Hot Water Drilling Operations Group

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Status Report of Clean Hot Water Drilling Systems (CHWDS) Repair and Preparations for SALSA* Project

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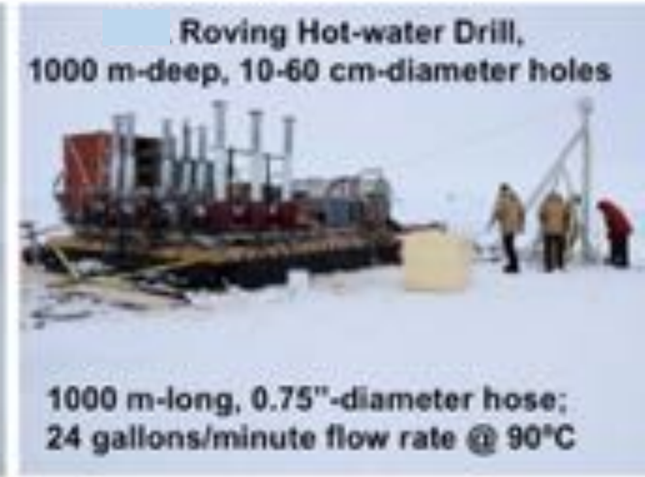
Note: An IDDO Driller will join the Team for SALSA drilling

***Subglacial Antarctic Lakes Scientific Access (SALSA): Integrated study of carbon cycling in hydrologically-active subglacial environments**

BACKGROUND:

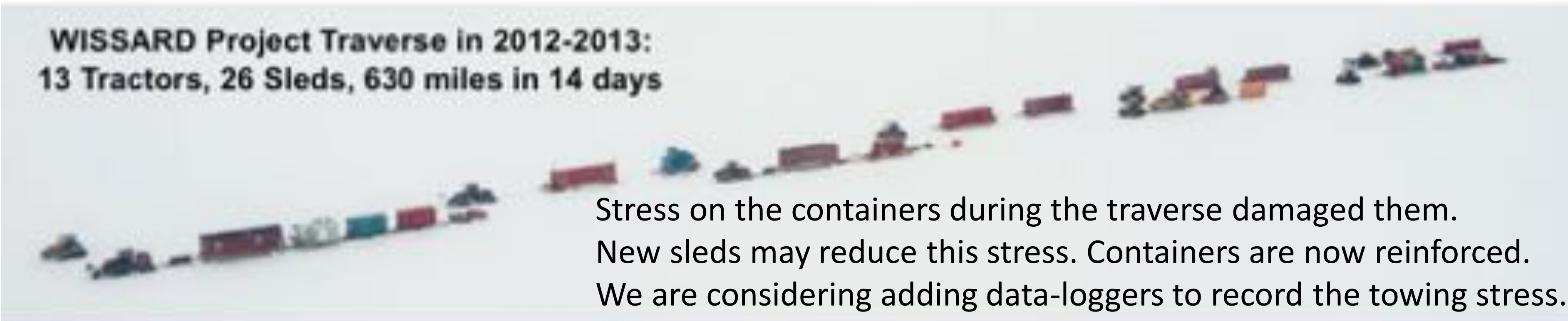
UNL's Antarctic Hot Water Drilling Systems have Supported Geophysical Studies, Ice Shelf Exploration, and Clean Access into Subglacial Lakes



WISSARD Clean Hot Water Drill System (CHWDS) will be used for the SALSA Project

BACKGROUND:

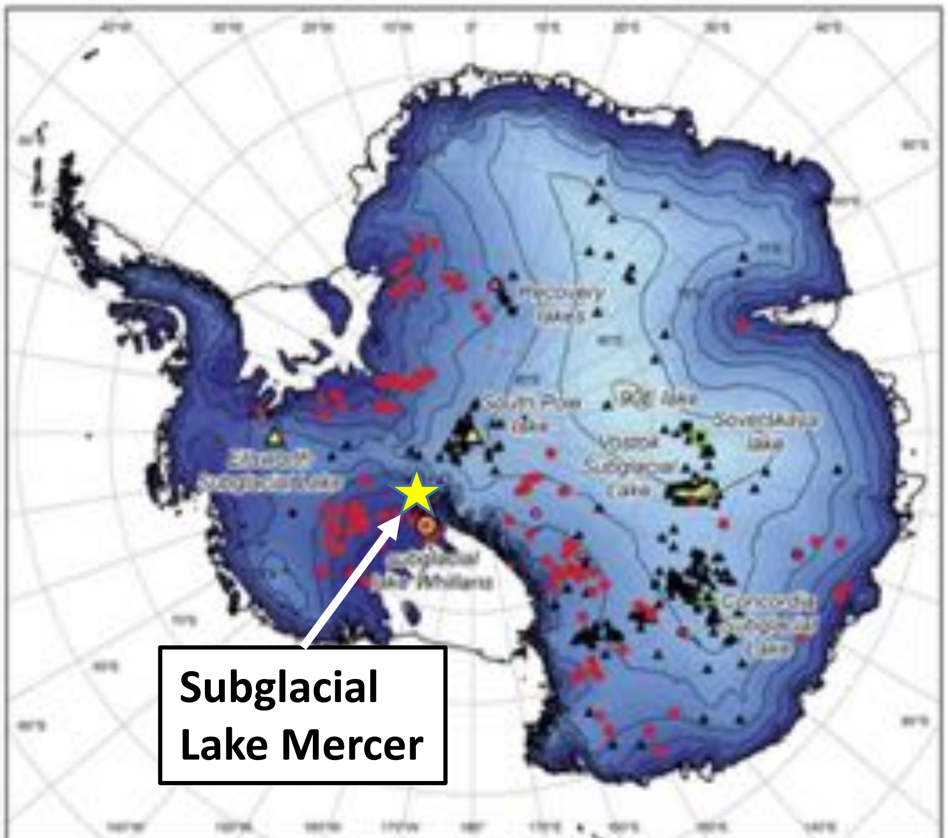
USAP Traverse, WISSARD Hot Water Drill, & Camp at SLW and the GZ



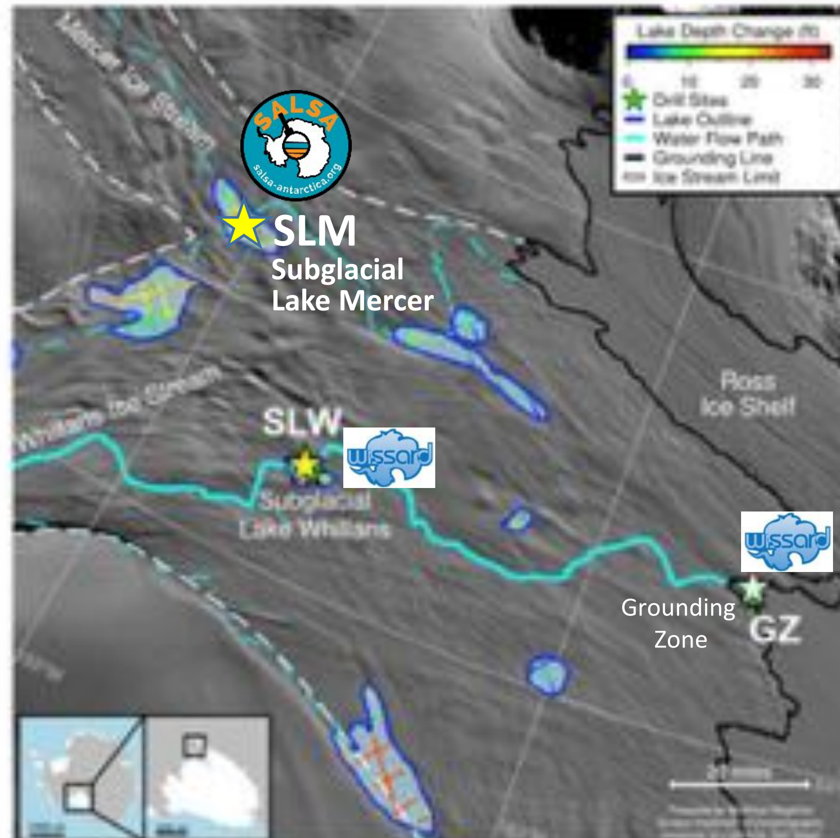
Stress on the containers during the traverse damaged them.
New sleds may reduce this stress. Containers are now reinforced.
We are considering adding data-loggers to record the towing stress.

BACKGROUND:

Subglacial Lake Exploration is enabled through the use of Hot Water Drill Systems that provide Clean Access Boreholes through significant thicknesses of ice, and comparative analyses with other environments.



Wright, A., and Siegert, M., 2012. Antarctic Science, 24(6): 659-664; doi:10.1017/S095410201200048X



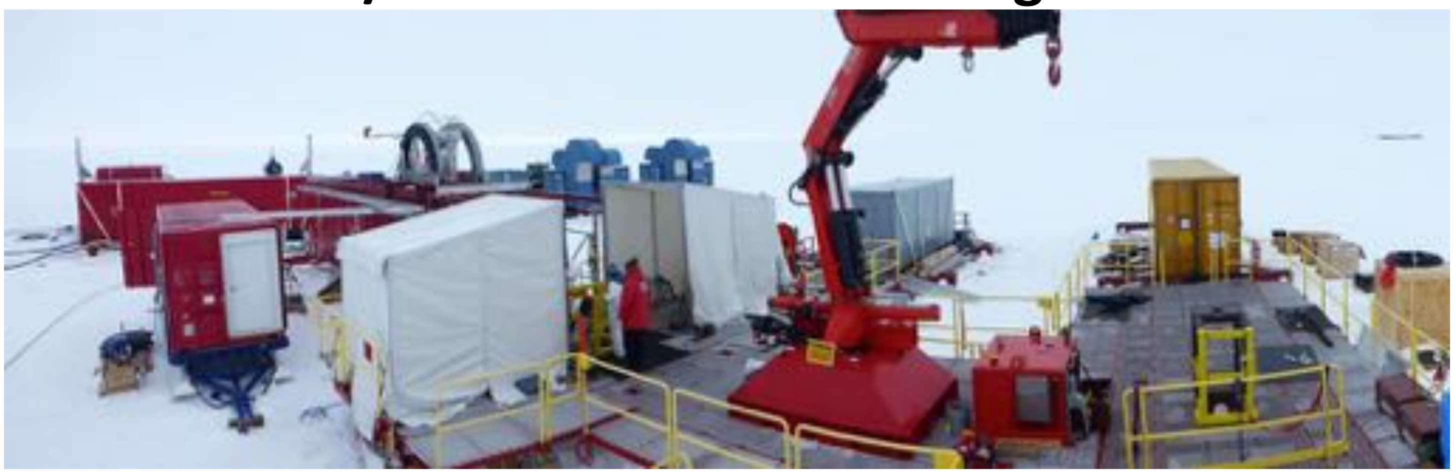
2014 WISSARD Map, prepared by Matthew Siegfried, Scripps Institution of Oceanography, UC-San Diego

BACKGROUND:

Success with CHWDS at Subglacial Lake Whillans in January 2013

- Following 5.5 days of set-up, started drilling keyhole with main hose @ 09:15 on Wednesday, January 23, 2013; payout speed = 0.5 m/min. to 1 m/min., ave. drill water flow = 28-38 gallons per minute (gpm); output water temperature = 79-85°C; enlarged hole to 110 m; Finished drilling keyhole @ 13:00, recovered hose at 4 m/min.
- Deployed return water pump to ~110 meters in main hole; started drilling main hole while resolving many start-up operational issues regarding the drill system & sensors; payout speed = 0.2 m/min. to 0.6 m/min to 700 m, ave. drill water flow = 40-50 gpm, drill water pressure = 520-560 pounds/square inch (psi), ave. return flow = 45 gpm.

