

FINAL TECHNICAL REPORT

Project Reporting Period: July 1, 2009 through June 30, 2013

Title: The Quaternary Geology of the Seattle-Tacoma Urban Corridor—
Building the Foundation for Geologic-Hazard Mapping: East Lake
Washington Area

Cooperative Agreement Number: G09AC00454 MODs 0001 through 0004

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Abstract

Work efforts for this award including the multiple modifications, were to 1) complete the Bellevue geological map and subsurface database, 2) complete geological maps for USGS publication, 3) provide a backup for Pacific Northwest Center for Geologic Mapping Studies (GeoMapNW), and 4) begin to rebuild/update GeoMapNW's database. We have several maps in the publication queue and several maps that exist only as maps of cities rather than as the standard quadrangle maps. City maps completed include: Bellevue, Kirkland, Mercer Island, and Seattle. Quadrangle maps completed during the time of the cooperative agreement include: Gig Harbor, Issaquah, Olalla, Puyallup, 4 quadrants of Seattle, Steilacoom, Suquamish, Tacoma North and Tacoma South, and Vashon and Maury Islands. These maps with their supporting databases will all be within the USGS publication queue before the end of 2014. Other geologic maps were completed under previous USGS cooperative agreements. The USGS Geologic Division will make all of our maps available to the public and provide a permanent record of the research efforts undertaken by GeoMapNW in the last 12 years. The Washington State Department of Natural Resources, Division of Geology and Earth Resources (WDGER) is now hosting the database of subsurface information, and the database of geochronology produced by GeoMapNW partly during the course of this award. About 20,000 pdf documents (including geotechnical reports with multiple boring logs) were transferred to WDGER for permanent access on their website. Subsurface information from about 80,000 explorations, including meta data and subsurface layers information, were transferred to WDGER for permanent access on their website. All of the city-based geological maps and many of the geological quadrangle maps completed are considered high-resolution geological maps because: they are mapped using a lidar hillshade base, include geomorphic analyses, and are accompanied by and used a subsurface database to glean shallow geologic information in addition to new field mapping.

Final Technical Report

Background

Our emphasis for this award including the multiple modifications, were to 1) complete the Bellevue geological map and subsurface database, 2) complete geological maps for USGS publication, 3) provide a backup for Pacific Northwest Center for Geologic Mapping Studies (GeoMapNW), and 4) begin to rebuild/update GeoMapNW's database. We have several maps in the publication queue and several maps that exist only as maps of cities rather than as the standard publishable quadrangle map. These maps with their supporting databases will all be within the USGS publication queue before the end of 2014. The USGS Geologic Division will make all of our maps available to the public and provide a permanent record of the research efforts undertaken by GeoMapNW in the last 12 years. The Washington State Department of Natural Resources, Division of Geology and Earth Resources (WDGER) is now hosting the database of subsurface information, and the database of geochronology produced by GeoMapNW partly during the course of this award.

Investigations undertaken

Investigations undertaken during the award period consist of the following: evaluation of backup options, creation of a new GeoMapNW database, and new subsurface data entered in the database from the City of Bellevue. Troost, now a faculty member at the University of Washington, in the Department of Earth and Space Sciences, is leading three research efforts in 2014 to help delineate fault locations in Bellevue and Seattle. The GeoMapNW database will be fundamental to these research efforts and for future applied research in the Puget Lowland, Washington. Furthermore, the GeoMapNW database has become a useful educational tool, for courses like Engineering Geology, Hydrogeology, Geologic Hazards, Fluvial Geomorphology, and Hillside Geomorphology.

Accomplishments

All GeoMapNW related maps are either submitted or in their final review stage. All should be final, but awaiting final layout for publication by the end of 2014.

The following maps were generated:

Table 1. Geologic Maps Generated or Co-Authored by GeoMapNW at the UW

GeoMapNW Quads	publisher USGS	publisher WDGER	Status	Scale	DB?
DesMoines	2004		SIM 2855	24K	N
Poverty Bay	2004		SIM 2854	24K	N
Olalla	2005		SIM 2902	24K	N
Lidar Olalla	2013		SIM 3277	24K	N

