole tip can be placed on the marker, while the antenna does not have to remain level and steady. The status of the tilt compensation is indicated by an icon and the Tilt LED.

5 Care and Transport

5.1 Transport

Transport in the field

When transporting the equipment in the field, always make sure that you

- either carry the product in its original container,
- or carry the tripod with its legs splayed across your shoulder, keeping the attached product upright.

Transport in a road vehicle

Never carry the product loose in a road vehicle, as it can be affected by shock and vibration. Always carry the product in its container and secure it.

For products for which no container is available use the original packaging or its equivalent.

Shipping

When transporting the product by rail, air or sea, always use the complete original Leica Geosystems packaging, container and cardboard box, or its equivalent, to protect against shock and vibration.

Shipping, transport of batteries

When transporting or shipping batteries, the person responsible for the product must ensure that the applicable national and international rules and regulations are observed. Before transportation or shipping, contact your local passenger or freight transport company.

5.2 Storage

Product

Respect the temperature limits when storing the equipment, particularly in summer if the equipment is inside a vehicle. Refer to 6 Technical Data for information about temperature limits.

Li-Ion batteries

- Refer to 6 Technical Data for information about storage temperature range.
- Remove batteries from the product and the charger before storing.
- After storage recharge batteries before using.
- Protect batteries from damp and wetness. Wet or damp batteries must be dried before storing or use.
- A storage temperature range of 0 °C to +30 °C / +32 °F to +86 °F in a dry environment is recommended to minimize self-discharging of the battery.
- At the recommended storage temperature range, batteries containing a 40% to 50% charge can be stored for up to one year. After this storage period the batteries must be recharged.

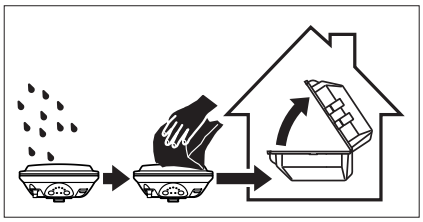
5.3 Cleaning and Drying

Product and Accessories

- Use only a clean, soft, lint-free cloth for cleaning. If necessary, moisten the cloth with water or soapy water. Do not use other liquids; these may attack the product surface.

Damp products

Dry the product, the transport container, the foam inserts and the accessories at a temperature not greater than 40 °C [104 °F] and clean them. Remove the battery cover and dry the battery compartment. Do not repack until everything is dry. Always close the transport container when using in the field.



Cables and plugs	Keep plugs clean and dry. Blow away any dirt lodged in the plugs of the connecting cables.
Connectors with dust caps	Wet connectors must be dry before attaching the dust cap.

6 Technical Data

6.1 GS18 Technical Data

6.1.1 Tracking Characteristics

Satellite reception

Multi-frequency

Instrument channels

☞ Depending on the satellite systems and signals configured, a maximum number of 555 channels is allocated.

Supported signals

System	Signal
GPS	L1, L2, L2C, L5
GLONASS	L1, L2, L2C, L3*
Galileo	E1, E5a, E5b, AltBOC, E6*
BeiDou	B1I, B2I, B2a, B3I
QZSS	L1, L2C, L5, L6*
NavIC	L5
SBAS (WAAS, EGNOS, MSAS, GAGAN) Terrastar	L-band

* GLONASS L3, Galileo E6 and QZSS L6 will be provided through future firmware upgrade.

☞ Carrier phase and code measurements on L1, L2 and L5 (GPS) are fully independent with AS on or off.

☞ Support of NavIC L5 is incorporated and will be provided through future firmware upgrade.

6.1.2 Accuracy

☞ Accuracy is dependent upon various factors including the number of satellites tracked, constellation geometry, observation time, ephemeris accuracy, ionospheric disturbance, multipath and resolved ambiguities.

The following accuracies, given as **r**oot **m**ean **s**quare, are based on measurements processed using Leica Infinity and on real-time measurements.

The use of multiple GNSS systems can increase accuracy by up to 30% relative to GPS only.

Differential code

The baseline precision of a differential code solution for static and kinematic surveys is 25 cm.

Differential phase in post-processing

Type	Horizontal	Vertical
Static and rapid static	3 mm + 0.5 ppm	5 mm + 0.5 ppm
Kinematic	8 mm + 1 ppm	15 mm + 1 ppm

Type	Horizontal	Vertical
Static with long observations	3 mm + 0.1 ppm	3.5 mm + 0.4 ppm

Differential phase in real-time

Type	Horizontal	Vertical
Single Baseline (<30 km)	10 mm + 1 ppm	20 mm + 1 ppm
Network RTK	10 mm + 0.5 ppm	20 mm + 0.5 ppm

Tilt

Tilt compensated in real-time

Additional Hz pole tip uncertainty:

Typically less than 8 mm + 0.4 mm/° tilt down to 30° tilt for topographic points (not for static control points)

Imaging

Typically 2 cm to 4 cm (2D) within the distance of 2 m to 10 m between the camera and the object

The accuracy depends on the prevailing GNSS accuracy and the type of the trajectoy.

A curve in the trajectory increases the accuracy of an image point measurement.

6.1.3 Technical Data

Dimensions

Height:	0.109m
Diameter:	0.190 m

Weight

Instrument weight without battery, SIM card and SD card:

Type	Weight [kg]/[lbs]
GS18 I	1.25/2.75
GS18 T	1.23/2.71

Recording

Data (Leica GNSS raw data and RINEX data) can be recorded on the SD card.

1 GB is sufficient for over 1 year of raw data logging based on logging every 15 s from an average of 15 satellites.

Power

Power consumption:	Radio excluded: 3.5 W typically, 300 mA (with external battery), 320 mA (with internal battery)
External supply voltage:	Nominal 12 V DC (⎓, GEV71 car battery cable to a 12 V car battery), voltage range 12 V-24 V DC

Internal battery

Type	Battery	Voltage	Capacity	Operating time, typical*
GEB331	Li-Ion	11.1 V	2.8 Ah	8 h

* Operating time depends on use of wireless communication devices.

External battery

Type	Battery	Voltage	Capacity
GEB371	Li-Ion	13 V	16.8 Ah

Operating times

The given operating times are valid for

- GS18: instrument; one fully charged GEB331 battery.
- Room temperature; operating times will be shorter when working in cold weather.

