

DEQ / Killian Stotenberg, Administrative Coordinator  
May 23, 2024

Dear Killian,

Enclosed please find the Initial Seismic Vulnerability Assessment Report (May 15, 2024) prepared for NW Natural by HDR, Inc. The report is for NW Natural's liquified natural gas facility located at 7900 NW St. Helens Rd., Portland. The Report describes the efforts undertaken to date to complete the seismic assessment, identifies the tasks remaining to be completed, and provides a timeline through expected completion and submittal to DEQ of a Final Assessment Report.

Pursuant to OAR 340-300-0003(3)(b)(B), NW Natural requests an extension to December 20<sup>th</sup>, 2024 of the deadline to submit a complete assessment final report. NW Natural received DEQ's new rules in September 2023. Following evaluation of the required scope of work under the rules, NW Natural identified possible consultants with sufficient experience to undertake the assessment and ultimately contracted with HDR. Since that time, HDR has made and continues to make progress toward completing the tasks required by the seismic rules. As detailed in its the report, HDR has begun the assessment process, including the important task of identifying and analyzing the appropriate code provisions. There are currently significant gaps in the data necessary for evaluating the seismic stability of the tank. HDR intends to commence the collection of field data required for the completion of the assessment in coming weeks. For these reasons, NW Natural has shown good cause for an extension under OAR 340-300-0003(8).

Sincerely,



Andrew Bauer RG, LG  
NW Natural – Manager  
Environmental Compliance



# Initial Seismic Vulnerability Assessment Report

Portland LNG Facility

Prepared for NW Natural

*Portland, OR*  
May 15, 2024



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## Contents

Executive Summary .....	2
Introduction.....	2
Work Performed to Date .....	3
Code Evaluation .....	3
Development of an Assessment Approach.....	3
Consideration of Environmental Conditions.....	4
Work to be Performed .....	4
Geotechnical/Geophysical Exploration .....	4
Preliminary Liquefaction Hazard Evaluation .....	5
Site-Specific Ground Motion Evaluation .....	6
Structural Evaluation .....	6
LNG Tank .....	6
Process Area .....	7
Supporting Buildings .....	7
Piping Evaluation.....	7
Balance-of-Plant Evaluation .....	7
Conclusion.....	8
References .....	8
Appendix A – Schedule.....	10

## Executive Summary

NW Natural (NWN) owns and operates an LNG peakshaving facility adjacent to the Willamette River in Portland, Oregon. The facility is subject to compliance with ORS 468.510-515 and OAR 340-300-0000 et seq. By June 1, 2024, submission of either a facility-wide assessment or an initial assessment report is required. This report serves as the initial assessment report and extension justification under OAR 340-300-0003(3)(b)(B) and – 003(8). It summarizes the work completed to date and tasks remaining to be completed. It includes a proposed schedule for completion and justification for the requested extension.

In addition to compiling a team of seismic and other internal industry experts, HDR has engaged in negotiations with fuel tank seismic experts, geotechnical subconsultants, and underground piping seismic experts. Existing plant documentation, including existing seismic reports and geotechnical reports, has been provided to HDR and is under review. HDR expects geotechnical exploration to begin shortly.

The schedule shown in Appendix A communicates HDR's anticipated timeline for completion of a Final Assessment Report. This schedule includes a final report submittal date of December 9, 2024. Simultaneously with this report, NW Natural is submitting a request for an extension of the June 1, 2024 deadline to submit a Final Assessment Report to December 9, 2024.

## Introduction

NWN's Portland LNG Facility was commissioned in 1969. It serves as a storage facility to supply Portland with critical natural gas during periods of peak demand and as a safeguard against pipeline interruptions. The facility operates by taking gas off the pipeline during low-demand times, liquefying the gas, and storing it in a 175,000 barrel (7.4 million gallon) cryogenic storage tank at approximately atmospheric pressure. When needed, the liquid is revaporized and supplied back to the pipeline.

See Figure 1 for an overview of the site with major components identified.



**Figure 1. Portland LNG Site Overview**

Source: Google Earth

## Work Performed to Date

### Code Evaluation

LNG facilities must comply with 49 CFR 193 which references the 2001 and 2006 editions of NFPA 59A. Code references listed in the Rule are primarily to the 2013 edition of NFPA 59A with one reference to the 2023 version. HDR is in the process of comparing versions as they relate to the seismic assessment to provide a recommended version and justification for the recommended version.