Seattle NW (Shilshole Bay)	2005		SIM 2903	12K	Y
Seattle NE (Seattle North)	2009		SIM 3065	12K	Y
Seattle SW (Duwamish Head)	2014-2015		SIM	12K	Y
Seattle SE (Seattle South)	2014-2015		SIM	12K	Y
Seattle Composite	2005		OFR 2005-1252	12K	Y
Issaquah	2012	Co-author	SIM 3211	24K	Y
Tacoma North	2014-2015		OFR	24K	N
Tacoma South	2014-2015		OFR	24K	N
Steilacoom	2014-2015		OFR	24K	N
Puyallup	2014-2015		OFR	24K	N
Gig Harbor	2014-2015		OFR	24K	N
Fox Island	2006	Lead	GM 63	24K	Y
Vashon Quad	2014-2015		OFR	24K	Y
Mercer Island (City)	2014-2015		At Mercer Island	12K	Y
Kirkland (City)	2014-2015		At Kirkland	12K	Y
Bellevue (City)	2014-2015		At Bellevue	12K	Y
Maltby	2016	Lead	proposed	24K	Y
Bothell (City)			At Bothell	12K	Y
Suquamish	2011		SIM 3181	24K	Y

By the time GeoMapNW had to close, the database of subsurface exploration points consisted of about 80,000 locations. Each geotechnical report was at least partially scanned so that pdf images of the exploration logs were also available and linked to each point.

Problems encountered

The first problem encountered is that of scheduling. The contractor, Troost, was late in starting the work due to a scheduling problem. The delays in getting all authorizations for this work to proceed meant that Troost had to take on another contract project in the interim.

The second, and last problem encountered is that of closure of GeoMapNW. The GeoMapNW servers that originally hosted and served the data and maps have been decommissioned. As a backup, copies of the subsurface data are available via the WDGGER map portal: <https://fortress.wa.gov/dnr/geology/?Theme=subsurf>.

The WDGGER site is well done and serves as an excellent backup for the subsurface data, and the subsurface data set is growing geographically. But the WDGGER admits that, due to budgetary constraints, QA is not part of their process when entering data. QA was an essential part of the GeoMapNW dataset. Another factor is that the interactive high-resolution geologic maps served by GeoMapNW are not available on the WDGGER site. Long-term accessibility and integrity of these data are critical for continued high-resolution geologic mapping in the Pacific Northwest. The GeoMapNW system is now rebuilt and will be on-line sometime in late 2014 through ESS. Permanent solutions are needed to maintain the software, hardware, storage, and accessibility of the mapping/database system outside of the WDGGER site.

Publications and/or presentations

Many presentations, field trips, and publications have been completed, partly supported by this USGS Cooperative agreement (Table 2). For a list of our publications related to this cooperative agreement, refer to the list at end of this report.

Table 2. Invited Presentations, Field Trips, and Short Courses

Type	Title	For	Date
Field Trip	Landslides near Mt. Rainier, Washington	AEG	Jan 2009
Field Trip	Geology of the Seattle Area	Northwest Scientific Association	Mar 2009
Presentation	Latest Understanding of the Late Pleistocene Stratigraphy in the Central Puget Lowland	Northwest Scientific Association	Mar 2009
Keynote Speaker (D. Booth)	One Million Years of Glaciers, and the Origin of Puget Sound	Northwest Scientific Association	Mar 2009
Field Trip	Seattle to Bremerton Ferry	AEG	Apr 2009
Boat Field Trip	Coastal Geology of Tacoma	7 th Washington Hydrogeology Symposium	Apr 2009
Presentation	Is the Seattle Fault Beneath Downtown Seattle	WA Emergency Management Officials	May 2009
2-Day Short Course and 1-Day FT	Quaternary and Engineering Geology of the Puget Lowland	AEG, Geoscientists	Sep 2009
2-Day Short Course and 1-Day FT	Quaternary and Engineering Geology of the Puget Lowland	Geoscientists	Nov 2009
Presentations	Jökulhlaups from Glacial Lake Puyallup, Pierce County, Washington	NWGS and Jefferson Land Trust Geology Group	May 2010 and Sep 2013
Presentation	High Resolution Geologic Mapping and Geologic Information for the City of Kirkland	City of Kirkland Employees	June 2010