CHWDS at the WAIS/Ross Ice Shelf Grounding Zone Site 2014-15



The UNL drill team arrived at the GZ site on Dec. 29, 2014 and began to set-up and perform maintenance on the HWDS, which had been stored in the deep field at the SLW site for two years. The key hole was drilled on Jan. 5, 2015 followed by the primary access hole (60 cm-diam.; drilling rate = 0.1 to 0.25 m/min., water flow = 40 gpm, water temp. = 82-85°C @ ~530 psi), which was completed 4 days ahead of schedule on Jan. 9th, thereby providing additional days for the deployment of scientific instruments and measurement tools, as well as the Deep-SCINI ROV, into the ice shelf cavity near the grounding zone of the Ross Ice Shelf.

Subglacial Antarctic Lakes Scientific Access

Integrated study of carbon cycling in hydrologically active subglacial environments

Principal Investigators	
John Priscu (Chief Scientist)	Montana State University
Brent Christner (Chair ExCom)	University of Florida
Helen Amanda Fricker (ExCom)	Scripps Institution of Oceanography, UCSD
Jim McManis (ExCom)	University of Nebraska
Brad Rosenheim (ExCom)	University of South Florida
Eugene Domack	University of South Florida
John Dore	Montana State University
David Harwood	University of Nebraska
Kathy Kasic	Montana State University
Amy Leventer	Colgate University
Berry Lyons	The Ohio State University
Mark Skidmore	Montana State University
Project Staff	
Justin Burnett (ROV Operator)	University of Washington
Cindy Dean (Project Manager)	Montana State University
Dennis Duling (Lead Driller)	University of Nebraska
Bob Zook (ROV Operator)	University of Nebraska
Post Doc	
Wei Li	Montana State University
Matthew Siegfried	Scripps Institution of Oceanography, UCSD
International Collaborators	
Carlo Barbante	University of Venice Ca'Foscari
Ok-Sun Kim	Korea Polar Research Institute
Martyn Tranter	University of Bristol

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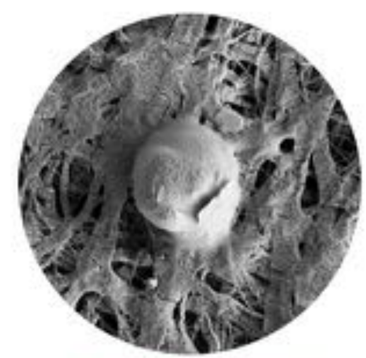
HYDROLOGY

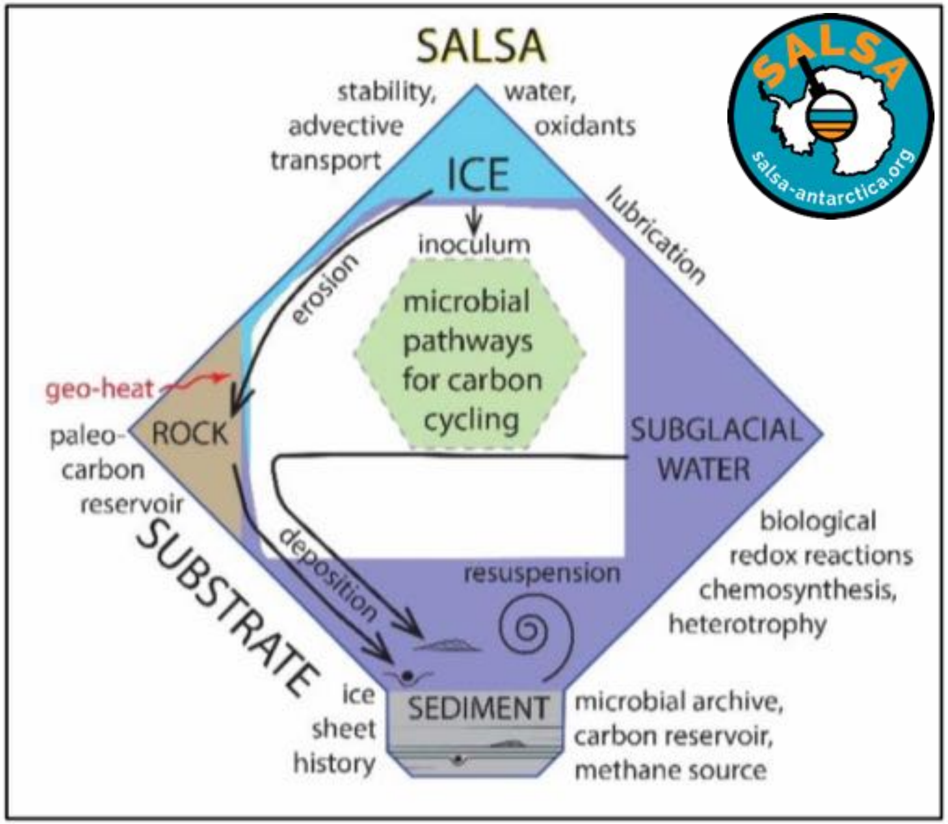
GEOLOGY



GEOMICROBIOLOGY

Overarching hypothesis:

Contemporary biodiversity and carbon cycling in hydrologically-active subglacial environments associated with the Mercer and Whillans ice streams are regulated by the mineralization and cycling of relict marine organic matter and through interactions among ice, rock, water and sediments.



Hypothesis 1: Subglacial Lake Mercer is a relatively permanent feature (on decadal to centennial scales), but exhibits large temporal and spatial variability on shorter (sub-decadal) time scales. Both the "permanent" and "variable" aspects of these features have implications for ice-sheet stability, including controlling the position of the grounding line and influencing the regional ice flow speed of the Whillans and Mercer ice streams.

Hypothesis 2: Sedimentary organic carbon beneath the WIP is a relict of past marine incursions and can provide information on grounding line oscillations in this region of Antarctica. Relict organic matter in the sediments is a source of CH4 resulting from methanogenesis in deeper anoxic sediments. Age spectra of this sedimentary carbon will yield old ages in less reactive fractions of the total carbon.

Hypothesis 3: Reduced compounds (e.g., CH4, H2, NH4+, NO2-, Fe2+, H2S) derived from the decomposition of relict marine sedimentary organic matter and mineral weathering provide the substrates for chemosynthesis, which, in addition to relict marine organic matter, provides additional energy and carbon for heterotrophic processes in Subglacial Lake Mercer.

Hypothesis 4: Basal ice debris is rich in organic carbon and nutrients derived from relict marine organic matter. This debris can be transported to the grounding zone and contribute to modern coastal ecosystem productivity.

OBJECTIVES: (1) To repair and strengthen containers damaged during the traverse to and from Subglacial Lake Whillans

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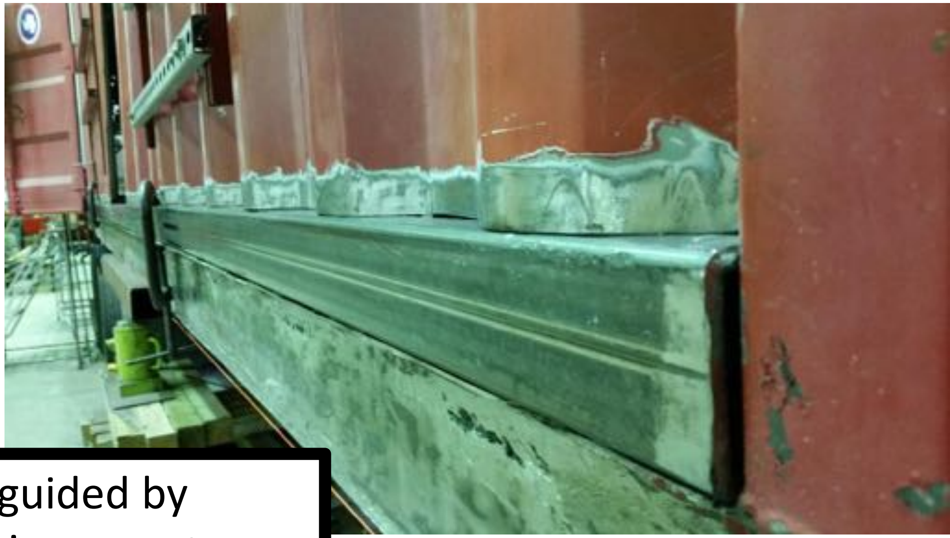
(1a) Hose Reel Container



Repair plan was guided by a stress engineering report; the repairs passed ‘lift-test’; container shipped to McMurdo.

OBJECTIVES: (1) To repair and strengthen containers damaged during the traverse to and from Subglacial Lake Whillans

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(1b) Heater Pump Unit - 1

Field repairs to bring HPU-1 back from the field.

During Field Season 2016-17: Stiffening members were added under the doors, but this must still be completed for the container ends. A crane and operator from ASC is needed to complete this repair during 2017-18 field season.