In accordance with the standards of ethics and care that we maintain as professionally licensed engineers, we will adopt and use the most appropriate editions of referenced codes and standards in our proposed analysis and recommendations. Doing so enhances our incorporation of the current methods of engineering analysis and the current community understanding of seismic hazards affecting the site of interest.

### Development of an Assessment Approach

A seismic performance assessment of the NWN facility in accordance with the Fuel Tank Seismic Stability Rules per OAR 340-300-0000 et seq. is currently underway. Our assessment is currently

engaged in geotechnical earthquake engineering analysis of the soils underlying the LNG site. We are performing a preliminary geotechnical assessment using prior geotechnical subsurface information collected by other engineering contractors and made available to our team by NWN. We are also in the process of organizing our own new geotechnical subsurface investigation at the NWN LNG site that will provide us with the information needed to perform the geotechnical earthquake engineering analysis in accordance with the specified codes and standards; the DEQ rule; and the environmental and safety standards mandated by DEQ and NWN. Once our geotechnical site exploration is underway, we anticipate a minimum of 16 weeks to provide the geotechnical earthquake engineering assessment of the NWN LNG site.

In our preliminary assessment of available geotechnical exploration information provided to us by NWN, we have observed a tremendous amount of variability, contaminated soil conditions, soil conditions susceptible to liquefaction-related hazards, and soft/compressible soils. In addition, the presence of the active Portland Hills fault immediately adjacent to the LNG site presents significant seismic risk to the LNG facility. Given these findings, we propose to begin our seismic performance assessment considering soil liquefaction and its potential effects to assess how they may impact the existing LNG facilities at the NWN site. If we observe a high likelihood of inadequate structural performance to the anticipated soil deformations resulting from soil liquefaction and/or fault displacement, then there may not be a need to continue with the remaining elements of the seismic performance assessment (e.g., site-specific site response analysis, development of MCE, ODE, and MDE response spectra for existing soil conditions). However, given the significant data gap in available subsurface information beneath certain LNG structures, including the large LNG tank and its retention basin, we recommend the continuation and completion of our proposed geotechnical site investigation.

## Consideration of Environmental Conditions

The site is known to contain contaminated soils which require special coordination of personnel qualifications, work procedures, and soil disposal. The facility is part of a site subject to a Consent Order with the Oregon Department of Environmental Quality and an Administrative Settlement and Order on Consent with the United States Environmental Protection Agency. The orders require environmental investigation and remediation, and any actions taken on-site must be coordinated with NW Natural's environmental team and consultants. HDR has subcontracted a consultant familiar with the site and applicable regulations to verify compliance with local, federal, and other applicable regulations and ensure seismic testing does not create any environmental concerns. This coordination extends the project schedule when compared to sites without contaminated soil.

## Work to be Performed

### Geotechnical/Geophysical Exploration

HDR will subcontract Cornforth Consultants, Inc. ("Cornforth") to perform field data collection to support the geotechnical and seismic evaluation of the LNG facility. The current field exploration program consists of performing two cone penetration test (CPT) soundings and two seismic CPT (SCPT) soundings to collect continuous subsurface data at various locations across the LNG facility. Each of the CPTs and SCPTs will be performed to 150 feet below existing grade or to refusal.



Additionally, four horizontal-to-vertical spectral ratio (HVSr) geophysical tests will be performed adjacent to each of the CPTs. The HVSr tests will be used to identify the fundamental period or frequency of vibration of the ground at the ground surface and will be calibrated against the observed soil profile from the adjacent CPT sounding. This will better capture the dynamic behavior of the soil profile in HDR's future modeling efforts.

Cornforth will prepare a geotechnical data report that will include the following:

- A site plan and a vicinity map showing the location of the project site and the exploration locations.
- A description of the site location and geology, site topography, and subsurface and groundwater conditions.
- A description of the field procedures.
- CPT/SCPT logs, including up to two subsurface profiles.
- Raw and interpreted CPT data.
- HVSr results, interpretations, and a description of the testing.

HDR will use the collected data in the geotechnical and seismic assessment of the LNG facility. The field exploration detailed in this section is considered the first phase of field exploration. Due to the variability of the geotechnical conditions at the site based on our existing data review, future phases of field exploration may be required.

## Preliminary Liquefaction Hazard Evaluation

HDR will first evaluate the potential for triggering of liquefaction and subsequent effects, particularly soil deformations, at the site according to ASCE 7-22, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" (published by the American Society of Civil Engineers [ASCE]). This liquefaction hazard assessment will be considered preliminary in that it will incorporate generic codified ground motions per ASCE 7-22. Likely performance of existing infrastructure and facilities at the LNG site due to the analyzed liquefaction effects will be assessed. These effects include loss of shear strength (*i.e.*, bearing capacity), lateral spread displacement, potential for liquefaction flow failure, and post-liquefaction settlement. HDR's methodology for assessing these potential hazards will be the application of simplified empirical or semi-empirical methods, which arguably remains the prevailing methodology applied by geotechnical engineers throughout the world today.