Table 2. cont. Invited Presentations, Field Trips, and Short Courses

Poster Presentation	Recent Findings: Late-Pleistocene Stratigraphy in the Central Puget Lowland, Washington	Research Gala, ESS Dept., UW	Mar 2011
Boat Field Trip	Coastal Geology of Tacoma	8 th Washington Hydrogeology Symposium	Apr 2011
2-Day Short Course	Quaternary and Engineering Geology of the Puget Lowland	Geoscientists	May 2011
Field Trip	Jökulhlaups from Glacial Lake Puyallup, Pierce County, Washington	NWGS	Oct 2011
Presentations	The Penultimate Glaciation in the Puget Lowlands – Different from the Last Glaciation?	UW, Geoscientists, and NWGS	Feb 2012
Presentation	Glacial Geology of the Puget Lowlands	UW Civil and Environmental Engineering Dept.	Mar 2012
Presentation	Jökulhlaups from Glacial Lake Puyallup, Pierce County, Washington	Ice Age Floods Institute	Apr 2012
Presentations	Geologic Mapping and GeoDatabase Project for the City of Bellevue	City of Bellevue Employees	May 2012 and Oct 2012
Presentation	Geotechnical Employment	Preparing Students in Two-year Colleges for Geoscience Degrees and Careers Workshop	July 2012
Field Trip	Geology of Seattle	SACNAS	Oct 2012
2-Day Short Course	Geology of the Seattle/Edmonds Area	Landau, Geoscientists	Oct 2012
Presentation	History of Sedimentation and Lake Level Rise, Lake Washington, Seattle	UW, Geoscientists	Nov 2012

Public Access to Geologic Data

All of the data generated from this cooperative agreement is or will be available to the public. Borehole data, including pdf images of the boring logs are available on the WDGGER map portal (<https://fortress.wa.gov/dnr/geology/?Theme=subsurf>). The geologic maps completed for cities are available from each city and will be available on the revised GeoMapNW website by the end of 2014, and these maps will also be published by the USGS, time and funds permitting. The quadrangle maps will be published by the USGS, time and funds permitting. Because of the file sizes, these maps are not included in this report.

About 20,000 scanned documents (with their explorations) are available on the WDGGER website as a result of the work by GeoMapNW with the support of this and previous cooperative agreements from the USGS. Examples of the WDGGER website are shown in Figures 1 and 2. An example of the revised GeoMapNW website is shown in Figure 3.

Subsurface Geology Information System

This theme presents a database of subsurface geologic information in Washington State. It began with the work of Kathy Troost and Aaron Wisher of the Pacific Northwest Center for Geologic Mapping Studies (GeoMapNW) at the University of Washington. The data in the GeoMapNW database are mainly in the greater Seattle area and were funded by grants from the U.S. Geological Survey and from agreements with the following jurisdictions: the Cities of Bainbridge Island, Bellevue, Kirkland, Mercer Island, Redmond, and Seattle; many departments in King County; Washington State Department of Transportation; and the Division of Geology and Earth Resources in the Washington State Department of Natural Resources. Many consulting firms voluntarily contributed large volumes of subsurface data including Associated Earth Sciences Inc., Creative Engineering Options, GeoEngineers, and Yonemitsu Geological Services.

The database has recently been expanded to include statewide coverage using data from a wide variety of sources. These include the Washington State Department of Transportation, Department of Health, Department of Ecology, U.S. Geological Survey, Columbia Basin Groundwater Management Area, and many County Public Utility Districts.

Most of the information is derived from geotechnical boring logs, water well logs, and direct measurements. The map consists of points indicating where subsurface information is available; clicking on one of the points with the purple 'Identify' tool provides attribute information about the subsurface boring, including a link to a PDF of the associated geotechnical report or well log.

Figure 1. Note in the WDGGER map portal for Subsurface Geology Information; data from GeoMapNW's regional geologic database.