Type		Operating time
Static		8 h continuously
Rover	with cellular modem	6 h continuously
	with radio modem	7 h continuously
Base	with cellular modem	6 h continuously
	with radio modem 1 W output power	5 h continuously

Electrical data

Type		GS18
Voltage		-
Current		-
GNSS Signal	**Frequency**	
GPS L5 Galileo E5a BeiDou B2a	1176.4500 MHz	✓
Galileo AltBOC	1191.7950 MHz	✓
GLONASS L3	1202.0250 MHz	✓
Galileo E5bI BeiDou B2	1207.1400 MHz	✓
GPS L2	1227.6000 MHz	✓
GLONASS L2	1242.9375 - 1248.6250 MHz	✓
BeiDou B3I	1268.5200 MHZ	✓
Galileo E6 QZSS L6	1278.7500 MHz	✓
BeiDou B1I	1561.0980 MHz	✓
GPS L1 C/A GPS L1C Galileo E1 BeiDou B1C	1575.4200 MHz	✓
GLONASS L1	1598.0625 - 1605.3750 MHz	✓
Terrastar	1545.8250 - 1545.9050 MHz	✓
Gain (LNA)		Typically 29 dB
Noise Figure		Typically < 2 dB

Environmental specifications

Temperature

Type	Operating temperature [°C]	Storage temperature [°C]
GS18 I	–30 to +50	–40 to +85

Type	Operating temperature [°C]	Storage temperature [°C]
GS18 T	–40 to +65	–40 to +85
Leica SD cards	–40 to +85	–40 to +100
GEB331	–20 to +60	–40 to +70

Protection against water, dust and sand

Type	Protection
GS18 I/ GS18 T	IP66 & IP68 (IEC 60529), dust tight Protected against continuous immersion in water Tested for 2 hours in 1.40 m depth
GEB331	IP54 (IEC60529), dust protected Protection against splashing water from any direction. Humidity max. 95% non condensing.

Humidity

Protection
Up to 95% The effects of condensation are to be effectively counteracted by periodically drying out the instrument.

6.2 Conformity to National Regulations

6.2.1 GS18

Conformity to national regulations

- FCC Part 15, 22 and 24 (applicable in US)
- Hereby, Leica Geosystems AG declares that the radio equipment type GS18 is in compliance with Directive 2014/53/EU and other applicable European Directives.
  The full text of the EU declaration of conformity is available at the following Internet address: http://www.leica-geosystems.com/ce.
- This Class 2 equipment may be operated in: AT, BE, BG, CA, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MT, NL, NO, PL, PT, RU, RO, SE, SI, SK, US.

CE Class 2 equipment according to European Directive 2014/53/EU (RED) for which following EEA Member States apply restrictions on the placing on the market or on the putting into service or require authorisation for use:
  - France
  - Italy
  - Norway (if used in the geographical area within a radius of 20 km from the centre of Ny-Ålesund)

- The conformity for countries with other national regulations not covered by the FCC part 22 and 24 or European Directive 2014/53/EU has to be approved prior to use and operation.

- Japanese Radio Law and Japanese Telecommunications Business Law Compliance.
  - This device is granted pursuant to the Japanese Radio Law (電波法) and the Japanese Telecommunications Business Law (電気通信事業法).
  - This device should not be modified (otherwise the granted designation number will become invalid).

Frequency band

Type	Frequency band [MHz]
GS18	1227.60 1246.4375 - 1254.3 1575.42 1602.5625 - 1611.5
GS18, Bluetooth	2402 - 2480
GS18, WLAN	2401 - 2495
GS18, Radio	403 - 473
GS18, Cellular phone	Dual-Band GSM 900 / 1800 & Tri-Band UMTS 900 / 1800 / 2100 & Penta-Band LTE 800 (B20) / 900 (B8) / 1800 (B3) / 2100 B(7) / 2600 (B1)
GS18, Cellular phone (NAFTA)	Quad-Band GSM 850 / 900 / 1800 / 1900 & Tri-Band UMTS 850 / AWS 1700/2100 / 1900 & Penta-Band LTE 700 (B13) / 700 (B17) / 850 (B5) / AWS 1700/2100 (B4) / 1900 (B2)
GS18, Cellular phone (Japan)	Tri-Band UMTS 800 B6 / 800 B19 / 2100 B1 & Tri-Band LTE 800 (B19) / 1800 (B3) / 2100 (B1)

Output power

Type	Output power [mW]
GNSS	Receive only
Bluetooth	5
Radio	1000
WLAN	100
GS18 GSM	1000 / 2000
GS18 UMTS	250
GS18 LTE	200

Antenna

Type	Antenna	Gain [dBi]
GNSS	Internal GNSS antenna element (receive only)	-
Bluetooth	Internal Microstrip antenna	2 max.
UHF	External antenna	0
WLAN	Internal Patch antenna	2 max.
GSM/UMTS/LTE	External antenna	2 max.

6.2.2 Dangerous Goods Regulations

Dangerous Goods Regulations

Many products of Leica Geosystems are powered by Lithium batteries.

Lithium batteries can be dangerous under certain conditions and can pose a safety hazard. In certain conditions, Lithium batteries can overheat and ignite.

☞ When carrying or shipping your Leica product with Lithium batteries onboard a commercial aircraft, you must do so in accordance with the **IATA Dangerous Goods Regulations**.

☞ Leica Geosystems has developed **Guidelines** on "How to carry Leica products" and "How to ship Leica products" with Lithium batteries. Before any transportation of a Leica product, we ask you to consult these guidelines on our web page (http://www.leica-geosystems.com/dgr) to ensure that you are in accordance with the IATA Dangerous Goods Regulations and that the Leica products can be transported correctly.

☞ Damaged or defective batteries are prohibited from being carried or transported onboard any aircraft. Therefore, ensure that the condition of any battery is safe for transportation.

7 Software Licence Agreement/Warranty

Software Licence Agreement

This product contains software that is preinstalled on the product, or that is supplied to you on a data carrier medium, or that can be downloaded by you online according to prior authorisation from Leica Geosystems. Such software is protected by copyright and other laws and its use is defined and regulated by the Leica Geosystems Software Licence Agreement, which covers aspects such as, but not limited to, Scope of the Licence, Warranty, Intellectual Property Rights, Limitation of Liability, Exclusion of other Assurances, Governing Law and Place of Jurisdiction. Please make sure, that at any time you fully comply with the terms and conditions of the Leica Geosystems Software Licence Agreement.

Such agreement is provided together with all products and can also be referred to and downloaded at the Leica Geosystems home page at http://leica-geosystems.com/about-us/compliance-standards/legal-documents or collected from your Leica Geosystems distributor.

You must not install or use the software unless you have read and accepted the terms and conditions of the Leica Geosystems Software Licence Agreement. Installation or use of the software or any part thereof, is deemed to be an acceptance of all the terms and conditions of such Licence Agreement. If you do not agree to all or some of the terms of such Licence Agreement, you must not download, install or use the software and you must return the unused software together with its accompanying documentation and the purchase receipt to the distributor from whom you purchased the product within ten (10) days of purchase to obtain a full refund of the purchase price.

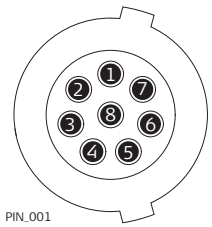
Appendix A Pin Assignments and Sockets

Description

Some applications require knowledge of the pin assignments for the instrument ports.

In this chapter, the pin assignments and sockets for the instrument ports are explained.