Lower frame repair on HPU-1

OBJECTIVES: (2) To prepare the CHWDS components for the SALSA Project and stage them for traverse to Subglacial Lake Mercer site

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2016-17 Work Site

Philip Jeff Dennis Graham

The Flat Rack Unit

OBJECTIVES: (2) To prepare the CHWDS components for the SALSA Project and stage them for traverse to Subglacial Lake Mercer site

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2016-17 Field Effort

Maintenance	Testing	Sorting
Condensing	Repairing	Staging

Alkota unit for high pressure test

Dennis and Graham sorting electrical inventory

Air compressors one and two located in Filtration container

OBJECTIVES: (3) To provide a clean access drillhole into Subglacial Lake Mercer for SALSA science

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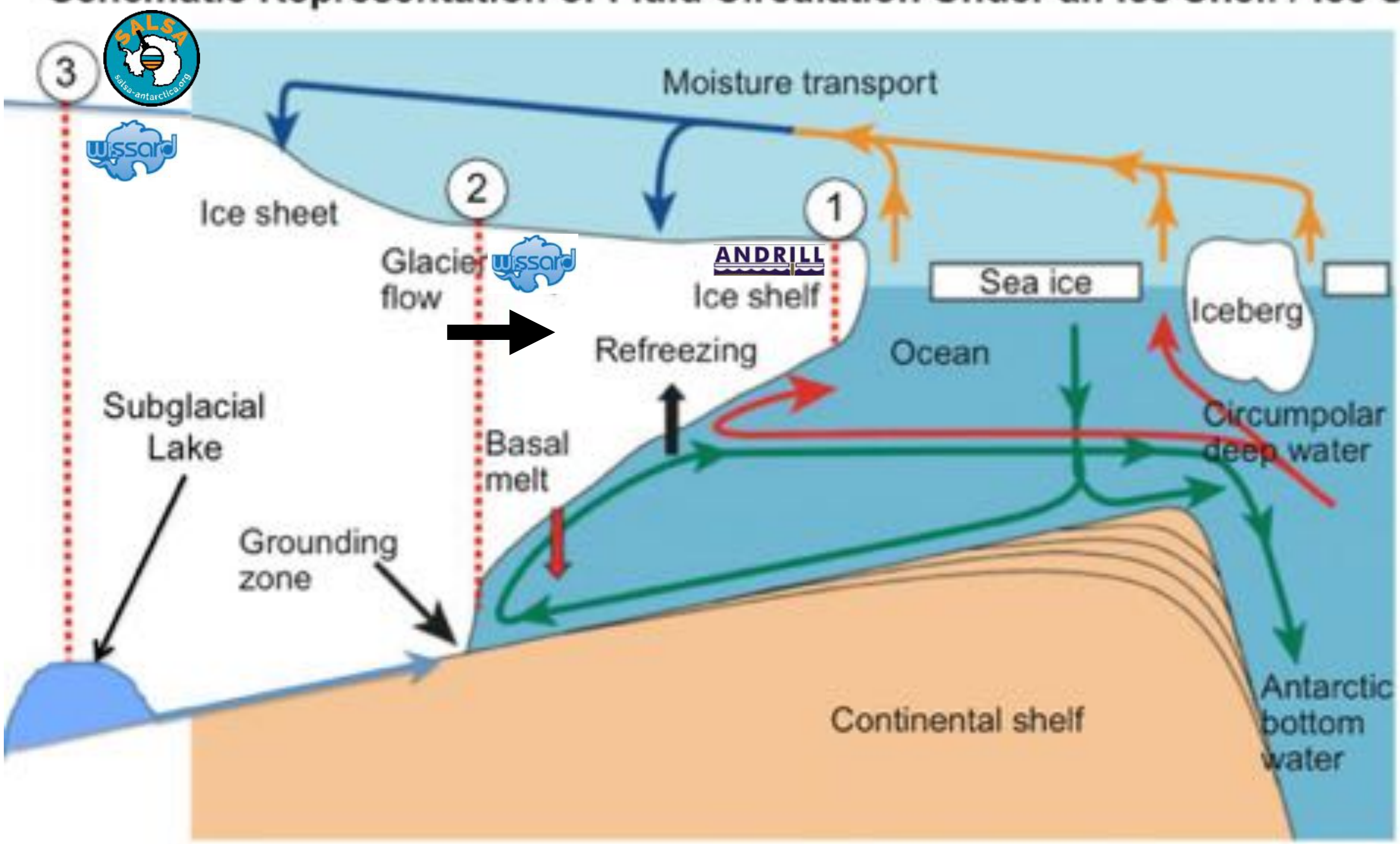
first 1000 m hole to deploy tools, corers, and to deploy deep-SCINI
second 1000 m hole to collect ice core of basal ice using Hot Water Corer

Schematic Representation of Fluid Circulation Under an Ice Shelf / Ice Sheet



Modified from Holland, 2013. Ocean Circulation and Climate, Vol. 103: Chapter 16 - The Marine Cryosphere, p. 413-442; http://dx.doi.org/10.1016/B978-0-12-391851-2.00016-7

OBJECTIVES: (4) To collect ‘Hot Water Ice Cores’ from basal Ice above Subglacial Lake Mercer

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Collecting Hot Water Ice Cores at the WAIS Grounding Zone

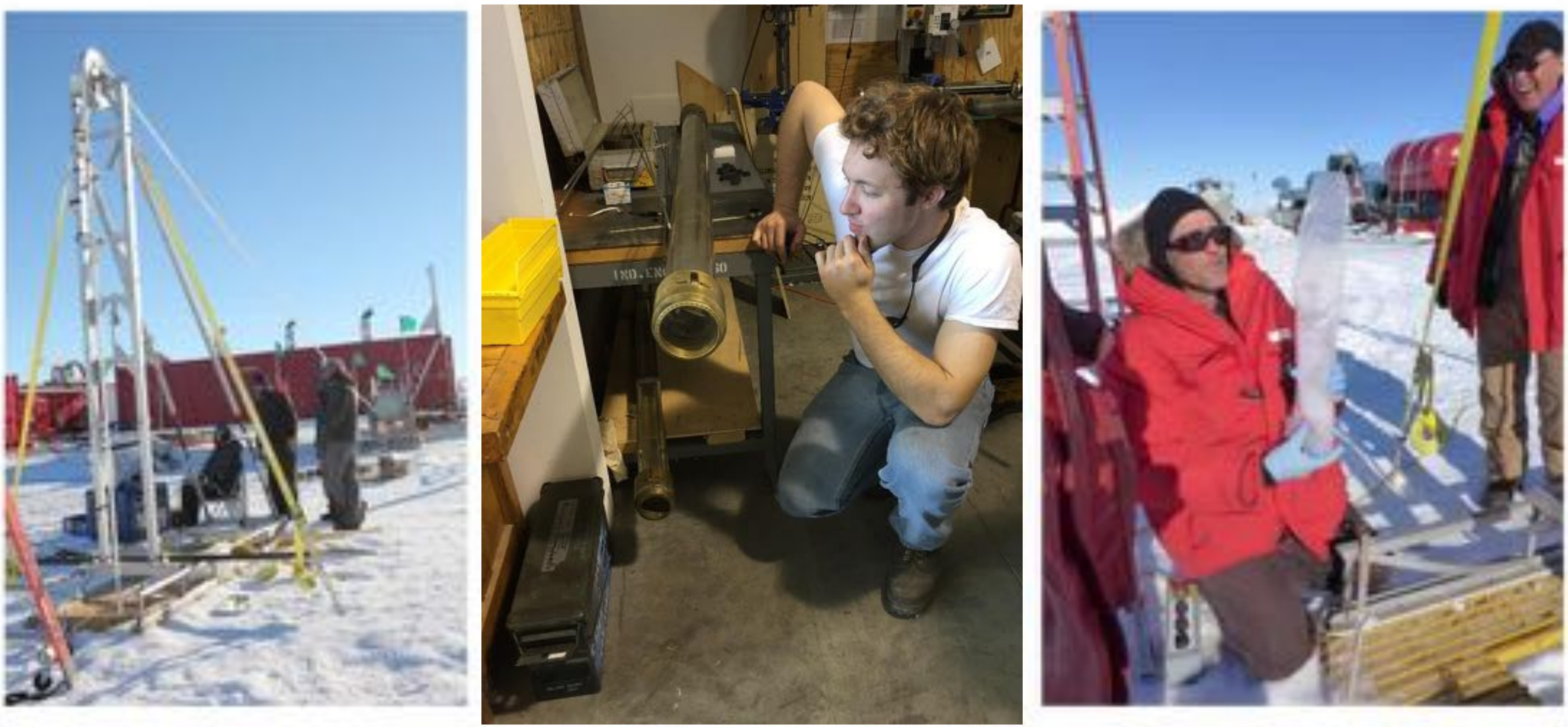


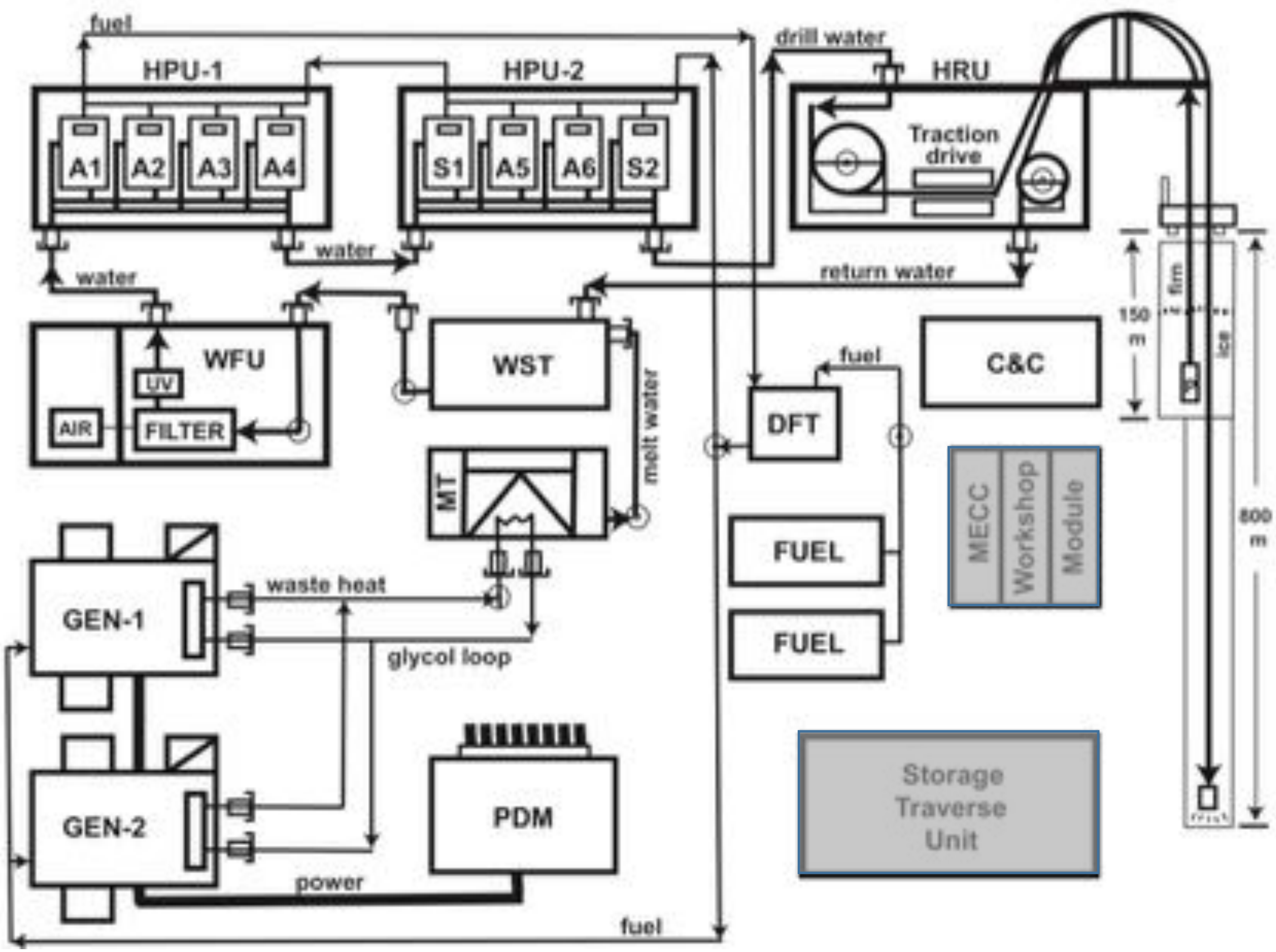
Image credits: B. Christner, R. Scherer, and the WISSARD Project