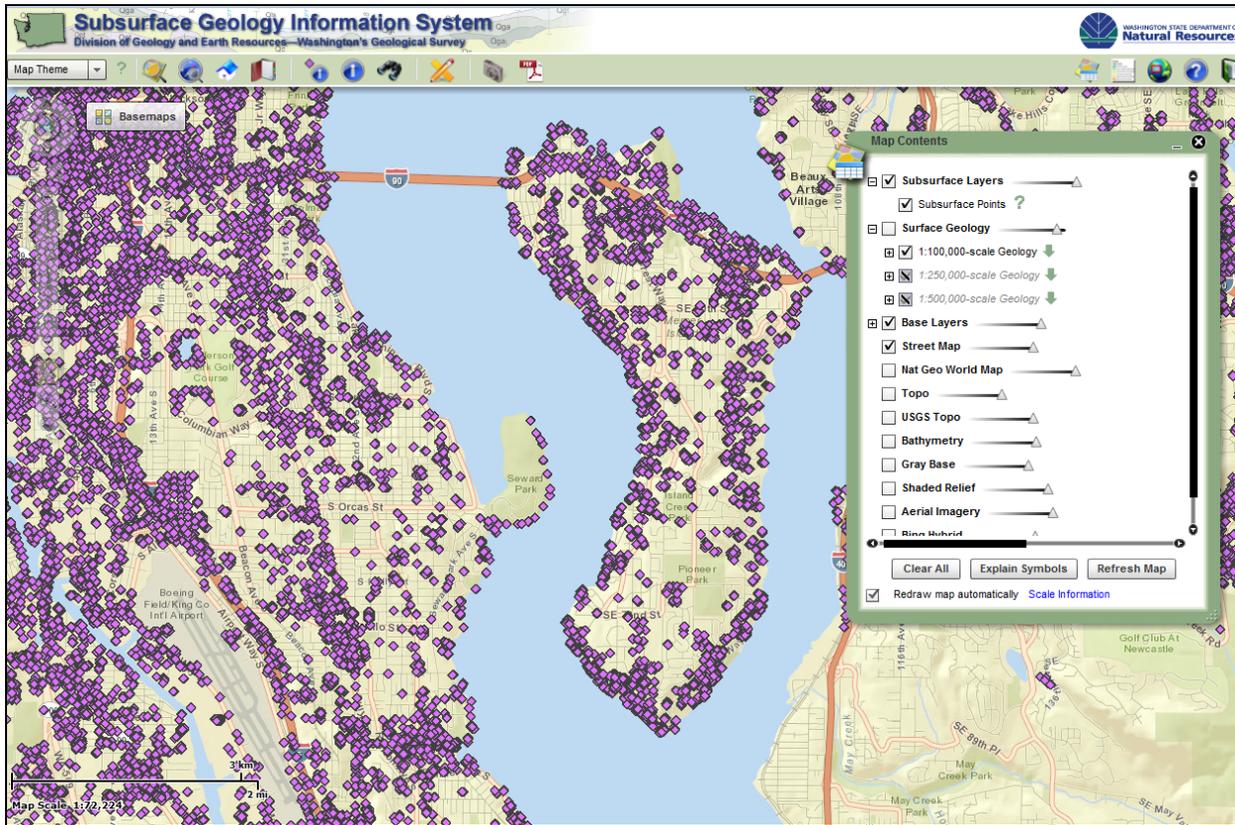


Figure 2. Web-based access to borehole data in WDGER regional geologic database, data are from GeoMapNW.