Pin assignments for port P1



PIN_001

Pin	Signal Name	Function	Direction
1	USB_D+	USB data line	In or out
2	USB_D–	USB data line	In or out
3	GND	Signal ground	-
4	RxD	RS232, receive data	In
5	TxD	RS232, transmit data	Out
6	ID	Identification pin	In or out
7	PWR	Power input, 10.5 V-28 V	In
8	GPIO	RS232, general-purpose signal	In or out

851580-2.0.0en
Original text (851580-2.0.0en)
Published in Switzerland

PART OF HEXAGON

- when it has to be **right**

Leica Geosystems

Leica Geosystems AG
Heinrich-Wild-Strasse
CH-9435 Heerbrugg
Switzerland
Phone +41 71 727 31 31

www.leica-geosystems.com

Appendix A-2.
Standard Operating Procedures

RTK SURVEY OF SITE FEATURES

PURPOSE

To provide methods and calculations necessary to conduct a topographic survey and establish a site benchmark.

Note: Field staff need to check with the principal-in-charge (PIC) and/or the project manager (PM) before conducting field work to confirm the actual field procedure to be followed and to discuss and document any deviations to GZA's standard operating procedure (SOP).

EQUIPMENT AND MATERIALS

- Field Book;
- Pencil or pen;
- Leica GS-16 or GS-18 Sensor;
- Leica CS-30 or CS-35 data collector tablet;
- Survey pole;

PROCEDURES

1. Pre-survey

    a. Research known benchmarks in the vicinity of the project site.

    b. Develop field sketch of the survey area, identify important site features

2. Preparation for use

    a. Start the GS sensor by holding the power button until the power light flashes on.

    b. Attach the GS sensor to the survey pole. Verify that the screw connection is tight.

    c. Start the CS tablet and log into windows. The passwords for each unit are stored in the carrying case.

    d. When using the GS-16, right click on the GS-16 short cut on the windows desktop and select "connect using ad hoc network" The Bluetooth light on the GS sensor will turn blue. When using the GS 18, the Bluetooth connection will happen automatically. Verify that the Bluetooth light on the GS sensor is blue.

    e. Open Leica Captivate from the desktop shortcut or the start menu.

3. Job file creation

   a. Within Captivate, select "Create New Job". If a job has already been created for the site, select the existing job and proceed to step 3.

   b. Within the job creation menu, provide a job name, select the correct coordinate system for the project location and select the most recent Geoid.

   c. Select "Store "in the bottom right corner to save the job.

4. Survey

   a. Within Captivate, click on the tablet icon in the top right and select "start RTK stream" Wait until the GPS unit displays the "locked" icon.

   b. Once the unit is locked onto satellite connections, and the RTK accuracy rang is less than 0.1feet (horizontal and vertical) enter the "measure" application from the bottom carousel.

   c. Set the rod and sensor over the point to be surveyed. Verify that the level bubble on the rod is centered. Verify that the listed height on the tablet matches the actual rod height.

   d. The first survey point should be over a known benchmark if possible. Verify accuracy of the surveyed point to the known benchmark position and height.

   e. Label the point code to describe what the survey point represents and verify that the rod height on in the program matches the actual rod height set. Change the rod height into the measure application if required. A screen will pop up to ask for information to be verified before the point is saved.

   f. Click "measure" in the bottom right to collect the point that the rod is set over.

   g. The point will automatically save if the accuracy is within the set tolerances (.01 ft). If the point accuracy is not within the set tolerances, discard and repeat the steps above.

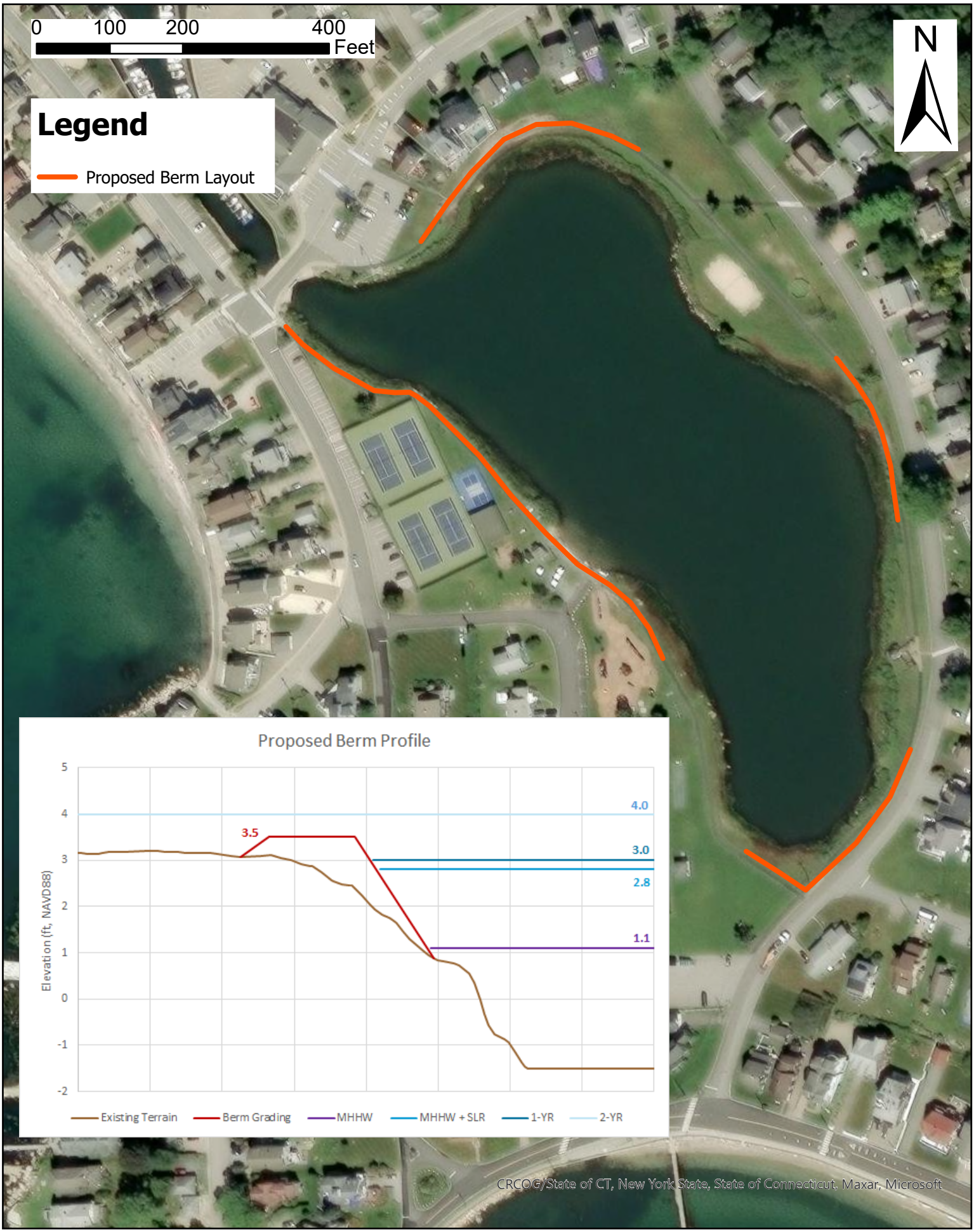
   h. Repeat as necessary until enough data has been collected to create an accurate topographic representation of the project site and all site features have been identified and field surveyed.