If HDR's preliminary liquefaction hazard evaluation suggests that the existing facilities and infrastructure at the LNG site would not achieve adequate performance without significant retrofits in the event of the predicted liquefaction effects, it may not be advisable or pertinent to continue performing other aspects of the seismic performance evaluation such as site-specific ground motion development or dynamic structural response modeling. These elements of seismic performance would not be considered as critical as the performance of the structures under the predicted liquefaction hazard at the site. Given such a result, HDR would communicate and work closely with NWN to strategize a path forward that could include early submission of a Final Assessment Report and commencement of work on a mitigation plan, including designing geotechnical mitigation of the prospective liquefaction hazard, retrofitting the existing infrastructure to improve its seismic performance, and/or designing new infrastructure that would achieve the desired level of seismic performance in the event of the design ground motions occurring.

HDR emphasizes the uncertain and complex nature of predicting liquefaction behavior in soils, particularly highly variable soils and/or soils that contain significant amounts of fines and/or organics, which appear to be pervasive in the soils underlying the LNG site. Research has shown that even the “best” predictions of liquefaction effects generally fall within a factor of 3.0 of the actual observed behavior of the soils. The quality and reliability of a given soil liquefaction hazard analysis is always directly correlated with the amount of high-quality and reliable geotechnical and geophysical data that can be obtained from a site.

## Site-Specific Ground Motion Evaluation

If adequate performance is predicted for the infrastructure at the LNG site from the preliminary liquefaction hazard assessment described above, then HDR will proceed with its site-specific ground motion evaluation of existing ground conditions for use in seismic structural evaluation of the existing facilities at the site. HDR is in the process of using existing geotechnical information provided by NWN to develop a preliminary geotechnical baseline model that will characterize soil stratigraphy as well as geotechnical and dynamic soil properties to a maximum depth of 150 feet below the ground surface, which we predict will be the approximate depth of bedrock in this area of Portland. This geotechnical baseline model will be refined with additional data collected from the geotechnical and geophysical explorations described above, as well as potential additional explorations that we recommend and perform in the future.

If needed/performed, our proposed site-specific ground motion evaluation will include development of the geotechnical baseline model, site-specific nonlinear effective stress site response analysis beneath each structure belonging to the LNG site, and development of site-specific 5%-damped response spectra extending to a maximum period of 15 seconds and that are in accordance with current ASCE 7-22 and National Fire Protection Association (NFPA) code standards. Our site response models will account for the phenomenon of liquefaction and cyclic softening on saturated soils and their predicted effect on the response spectra at the site. Such soft soil conditions have been observed to amplify long-period ground motions.

If we observe that soil liquefaction governs the predicted seismic performance of the existing structures at the LNG site, then we may recommend site-specific ground motion evaluation for potential engineered mitigation solutions for the site.

## Structural Evaluation

The structural evaluation work to be performed differs for the LNG tank, the process area, and the supporting buildings. HDR will visit the site to catalog the different structures in the process area and evaluate the condition of the LNG tank and foundation, process area structures (pipe supports), and the supporting buildings (emergency generator, control building, vaporization building, firewater pump building and the firewater tank).

### LNG Tank

Drawings of the LNG tank have been received and preliminarily reviewed. Once the geotechnical investigation is provided, the tank and its foundation will be structurally modeled and evaluated against the results of the geotechnical investigation to determine its behavior under anticipated earthquake loadings. From that, an evaluation can be made if retrofits or other actions are required.

## Process Area

Unique pipe racks and bridges will be identified during the site visit to allow similar structures to be evaluated and decrease the number of unique structures that must be modeled and analyzed. The site visit will also be used to catalog other pieces of equipment or structures in the process area that should be analyzed. Drawings for the process area are currently being obtained from NWN.

## Supporting Buildings

The evaluation of the supporting buildings will be performed in accordance with DEQ Form 8, and ASCE 41-23 “Seismic Evaluation and Retrofit of Existing Buildings.”

Once building drawings are received and reviewed, a determination of performance category can be made in accordance with ASCE 41 and Form 8, and whether a Tier 1 or Tier 2 analysis for each building will be required.

## Piping Evaluation

HDR is in the process of retaining an industry expert in seismic underground piping analysis. If underground piping needs to be evaluated this resource will be used.