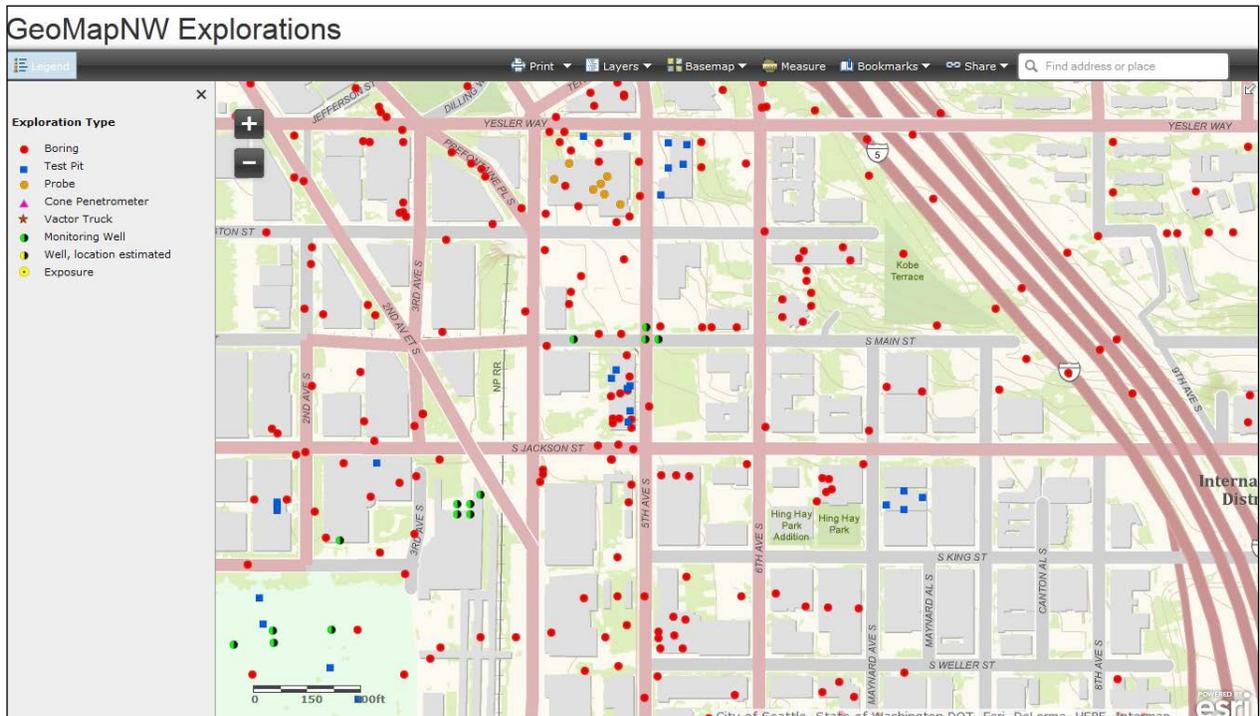


Figure 3. View of revised web-based GeoMapNW borehole database showing exploration point by type.

Education and Technical Outreach

We are active leaders, conveners, and participants in seminars, conferences, and workshops to educate the scientific and non-technical community about the geologic setting of the Seattle and Tacoma areas. During this last few years, we gave many presentations (all invited) led many field trips, and taught several short courses, Table 2.

References (2009-2013)

Booth, D.B., Troost, K.G., and Shimel, S.A., 2009, Geologic map of northeastern Seattle (part of the Seattle North 7.5' x 15' quadrangle), King County, Washington: U.S. Geological Survey Scientific Investigations Map 3065, scale 1:12000 and database.

Booth, D.B., Walsh, T.J., Goetz Troost, K., and Shimel, S.A., 2012, Geologic map of the east half of the Bellevue South 7.5' x 15' quadrangle, Issaquah area, King County, Washington: U.S. Geological Survey Scientific Investigations Map 3211, scale 1:24,000. (Available at <http://pubs.usgs.gov/sim/3211/>.)

Haugerud, R.A., and Troost, K.G., 2011, Geologic map of the Suquamish 7.5' quadrangle and part of the Seattle North 7.5' x 15' quadrangle, Kitsap County, Washington: U.S. Geological Survey Scientific Investigations Map 3181, scale 1:24,000, available at <http://pubs.usgs.gov/sim/3181/>.

Pratt, T.L. and Troost, K.G., in review, Location, kinematics and earthquake potential of the Seattle fault, Washington State.

Tabor, R.W., Haugerud, R.A., Booth, D.B., and Troost, K.G., 2013, Lidar-revised geologic map of the Olalla 7.5' quadrangle, King, Kitsap, and Pierce Counties, Washington: U.S. Geological Survey Scientific Investigations Map 3277, pamphlet 14 p., 1 sheet, scale 1:24,000, <http://dx.doi.org/10.3133/sim3277>.

Troost, K.G., 2007, Jokulhlaups from glacial lake Puyallup, Pierce County, Washington, Geological Society of America, Cordilleran Section Meeting, Bellingham, WA, Abstracts with Programs, Vol. 39, no. 4, p. 13.

Troost, K.G., 2009, Latest understanding of the Late Pleistocene stratigraphy in the Central Puget Lowland, Northwest Scientific Association program with abstracts, Seattle, WA, 2009.

Troost, K.G., 2011, Geomorphology and shoreline history of Lake Washington, Union Bay, and Portage Bay, Technical Memorandum, SR-520 I-5 to Medina Bridge Replacement and HOV Project, Prepared for Washington State Department of Transportation, Federal Highway Administration, September 2011, 92p.

Troost, K.G. and Booth, D.B., 2008, Geology of Seattle and the Seattle Area, in Baum, R., Godt, J., and Highland, L. eds., Landslides and Engineering Geology of the Seattle, Washington, Area, Geol. Soc. Amer., Special Papers XX, p.1-37, 2 plates.

Troost, K.G., Wisher, A.P., and Von der Ahe, M., 2009, Making Geological Hazard Maps of Mercer Island, WA Using High-Resolution Maps and a Subsurface Database, Geological Society of America Annual Meeting, Portland, Oregon, Abstracts with Programs, Vol. 41, No. 7, p. 280.