APPLICABLE STANDARDS AND REFERENCES

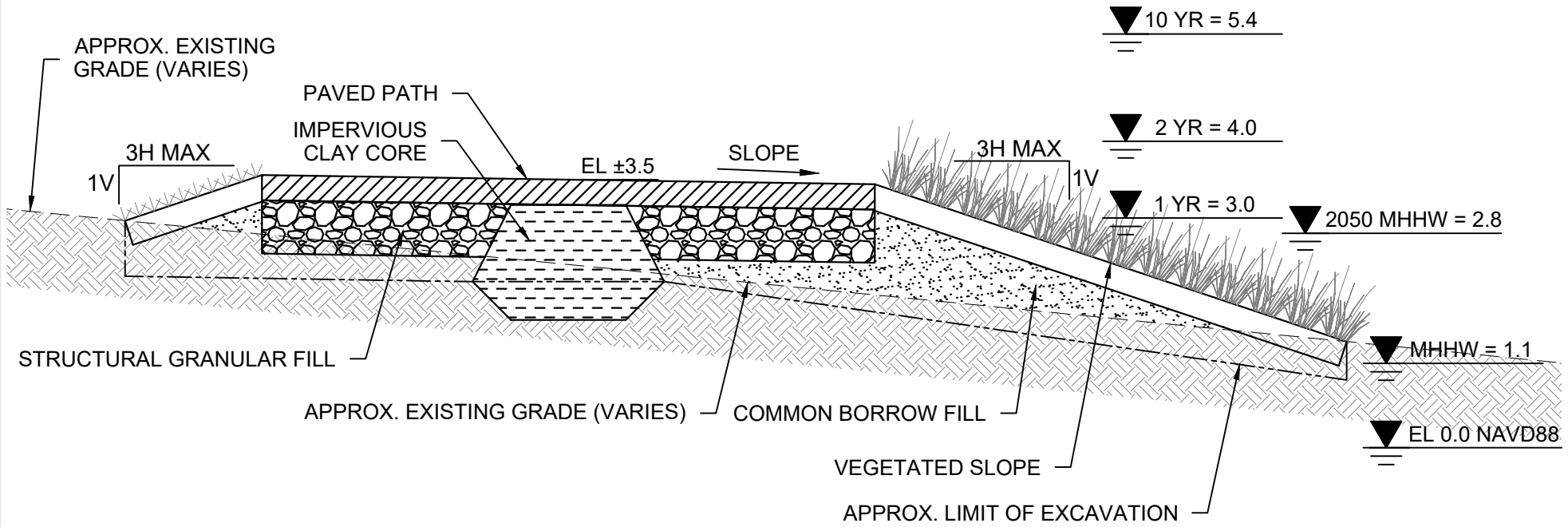
- Leica Captivate Technical Reference Manual, Leica Geosystems, 2015

Appendix D – Conceptual Design Drawings

1A - UPPER LAGOON MARSH MIGRATION PATH



GZA-\\gzanor\Jobs\170,000-179,999\177618\177618-00.MEG\Figures\CAD\177618_Groton Long Point Conceptual Alternatives.dwg [1A BERM] April 04, 2025 - 11:09am lucas.taylor



1A - UPPER LAGOON MARSH MIGRATION PATH

SCALE 1" = 2'

0 1' 2' 4'

SCALE IN FEET 1" = 2'

NOT FOR CONSTRUCTION

NO.	ISSUE/DESCRIPTION	BY	DATE

GROTON LONG POINT

1A - UPPER LAGOON MARSH MIGRATION PATH

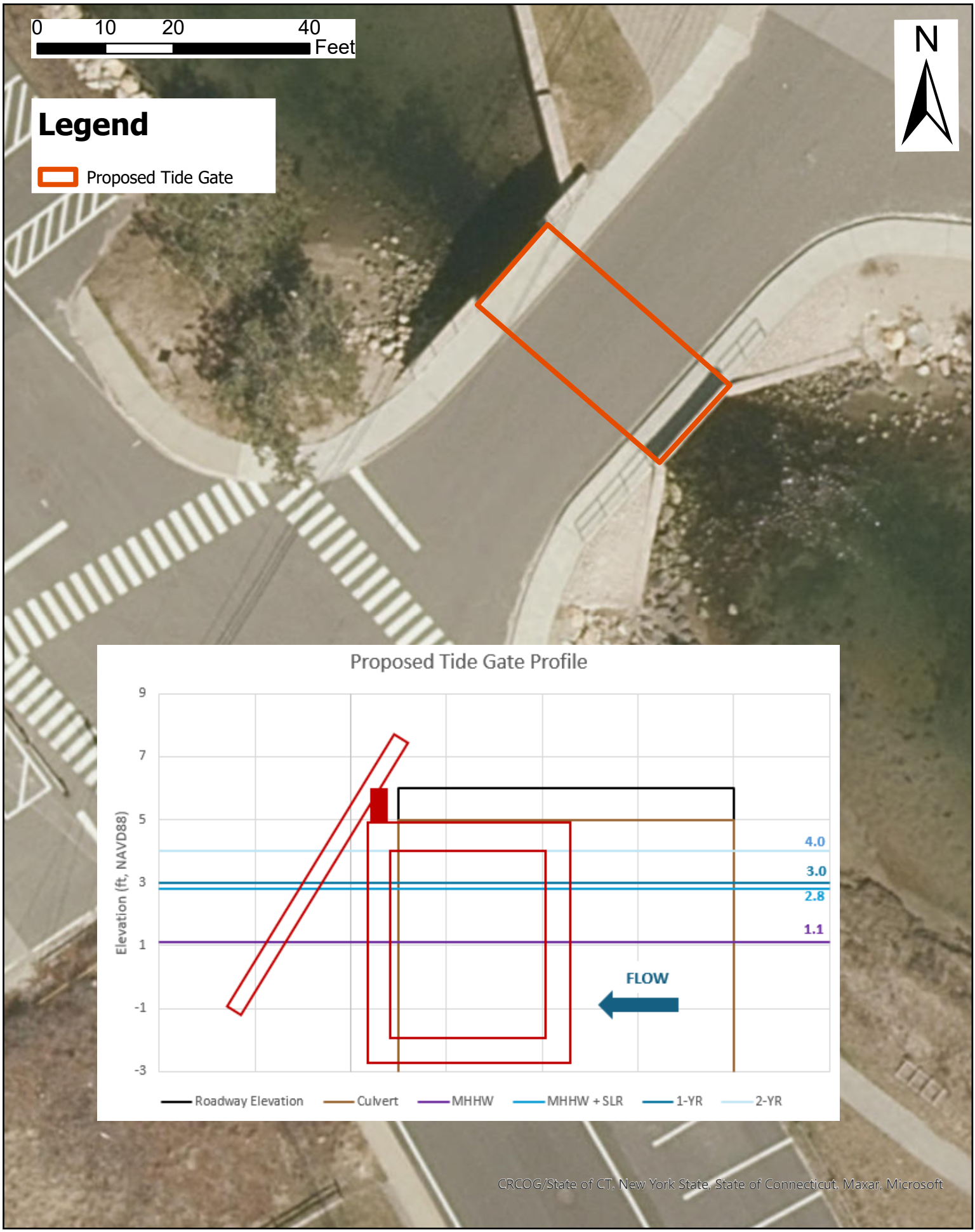
PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
GROTON LONG POINT ASSOCIATION