2016/17
Field Season

CHWDS Components to be used for the SALSA Project

Item	Location	Status	Notes
HRU - Hose Reel Unit	McM	arrived McMurdo	2017/18 season, spool up more hose
HPU-1 – Heater Pump Unit 1	McM	in need of repair ends	2017/18 season, planned repair work requires ASC crane and operator
GEN - Generator containers (2) and **PDU** - Power distribution Unit	McM	ASC to work on GEN only one is working	three 20’ containers Ice Cube generators (ASC)
LARS - Launch & Recovery System	McM	need to remove winch	2017/18 season work planed;
Fassi Crane is on one LARS unit	McM	unbolted & un-wired	requires ASC crane and operator
Flat Rack (FUEL, WST, MT)	Camp 20	staged and bermed	ready for transfer to SLM
HPU-2 - Heater Pump Unit 2	Camp 20	staged and bermed	ready for transfer to SLM
Filtration Units	Camp 20	staged and bermed	ready for transfer to SLM
Wire Winch	UNL	under construction	ship south in 2017
Fiber Winch	UNL	procured, to be tested	ship south in 2017
Roving Drill Tower	UNL	repaired	ready to be shipped 2017
Hose for HRC	UNL		airlift needed for 2017 field effort

Schematic of the WISSARD HWDS showing Main Units and Components



KEY:

HPU Heater Pump Unit
HRU Hose Reel Unit
WFU Water Filtration Unit
MT Melt Tank
GEN Generator Unit
PDM Power Distribution Module
WST Water Storage Tank
FUEL Fuel Unit
C&C Command & Control Unit

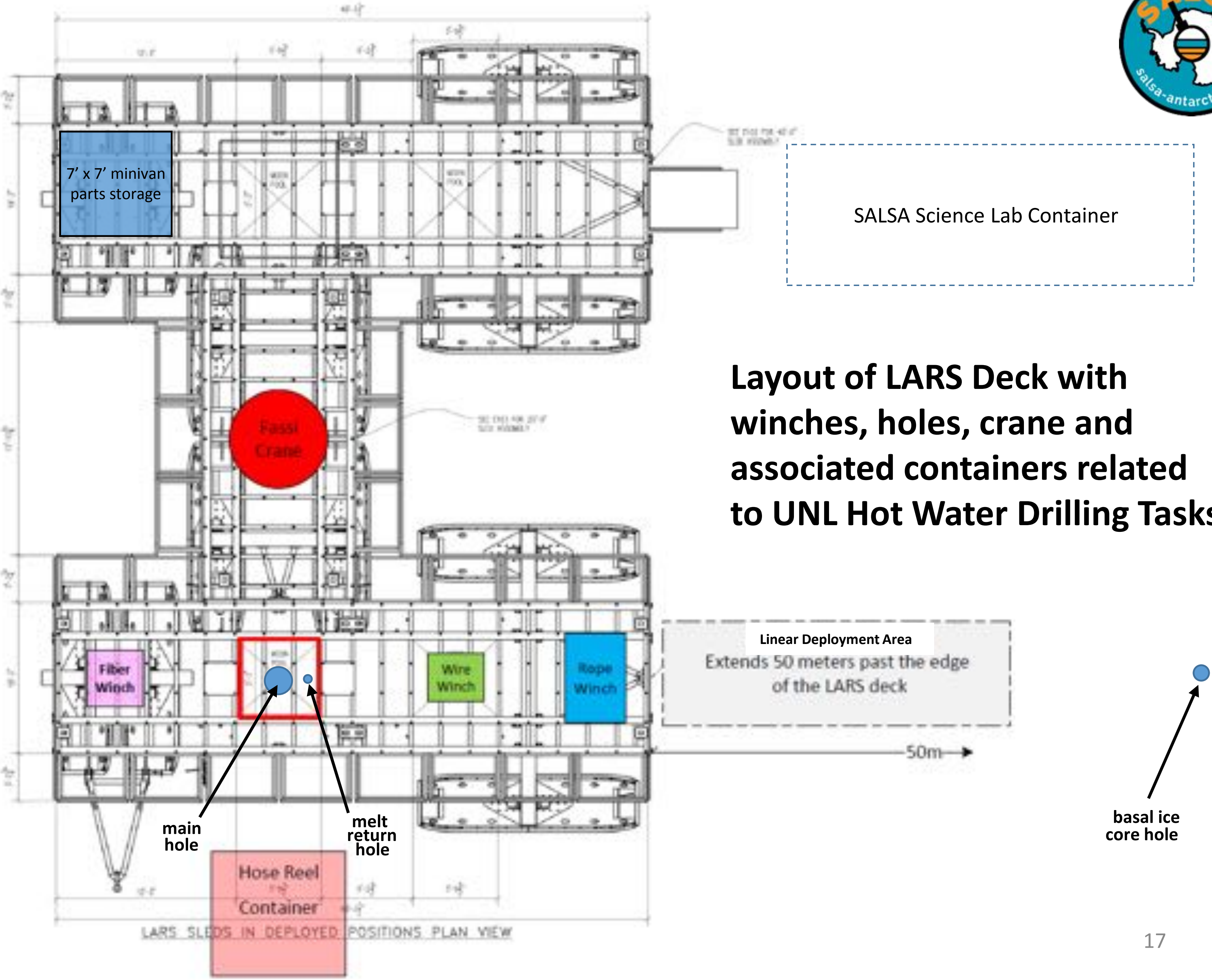
Not Shown:

LARS Decks (3 units)
Launch and Recovery System with Fassi Crane

FLAT RACK
Holds the WST, MT, & FUE L

Shaded Items will not be used in the SALSA Project

Layout of LARS Deck with winches, holes, crane and associated containers related to UNL Hot Water Drilling Tasks



2016-17 Field season (completed)

Prep. for Pre-season effort

- Ship HRU from Pt. Huememe to Lincoln, NE
- Disassemble, repair and reassemble CHWDS
- Engineering evaluation and guidance for repair
- Repaired HRU and shipped south (arrived in McM)

4 person crew – Dennis Duling, Philip Thalheim, Graham Roberts, Jeff Lemery

Main tasks on ice:

(1) Inspect, maintain, repair and test CHWDS components
(2) Repair HPU-2 and HPU 1 (in part – requires crane support from ASC)
(3) Inventory equipment, sort and condense and pack for traverse
(4) Installed new components into systems, pumps, batteries, etc.
(5) Retro equipment (e.g., Roving Drill components) to CONUS
(6) ahead of schedule allowed for additional testing
(7) Stage containers for SPOT Traverse; 3 were taken to Camp 20

Note: Work-site visit by:

SALSA Project PI – John Priscu
IDPO Program Manager – Blaise Stephanus
NSF Program Director Antarctic Research Facilities
and Special Projects – Mike Jackson

CHWDS is in excellent shape, and drillers refreshed their familiarity with systems

SPOT-3 traversed three UNL units – HPU-2, Filtration Unit, Flat Rack to Camp 20

2017-18 Field season (pending approval; SALSA is postponed 1 year)

Prep. for pre-season effort

Purchase equipment monitoring and control system components

Repair equipment in Lincoln, NE

CARGO to ship south to Pt Hueneme by mid August

Roving Drill tower

Additional Hose for Hose Reel Unit

Hot Water Corer

New Wire winch

4 person crew to deploy; Late Nov. to early January (6 weeks)

Main tasks on ice

(1) accept HRU, spool on more hose

(2) test system and computer program controls of HRU

(3) complete repair HPU1 (Heater Pump Unit -1); 50% repaired

requires ASC crane to lift container to complete repair

(4) remove NIU Winch from LARS Deck; it is unbolted & power disconnected

requires ASC crane to remove NIU winch

(5) Pack containers and stage on ice for SPOT Traverse

Activity this season would allow flexibility for SPOT traverse to SLM at their convenience in late 2017 or early in 2018 season

2018-19 Field season

Prep. for pre-season effort

CARGO to ship south to Pt Hueneme by mid August;

Minor and misc. items to ship, including DNF equipment

Full Drill crew of 6 to 8 drillers (including one driller from IDDO)

6 to 7 week season on ice (mid. Dec. to early Feb.)