Aboveground piping will be evaluated by in-house HDR experts using AutoPIPE software. Where adequate drawings are not available, site visits will be performed to field-document conditions.

## Balance-of-Plant Evaluation

HDR will:

- Describe existing buildings, structures, and ancillary components in terms of construction, age, inspection and maintenance, and operations.
- Summarize currently implemented spill prevention and mitigation measures and their ability to achieve the statutory performance objective.
- Evaluate the safety of operating conditions, shutdown procedures, and potential spills.
- Evaluate the integrity of fire control measures such as firewalls surrounding the facility to limit fire spreading into surrounding communities.
- Evaluate the availability of day and night onsite personnel trained in emergency response and able to respond in the event of an earthquake.

In its Final Seismic Vulnerability Assessment Report, HDR will include a safety assessment consisting of, but not limited to, descriptions of:

- Spill containment systems, equipment, and procedures for the event of an earthquake.
- Onsite emergency equipment, operational safety measures, and personnel policies and availability.

## Conclusion

HDR anticipates completion of the Final Assessment Report on or before December 9, 2024. Review of existing geotechnical data is ongoing, and a high degree of variability along with generally poor soil composition has been observed. HDR is engaging a geotechnical subconsultant to perform additional subsurface investigation and evaluation to obtain data required for seismic analysis. This will be used to perform a preliminary analysis, and if adequate performance of facility structures is observed in the preliminary analysis a detailed site-specific evaluation of ground motions and structural response will be performed.

## References

- American Concrete Institute (ACI) CODE-376, "Code Reqs for Design & Construction of Concrete Structures for Containment of Refrigerated Liquefied Gases & Comm"
- American Petroleum Institute (API) RP 14C, "Analysis, Design, Installation, and Testing of Safety Systems for Offshore Production Facilities"
- API Spec 6D, "Specification for Valves"
- API Std 620, "Design and Construction of Large, Welded, Low-Pressure Storage Tanks"
- API Std 625, "Tank Systems for Refrigerated Liquefied Gas Storage"
- API Std 650, "Welded Tanks for Oil Storage"
- The American Society of Mechanical Engineers (ASME) B31.3, "Process Piping"
- ASME B31.5, "Refrigeration Piping and Heat Transfer Components"
- ASME B31.8, "Gas Transmission and Distribution Piping Systems"
- ASME Boiler and Pressure Vessel Code
- The American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT-TC-1A, "Personnel Qualification and Certification in Nondestructive Testing"
- ASCE 7-22, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures"
- California Accidental Release Prevention (CalARP) Program
- Canadian Standards Association (CSA) Z276, "Liquefied natural gas (LNG) - Production, storage, and handling"
- Compressed Gas Association (CGA) S-1.3, "Pressure Relief Device Standards-Part 3-Stationary Storage Containers for Compressed Gases"
- NFPA 10, "Standard for Portable Fire Extinguishers"
- NFPA 11, "Standard for Low-, Medium-, and High-Expansion Foam"
- NFPA 12, "Standard on Carbon Dioxide Extinguishing Systems"

- NFPA 12A, "Standard on Halon 1301 Fire Extinguishing Systems"
- NFPA 13, "Standard for the Installation of Sprinkler Systems"
- NFPA 14, "Standard for the Installation of Standpipe and Hose Systems"
- NFPA 15, "Standard for Water Spray Fixed Systems for Fire Protection"
- NFPA 16, "Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems"
- NFPA 17, "Standard for Dry Chemical Extinguishing Systems"
- NFPA 20, "Standard for the Installation of Stationary Pumps for Fire Protection"
- NFPA 22, "Standard for Water Tanks for Private Fire Protection"
- NFPA 24, "Standard for the Installation of Private Fire Service Mains and Their Appurtenances"
- NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems"
- NFPA 59A, "Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)"
- NFPA 70, "National Electrical Code"
- NFPA 72, "National Fire Alarm and Signaling Code"
- NFPA 101, "Life Safety Code"
- NFPA 600, "Standard on Facility Fire Brigades"
- NFPA 1221, "Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems"
- NFPA 1901, "Standard for Automotive Fire Apparatus"
- NFPA 2001, "Standard on Clean Agent Fire Extinguishing Systems"
- Oregon Administrative Rule (OAR) 340-300
- Section 264.175 of Title 40 of the Code of Federal Regulations (CFR), "Containment."
- Part 193 of Chapter 49 of the CFR, "Liquefied Natural Gas Facilities: Federal Safety Standards"

# Appendix A – Schedule