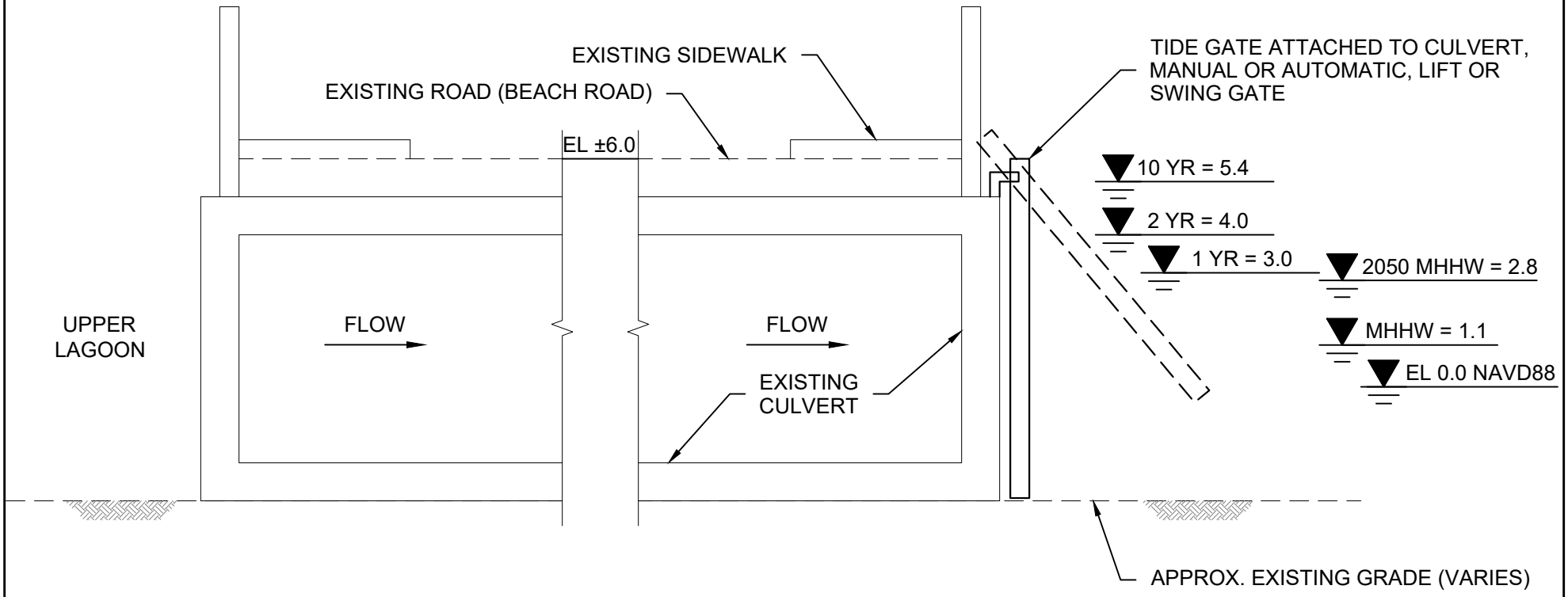
PROJ MGR:	MG	REVIEWED BY:	MG	CHECKED BY:	CKB
DESIGNED BY:	MG/AR	DRAWN BY:	LT	SCALE:	AS SHOWN
DATE:	APRIL 2025	PROJECT NO.	01.0177618.00	REVISION NO.	1

FIGURE
1A
SHEET NO.

1B - UPPER LAGOON TIDE GATE



GZA-\\GZANOR\Jobs\170,000-179,999\177618\177618-00.MEG\Figures\CAD\177618_Groton Long Point Conceptual Alternatives.dwg [1B TIDE GATE] April 03, 2025 - 12:43pm lucas.taylor



1B - UPPER LAGOON TIDE GATE

SCALE 1" = 4'

0 2' 4' 8'

SCALE IN FEET 1" = 4'