Assuming a later deployment if repair work done in 2017-18

Main tasks on ice

(1) set up Hot Water Drilling System

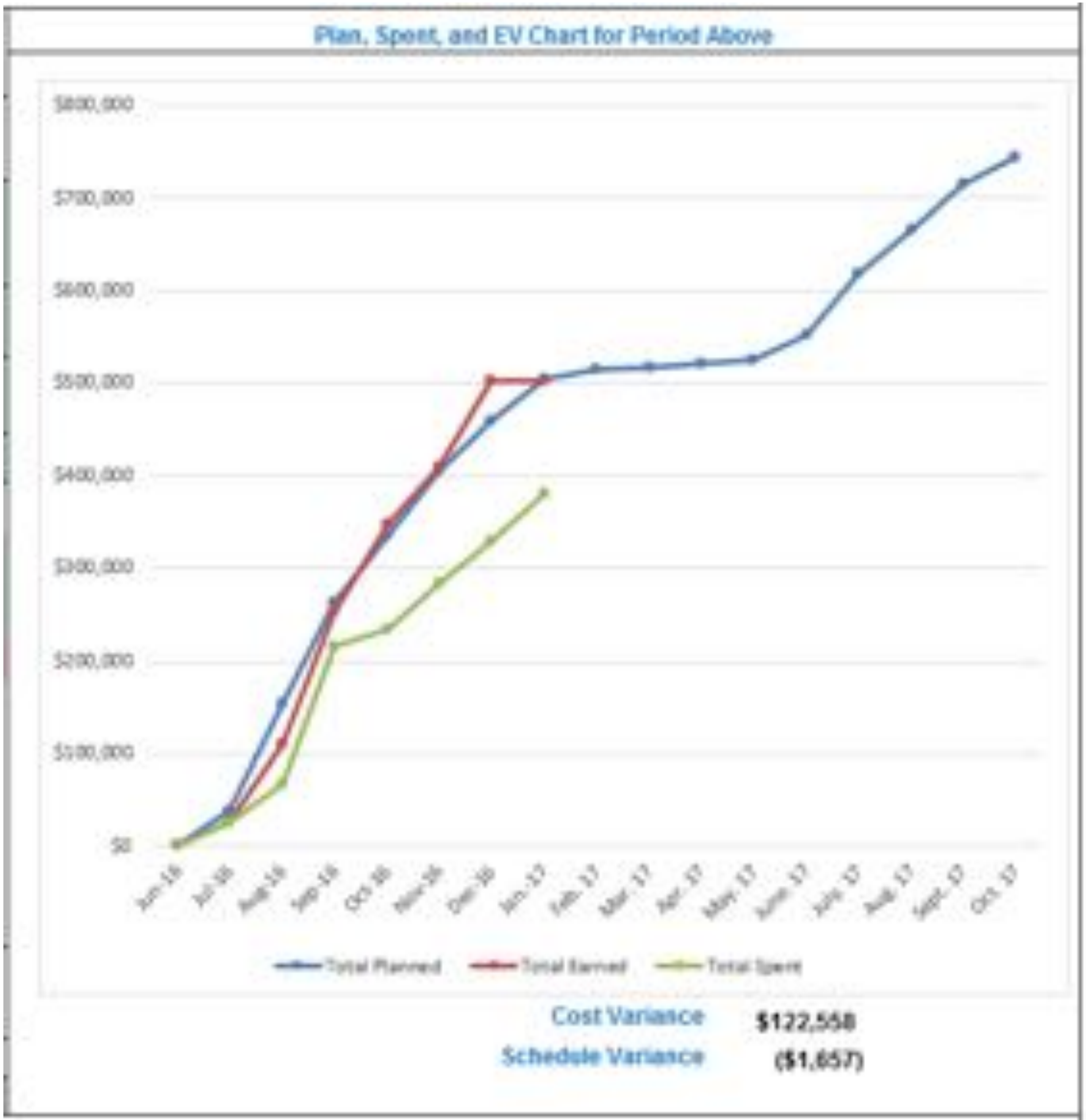
(2) drill +1000 m main hole

(3) drill hole to recover basal ice core and collect ice core

(4) pack containers for return traverse to McMurdo

2019-20 Field season

4 – 5 drill crew to Prepare containers to be shipped on Vessel back to UNL



UNL effort for SALSA Project is on schedule and under budget.

Combined data for 2016A, 2016B and 2017. January 2017

SALSA Project

<u>BOREHOLE TOOLS</u> (not in deployment order):

FIBER WINCH

1. SCINI (**Fiber winch** deep SCINI)

WIRE WINCH (design and construction is in progress at UNL now)

2. CTD
3. Niskin bottle
4. WTS-LV (water filtration system)
5. multi-corer
6. basal ice corer
7. others

ROPE WINCH

8. large-corer (on loan from UNOLS?)

WIRE Winch

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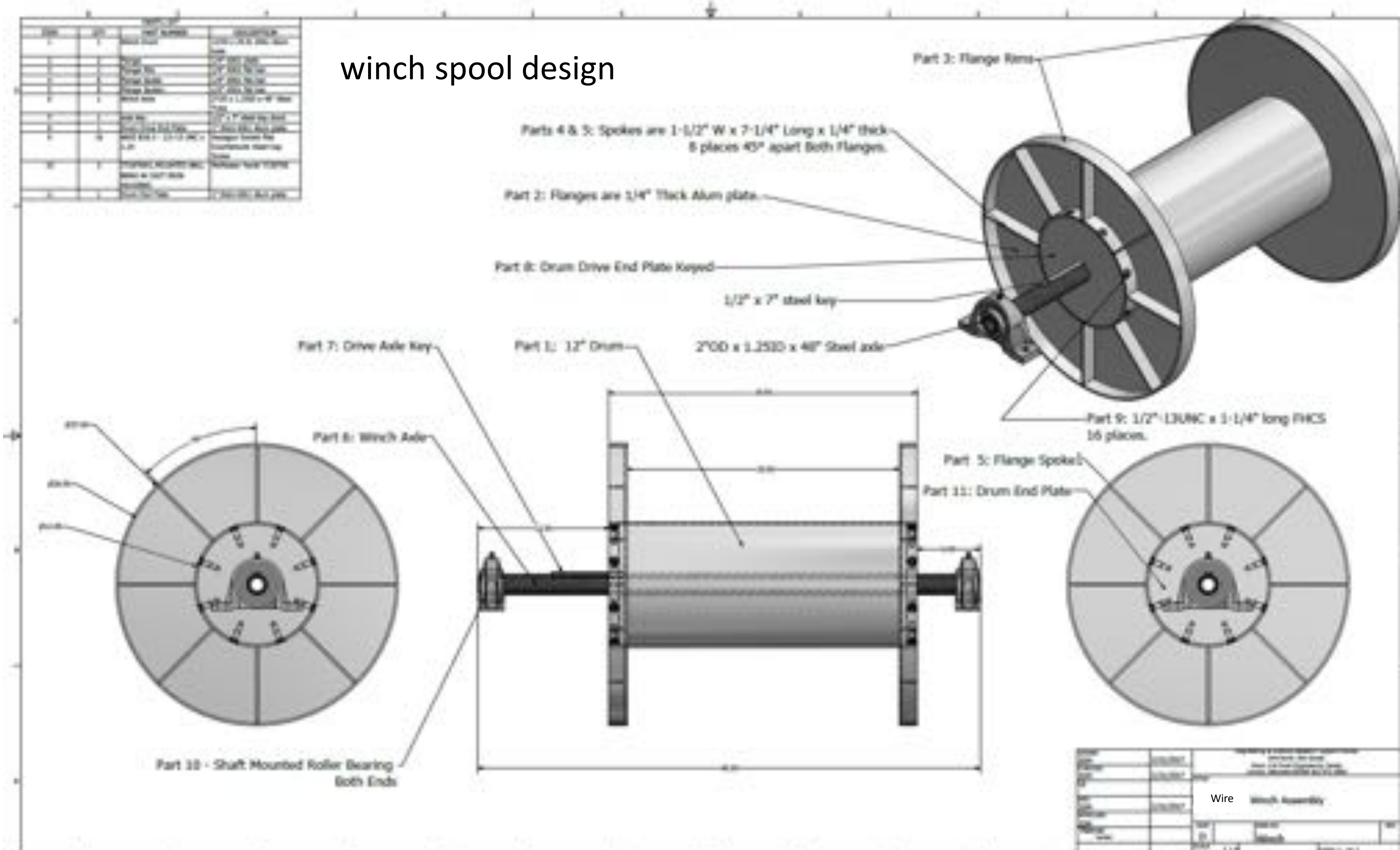
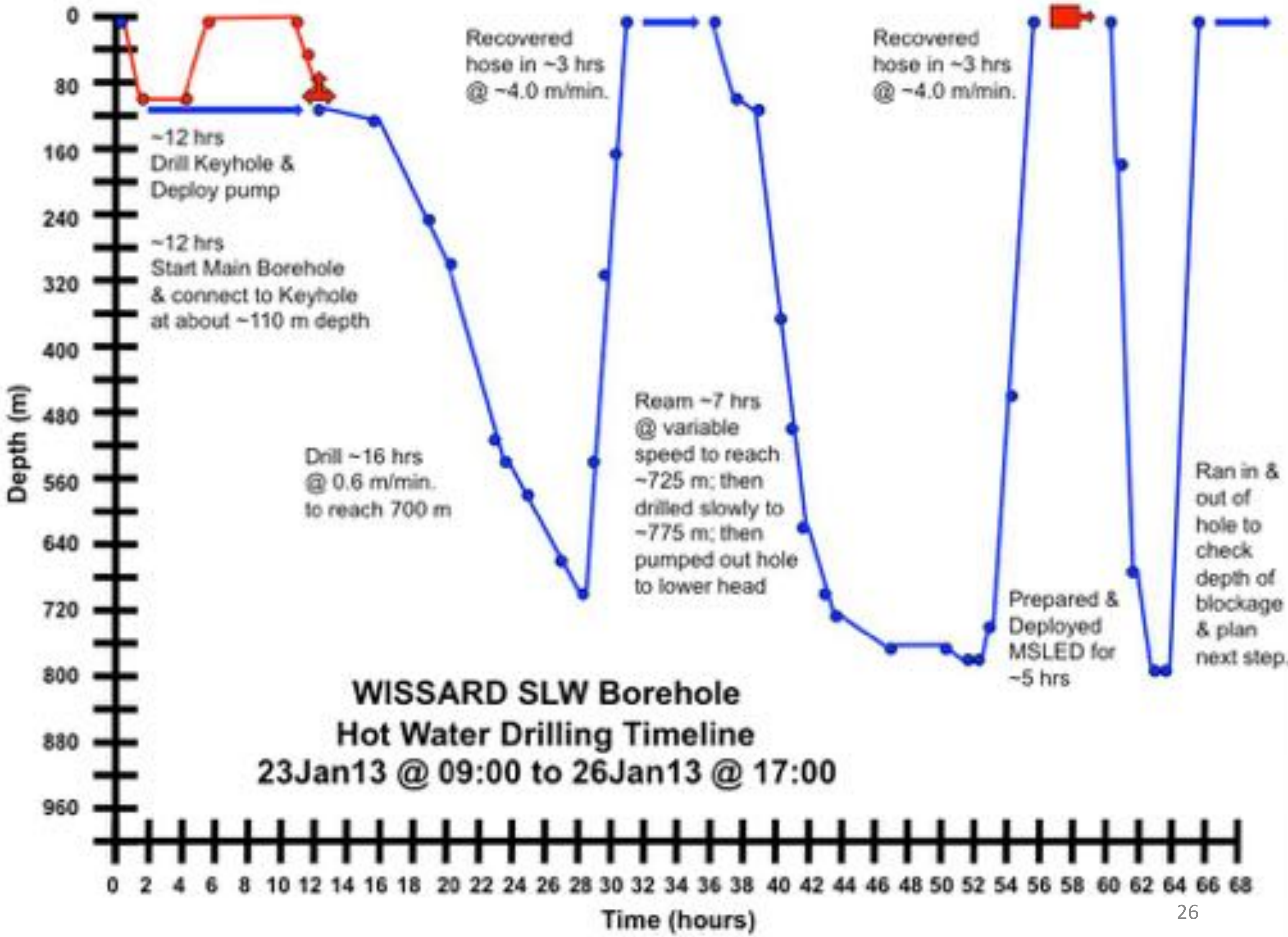
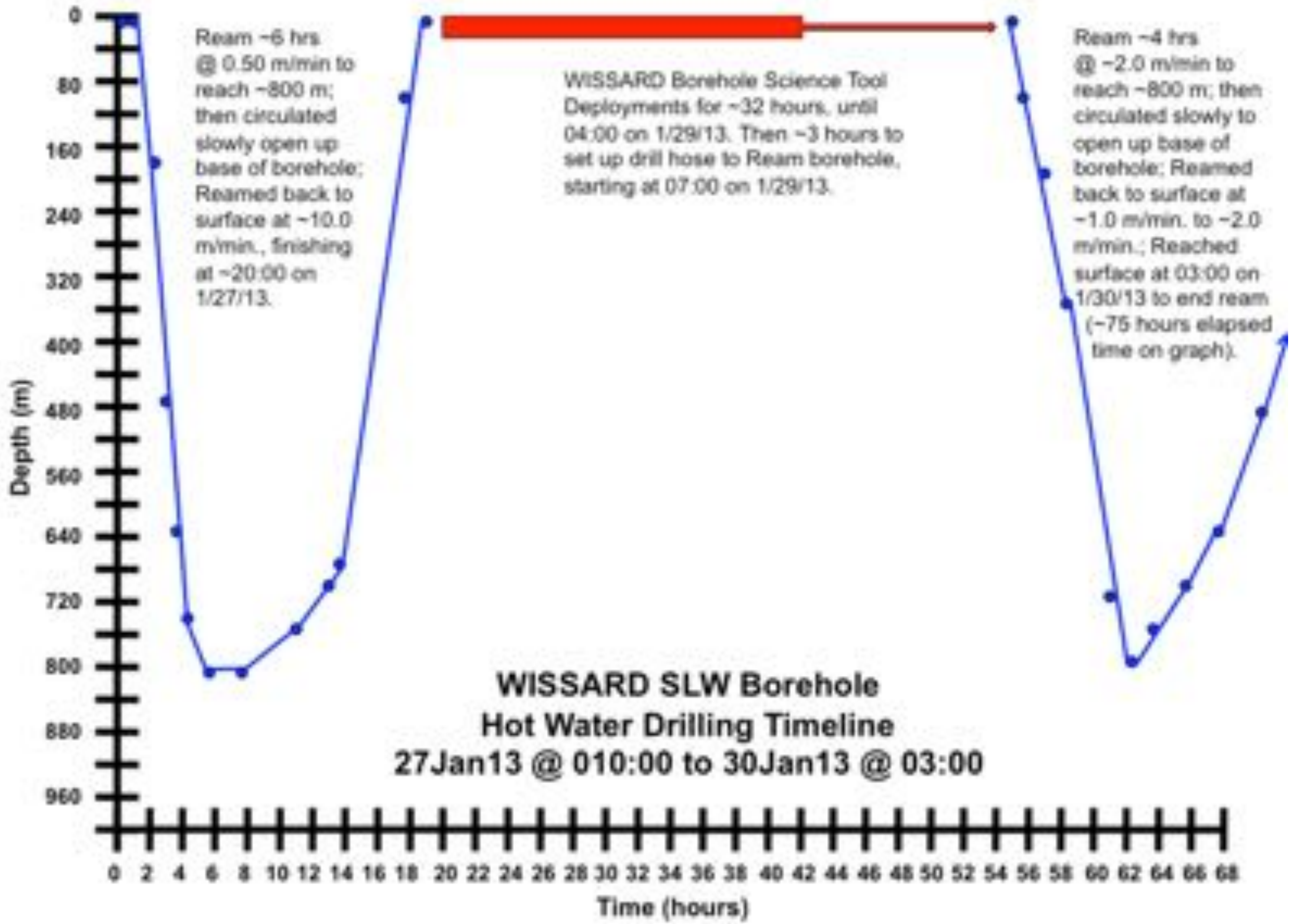
New winch designed and constructed at UNL