NOT FOR CONSTRUCTION

NO.	ISSUE/DESCRIPTION	BY	DATE

GROTON LONG POINT

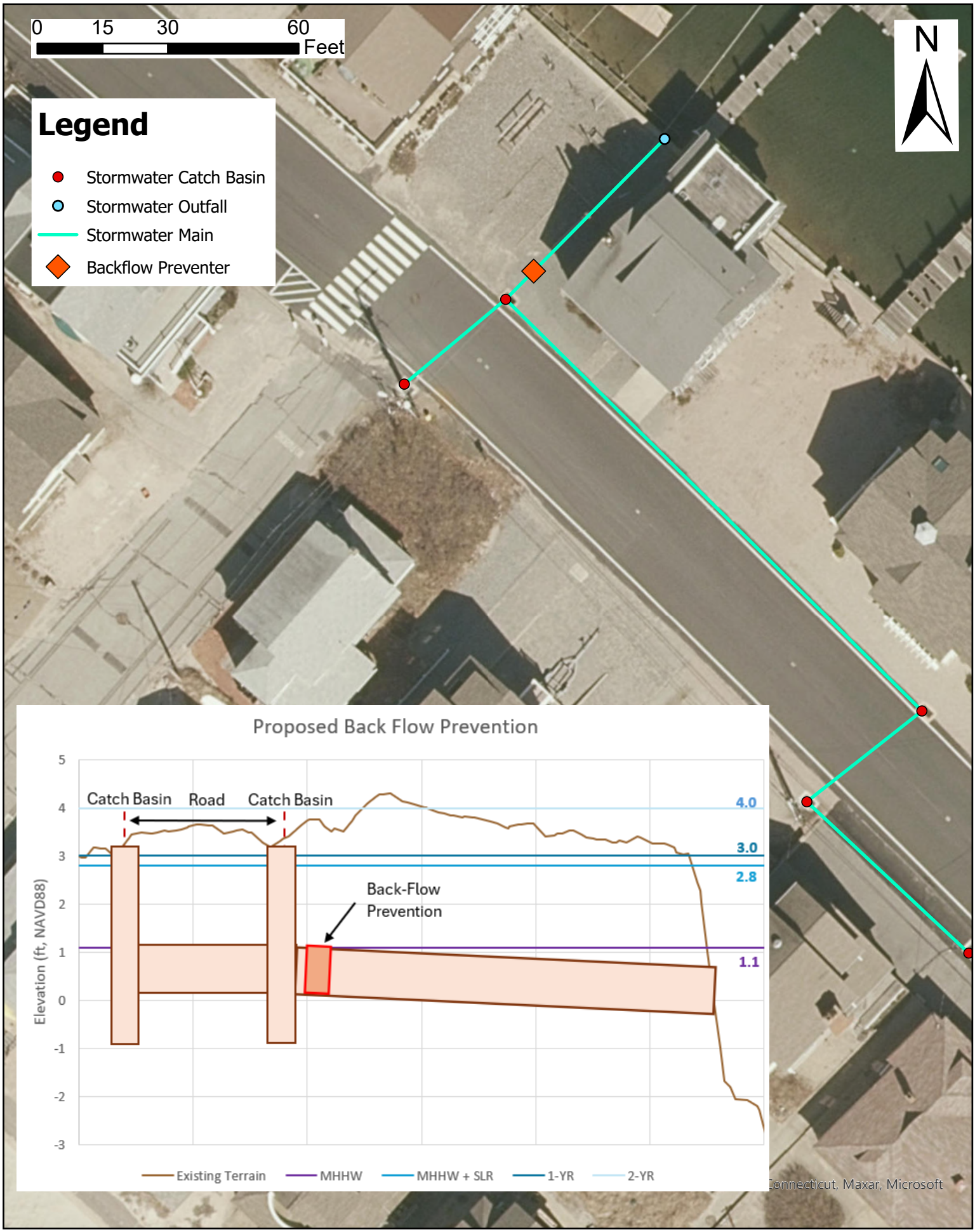
1B - UPPER LAGOON TIDE GATE

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

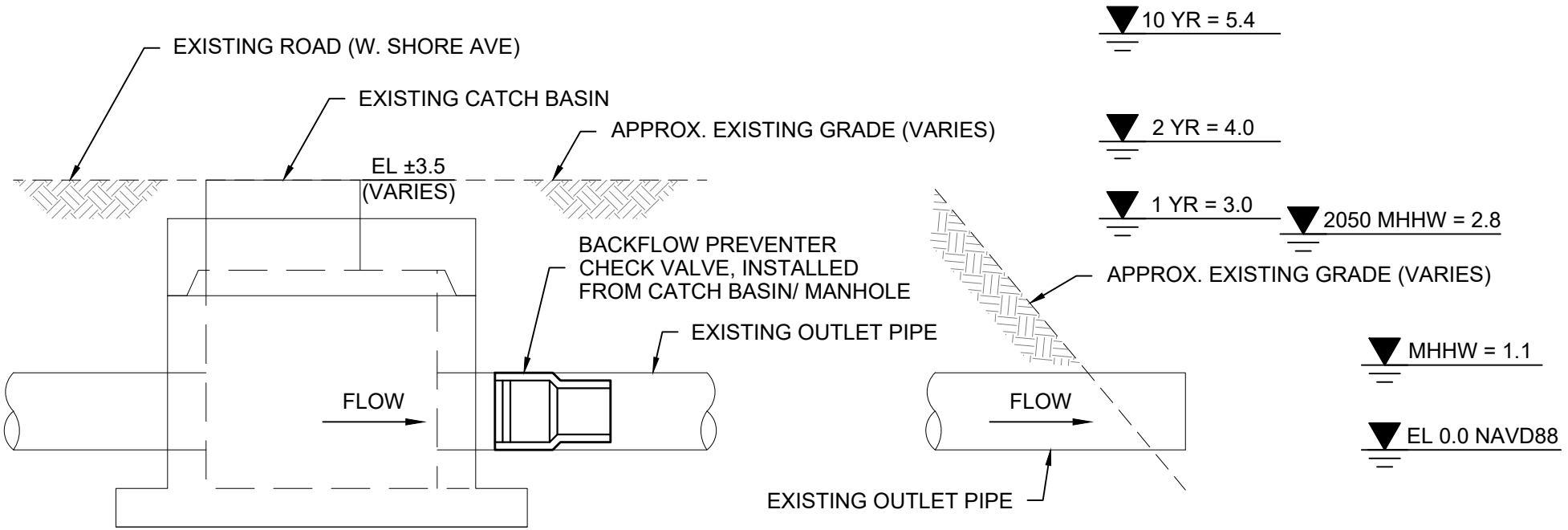
PREPARED FOR:
GROTON LONG POINT ASSOCIATION

PROJ MGR: MG	REVIEWED BY: MG	CHECKED BY: CKB	FIGURE
DESIGNED BY: MG/AR	DRAWN BY: LT	SCALE: AS SHOWN	1B
DATE: APRIL 2025	PROJECT NO. 01.0177618.00	REVISION NO. 1	SHEET NO.

2A - STORMWATER IMPROVEMENTS: BACKFLOW PREVENTERS



GZA-\\GZANOR\Jobs\170,000-179,999\177618\177618-00.MEG\Figures\CAD\177618_Groton Long Point Conceptual Alternatives.dwg [2A BACKFLOW CHECK VALVE] April 03, 2025 - 1:29pm lucas.taylor



2A - STORMWATER IMPROVEMENTS: BACKFLOW PREVENTERS

NOT FOR CONSTRUCTION

SCALE 1" = 2'

0 1' 2' 4'

SCALE IN FEET 1" = 2'