winch spool design



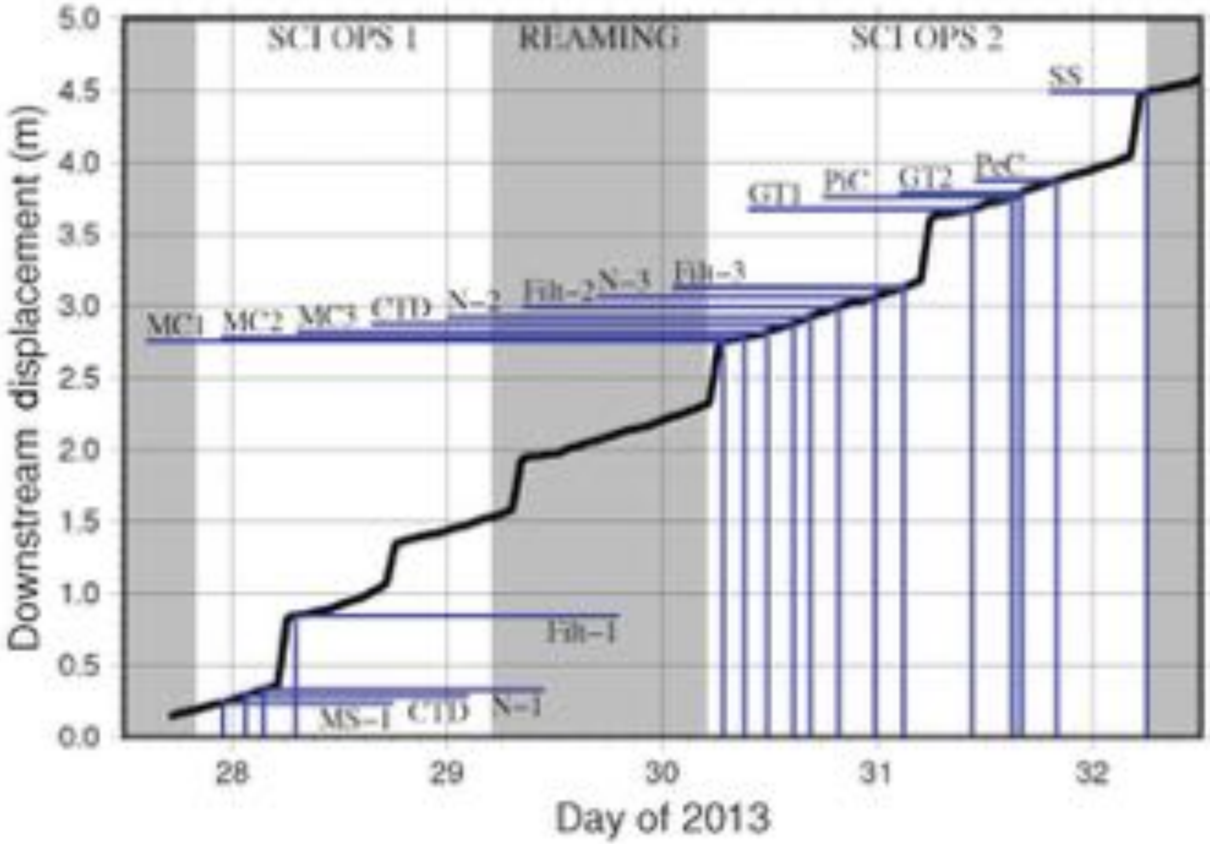
UNL's Hot Water Drilling Team at the conclusion of the WISSARD Project


WISSARD SLW Borehole
Hot Water Drilling Timeline
23Jan13 @ 09:00 to 26Jan13 @ 17:00
Depth (m)
Time (hours)
~12 hrs
Drill Keyhole &
Deploy pump
~12 hrs
Start Main Borehole
& connect to Keyhole
at about ~110 m depth
Drill ~16 hrs
@ 0.6 m/min.
to reach 700 m
Recovered
hose in ~3 hrs
@ ~4.0 m/min.
Ream ~7 hrs
@ variable
speed to reach
~725 m; then
drilled slowly to
~775 m; then
pumped out hole
to lower head
Recovered
hose in ~3 hrs
@ ~4.0 m/min.
Prepared &
Deployed
MSLED for
~5 hrs
Ran in &
out of
hole to
check
depth of
blockage
& plan
next step.