NO.	ISSUE/DESCRIPTION	BY	DATE

GROTON LONG POINT

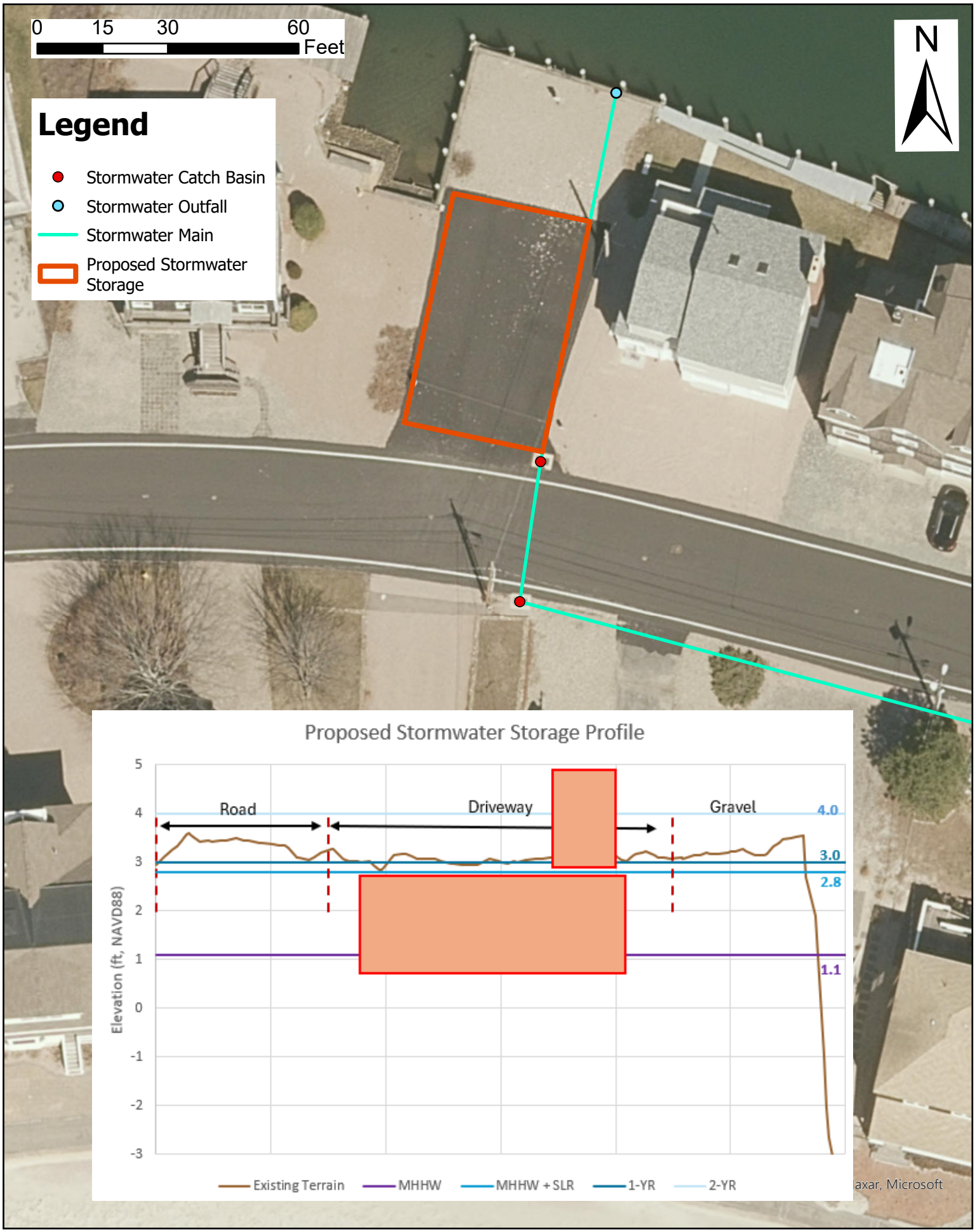
2A - STORMWATER IMPROVEMENTS: BACKFLOW PREVENTERS

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

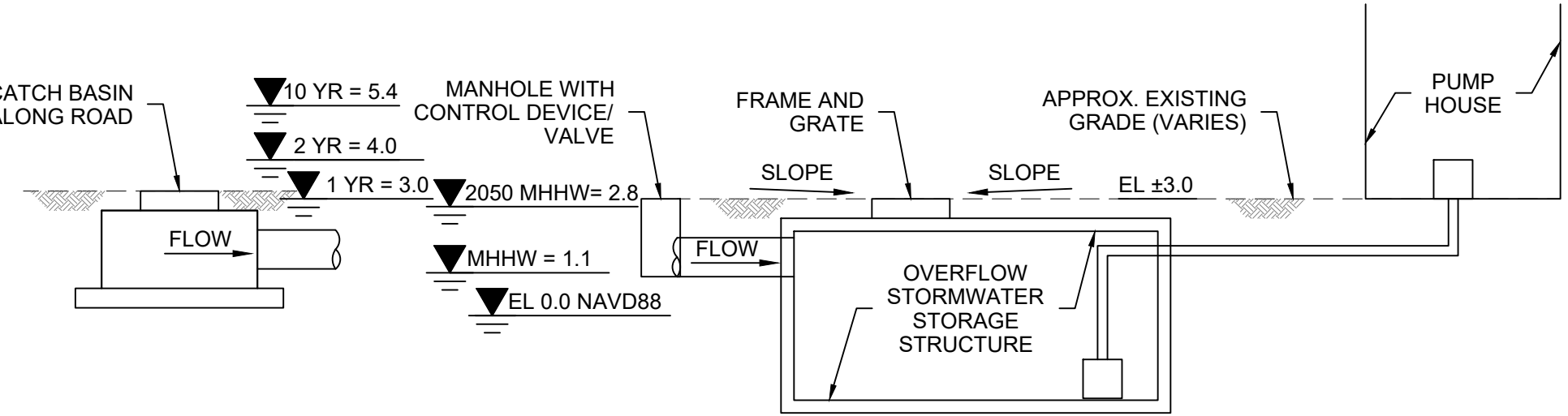
PREPARED FOR:
GROTON LONG POINT ASSOCIATION

PROJ MGR: MG	REVIEWED BY: MG	CHECKED BY: CKB	FIGURE
DESIGNED BY: MG/AR	DRAWN BY: LT	SCALE: AS SHOWN	2A
DATE: APRIL 2025	PROJECT NO. 01.0177618.00	REVISION NO. 1	SHEET NO.

2B - STORMWATER IMPROVEMENTS: STORAGE AND PUMP STRUCTURE



GZA-\\gzanor\Jobs\170,000-179,999\177618\177618-00.MEG\Figures\CAD\177618_Groton Long Point Conceptual Alternatives.dwg [2B STORAGE STRUCTURE] April 04, 2025 - 10:27am lucas.taylor



2B - STORMWATER IMPROVEMENTS: STORAGE AND PUMP STRUCTURE

NOT FOR CONSTRUCTION

SCALE 1" = 4'

0 2' 4' 8'

SCALE IN FEET 1" = 4'