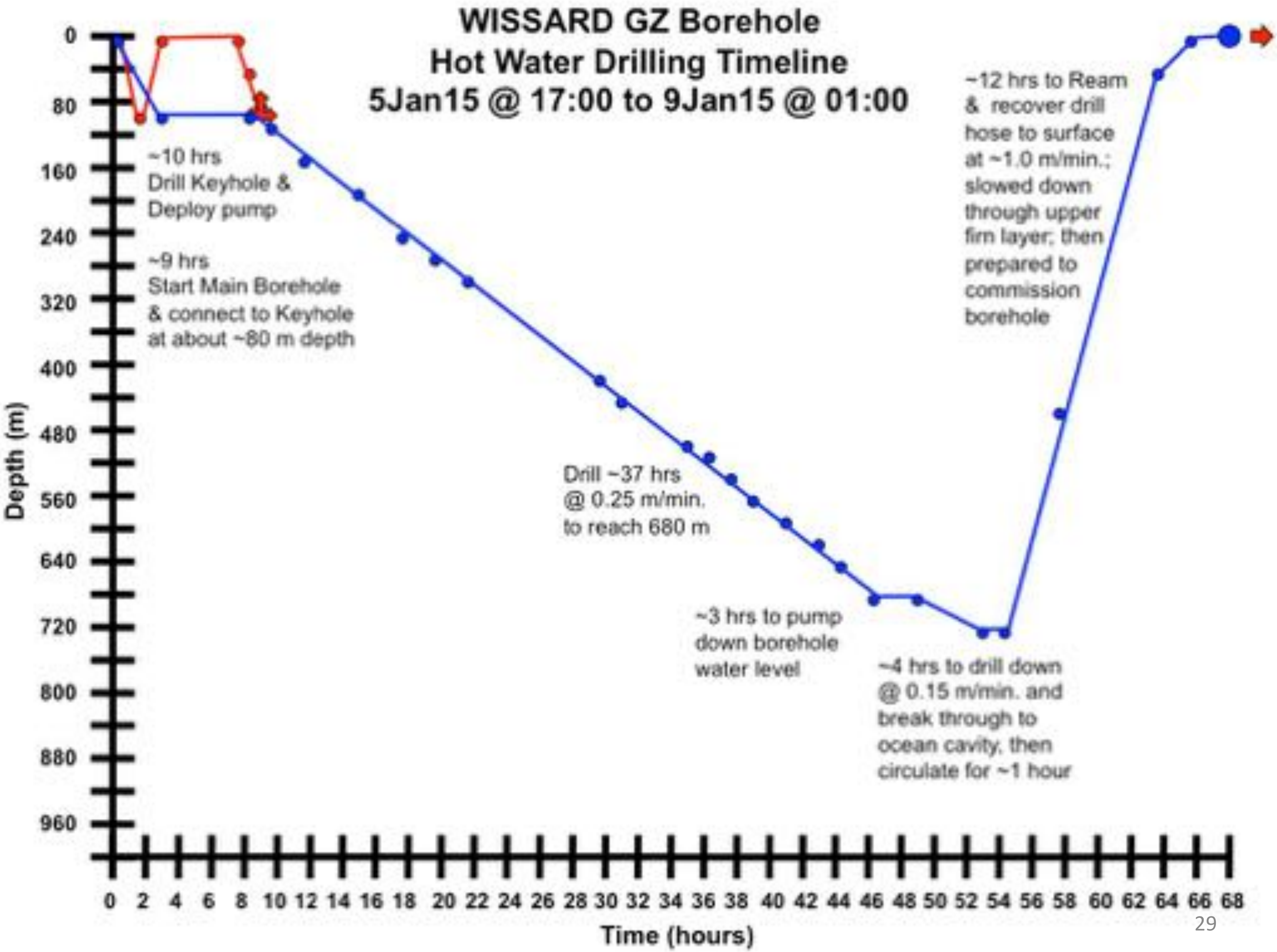
WISSARD SLW Borehole
Hot Water Drilling Timeline
27Jan13 @ 010:00 to 30Jan13 @ 03:00
Ream ~6 hrs @ 0.50 m/min to reach ~800 m; then circulated slowly open up base of borehole; Reamed back to surface at ~10.0 m/min., finishing at ~20:00 on 1/27/13.
WISSARD Borehole Science Tool Deployments for ~32 hours, until 04:00 on 1/29/13. Then ~3 hours to set up drill hose to Ream borehole, starting at 07:00 on 1/29/13.
Ream ~4 hrs @ ~2.0 m/min to reach ~800 m; then circulated slowly to open up base of borehole; Reamed back to surface at ~1.0 m/min. to ~2.0 m/min.; Reached surface at 03:00 on 1/30/13 to end ream (~75 hours elapsed time on graph).
Depth (m)
0
80
160
240
320
400
480
560
640
720
800
880
960
Time (hours)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68

Deployment of Sampling Instruments into SLW, Jan. 27-Feb. 1, 2013



(1) Borehole Camera (MS-1);
(2) Conductivity-Temp. probe (CTD);
(3) Niskin bottle (N);
(4) "*in situ*" water filtration unit (Filt.)
(5) sediment multicorer (MC);
(6) geothermal probe (GP);
(7) sediment piston corer (PiC);
(8) sediment percussion corer (PeC);
(9) geophysical sensor string (SS)

Tulaczyk et al., 2014, Annals of Glaciology, 55(65):51-58, doi:10.3189/2014AoG65A009.



WISSARD GZ Borehole
Hot Water Drilling Timeline
5Jan15 @ 17:00 to 9Jan15 @ 01:00
~10 hrs
Drill Keyhole &
Deploy pump
~9 hrs
Start Main Borehole
& connect to Keyhole
at about ~80 m depth
Drill ~37 hrs
@ 0.25 m/min.
to reach 680 m
~3 hrs to pump
down borehole
water level
~4 hrs to drill down
@ 0.15 m/min. and
break through to
ocean cavity, then
circulate for ~1 hour
~12 hrs to Ream
& recover drill
hose to surface
at ~1.0 m/min.;
slowed down
through upper
firn layer; then
prepared to
commission
borehole
Depth (m)
0
80
160
240
320
400
480
560
640
720
800
880
960
Time (hours)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68

UNL Hot Water Drilling Systems (status, ownership/stewardship, location, etc.)

Clean Hot Water Drilling System 'WISSARD Drill'

UNL owns most components and operate on behalf of the scientific community; some components of this system were repurposed from IceCube equipment; components are presently located in McMurdo and at Camp 20 near SPOT Traverse.

The development of the WISSARD Hot Water Drill System (HWDS) by the University of Nebraska-Lincoln was funded through three research grants from NSF-PLR, including: (1) ANT-AISS 0839142 to the University of California-Santa Cruz, (2) ANT-AISS 0839107 to Northern Illinois University, and (3) ANT-AISS 0838933 to Montana State University.

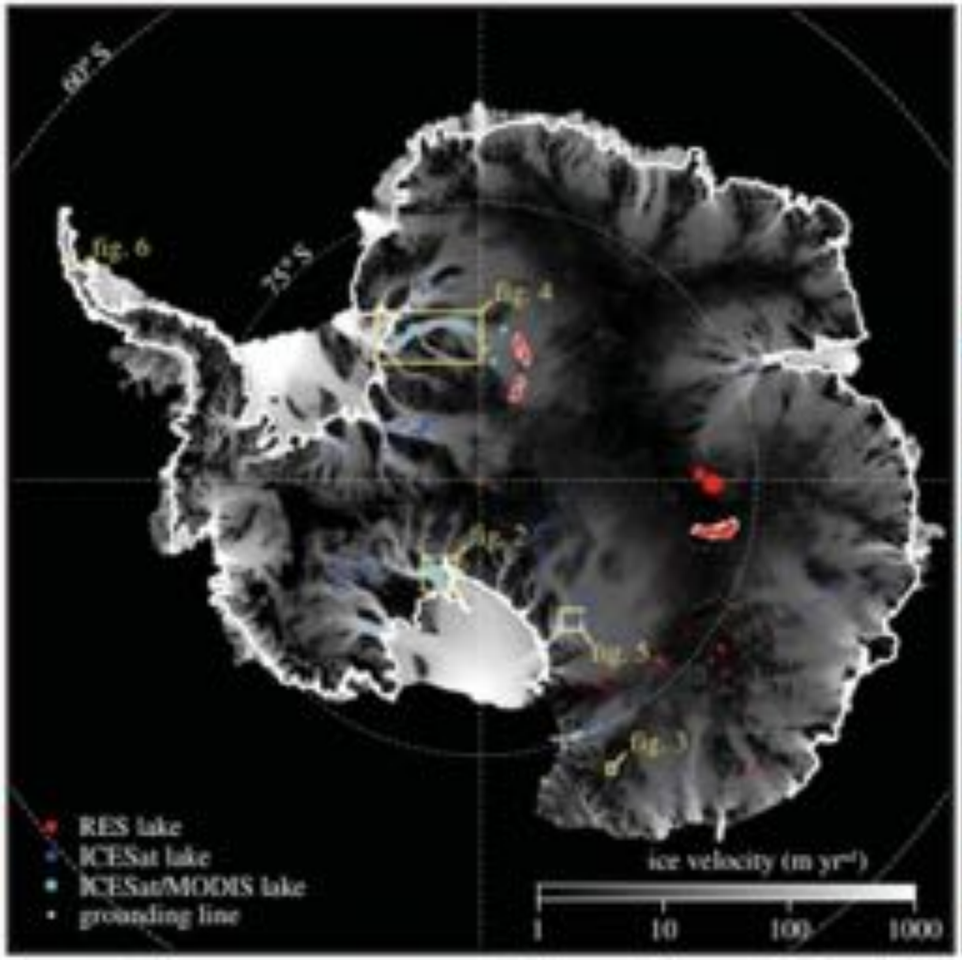
Shot Hole Drill

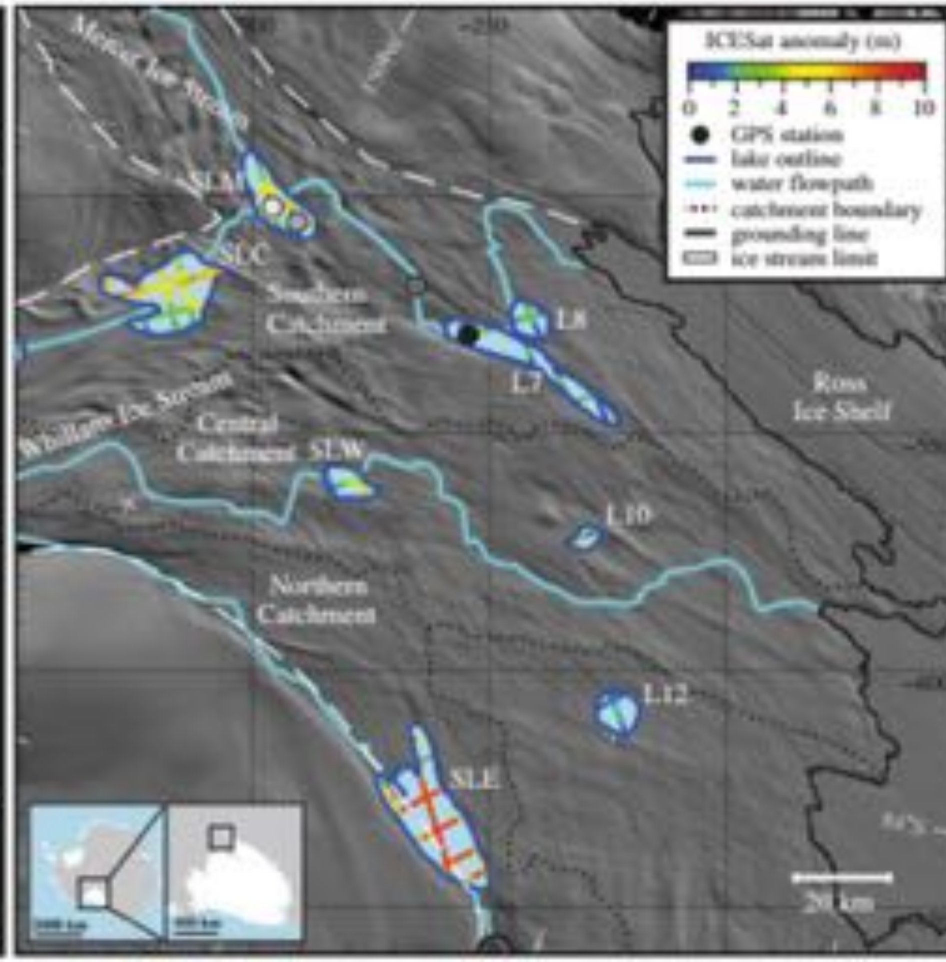
Owned by UNL; located at UNL Shop, Lincoln, NE.

Roving Drill

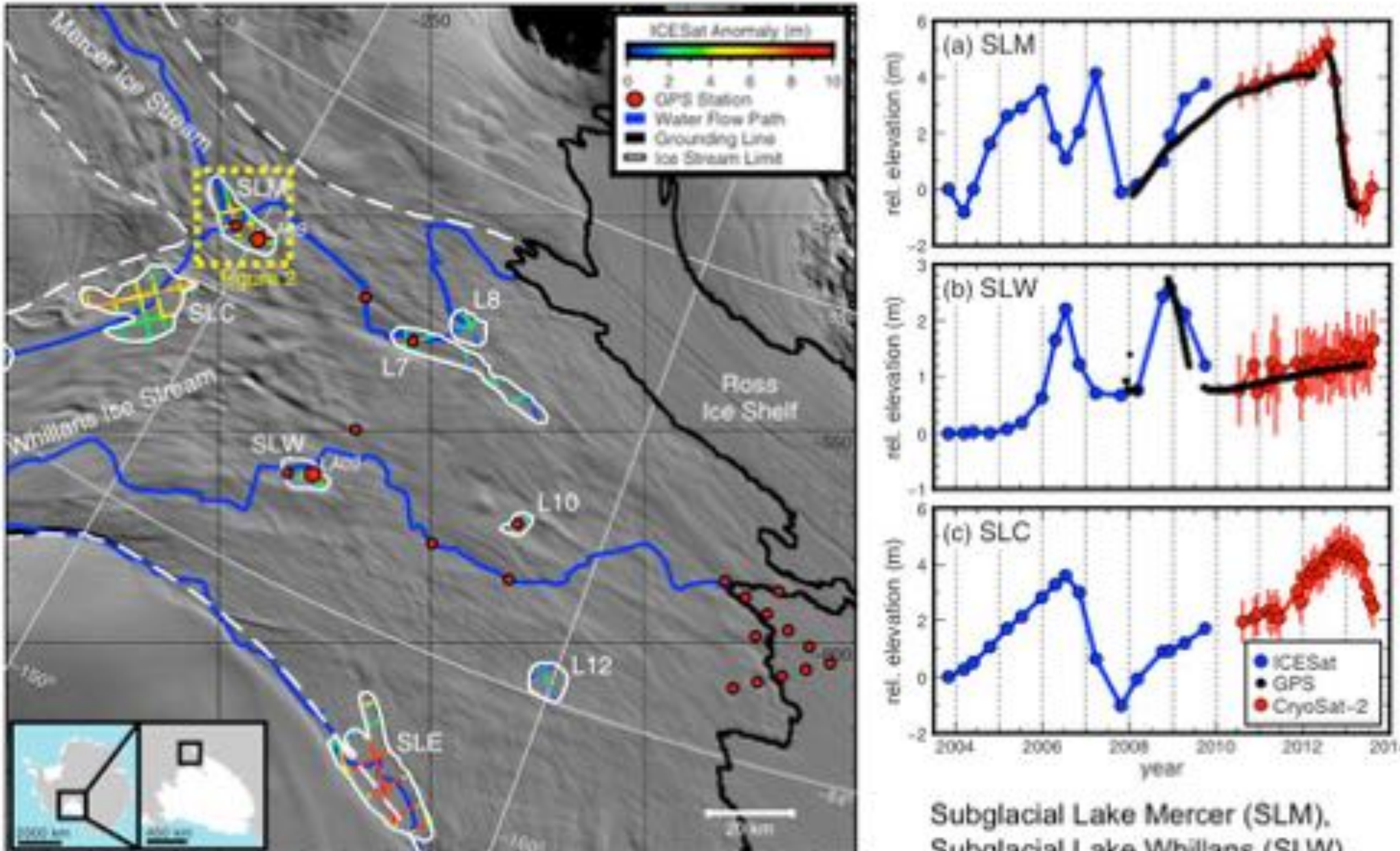
An assembly of component parts that are either UNL owned or on loan and stewarded by UNL (CalTech – pump, water tanks, sleds, tower+sled & IceCube parts – Rodwell heaters and main hose reel). Many components of the Roving Drill are at the UNL Shop or on the USAP vessel enroute to UNL. Remaining in McMurdo are the main water tank, snow melt tank, glycol tank, and back-up main hose reel. This is not a 'clean' drill, but it was designed for future upgrade.

The SALSA Project will use the main hose reel, the return hose reel and pump, the tower and sled assembly, and the hot water basal ice corer (to be refurbished); these are already in McMurdo or at UNL to be shipped south in 2017.


60° S
75° S
fig. 6
fig. 4
fig. 5
fig. 3
RES lake
ICESat lake
ICESat/MODIS lake
grounding line
ice velocity (m yr^{-1})
1
10
100
1000

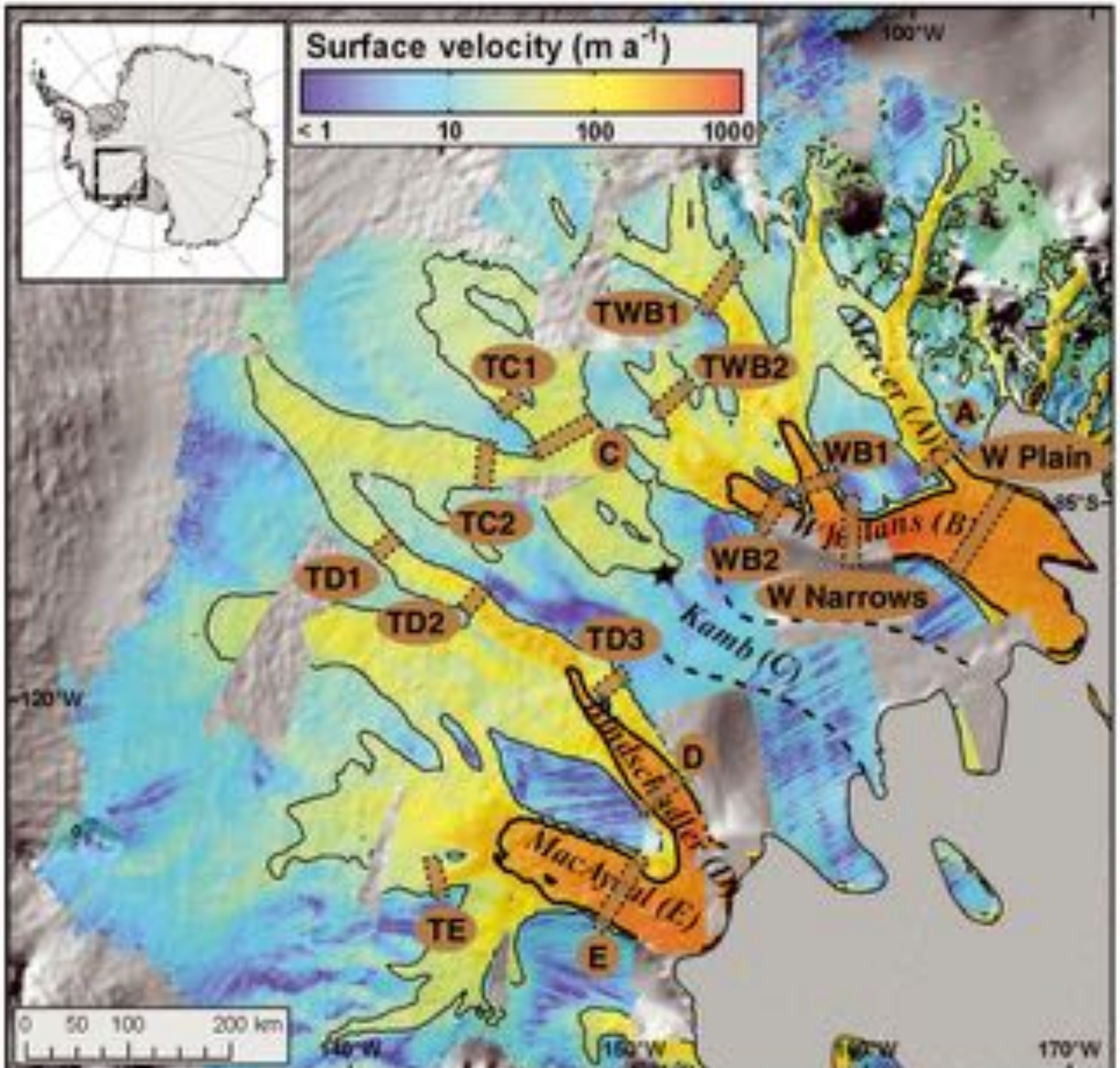

ICESat anomaly (m)
0 2 4 6 8 10
GPS station
lake outline
water flowpath
catchment boundary
grounding line
ice stream limit
Mercer Ice Stream
SLM
SLC
Southern Catchment
L8
L7
Ross Ice Shelf
Whillans Ice Stream
Central Catchment
SLW
L10
Northern Catchment
L12
SLE
20 km

Inferred Subglacial Water System below the Mercer/Whillans Ice Streams



Subglacial Lake Mercer (SLM), Subglacial Lake Whillans (SLW), Subglacial Lake Conway (SLC).

Siegfried, et al., 2014. Geophys. Res. Lett., 41:891–898; doi:10.1002/2013GL058616



Perol & Rice, 2015. Geophys. Res. Lett., 42:3406–3413, doi:10.1002/2015GL063638

The WISSARD Project is a multidisciplinary research project funded by the U.S. National Science Foundation, Directorate for Geosciences, Division of Polar Programs (GEO-PLR), Section for Antarctic Sciences, Antarctic Integrated System Science Program, utilizing funding from the American Recovery and Reinvestment Act (ARRA). We acknowledge the ongoing support provided through the US Antarctic Program (USAP) by Raytheon Polar Science Corporation (RPSC) and Lockheed-Martin Antarctic Support Contractor (ASC).

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