NO.	ISSUE/DESCRIPTION	BY	DATE

GROTON LONG POINT

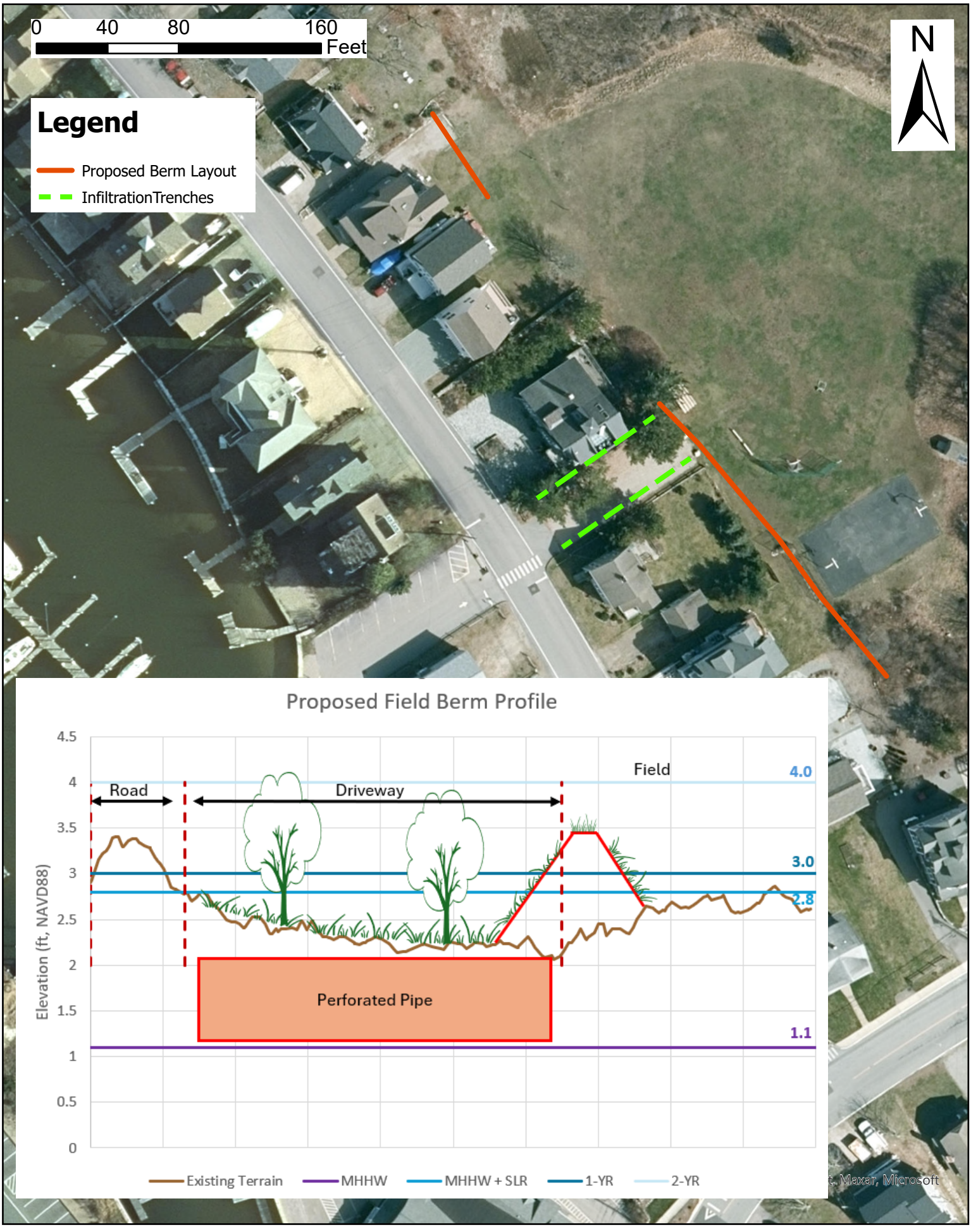
2B - STORMWATER IMPROVEMENTS: STORAGE AND PUMP STRUCTURE

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

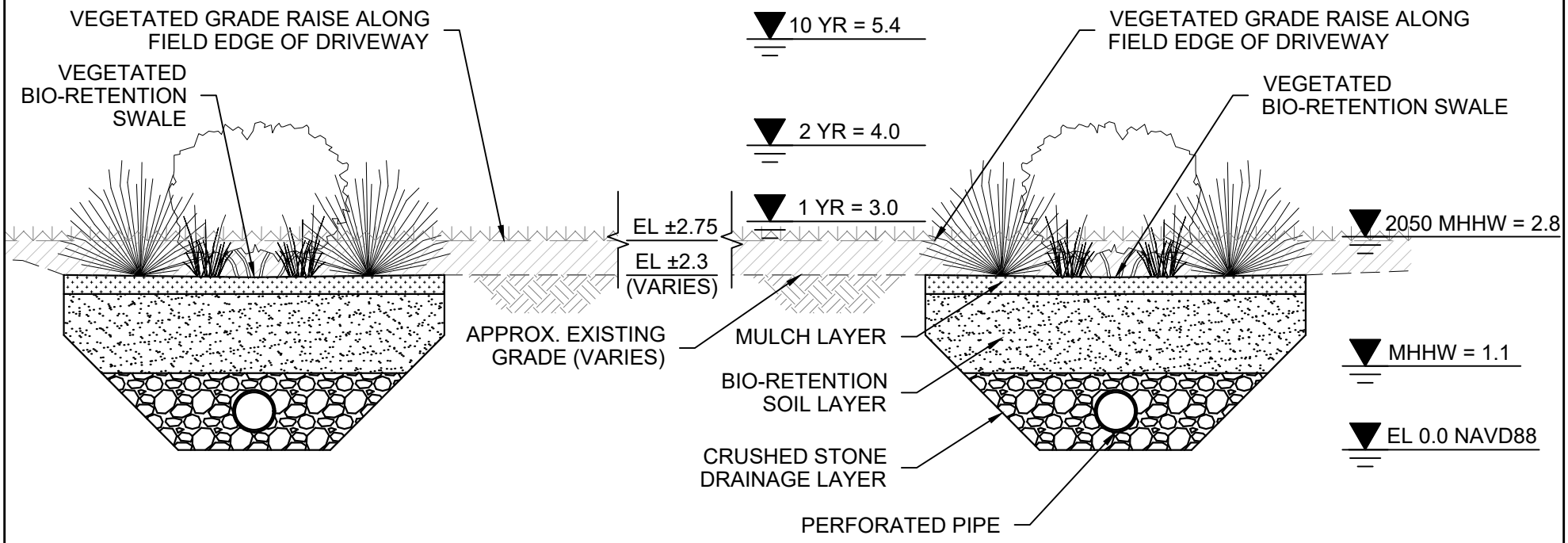
PREPARED FOR:
GROTON LONG POINT ASSOCIATION

PROJ MGR: MG	REVIEWED BY: MG	CHECKED BY: CKB	FIGURE
DESIGNED BY: MG/AR	DRAWN BY: LT	SCALE: AS SHOWN	2B
DATE: APRIL 2025	PROJECT NO. 01.0177618.00	REVISION NO. 1	SHEET NO.

3 - SPORTS FIELD VEGETATED GRADE RAISE AND BIO-SWALE



GZA-\\GZANOR\Jobs\170,000-179,999\177618\177618-00.MEG\Figures\CAD\177618_Groton Long Point Conceptual Alternatives.dwg [3 FIELD BIO-SWALE] April 03, 2025 - 12:49pm lucas.taylor



3 - SPORTS FIELD VEGETATED GRADE RAISE AND BIO-SWALE

NOT FOR CONSTRUCTION

SCALE 1" = 2'

0 1' 2' 4'

SCALE IN FEET 1" = 2'

NO.	ISSUE/DESCRIPTION	BY	DATE

GROTON LONG POINT

3 - SPORTS FIELD VEGETATED GRADE RAISE AND BIO-SWALE

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
GROTON LONG POINT ASSOCIATION

PROJ MGR: MG	REVIEWED BY: MG	CHECKED BY: CKB	FIGURE
DESIGNED BY: MG/AR	DRAWN BY: LT	SCALE: AS SHOWN	3
DATE: APRIL 2025	PROJECT NO. 01.0177618.00	REVISION NO. 1	SHEET NO.

GZA GeoEnvironmental, Inc.