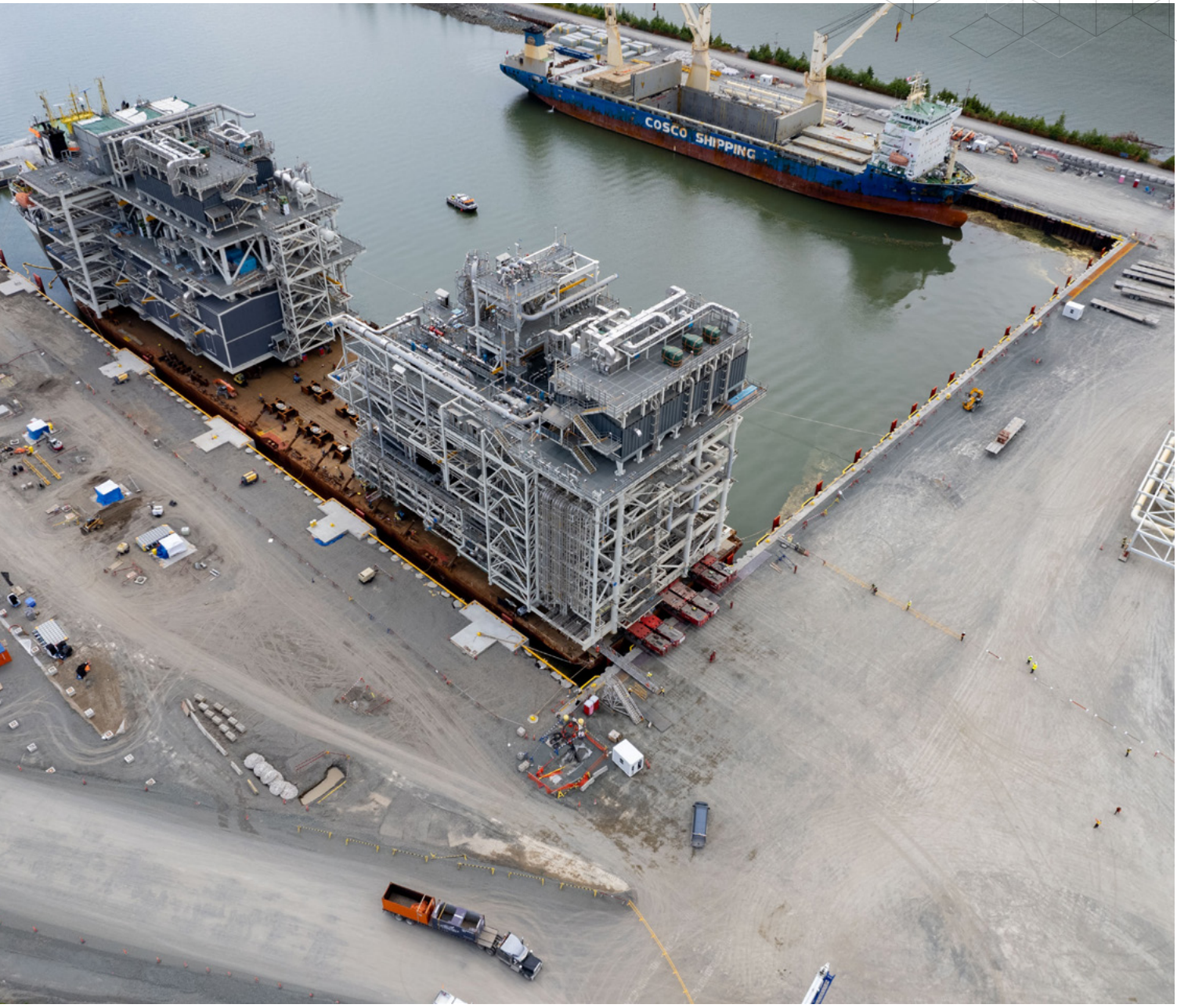
Stantec

2024
CANADIAN CONSULTING
ENGINEERING AWARDS

LNG Canada
Material Offloading Facility

North bulkhead construction of MOF before dredging

CONTENTS



LNG modules offloading onto MOF North wall via SPMT trains (Self Propelled Modular Transport)

PROJECT SUMMARY

The LNG Canada MOF, an iconic $96M project, stands as the largest steel sheet pile bulkhead in BC, designed to withstand extreme marine conditions and seismic activity. This 550-metre-wharf, located in Kitimat, BC, is designed to facilitate the construction of the largest private capital investment project in Canadian history. Stantec used innovative design solutions resulting in a wharf capable of handling the import of massive 8,000-tonne LNG plant modules to facilitate the terminal construction.

Q.1 INNOVATION

The LNG Canada Marine Facilities Offloading Facility (MOF) is a landmark project in Kitimat, BC, representing a significant stride in Canada's infrastructure development. This $96 million endeavor resulted in a 550-meter-long wharf designed to facilitate the construction of a $14B LNG export terminal. The MOF's primary function is to receive heavy-lift marine transport of construction materials and prefabricated LNG plant modules, some weighing up to 8,000 tonnes and towering over 10 stories high. The MOF's seamless operation is the most critical component in the construction and completion of this important export terminal.

Stantec's integrated project team was tasked to provide innovative design engineering solutions for the MOF to overcome hard design time-constraints due to the shipping schedule of the LNG modules. Stantec used a 100% BC local multidisciplinary team of structural, geotechnical, coastal, civil, and electrical engineers to respond to the fast-tracked Design-Build. Through an integrated project team approach and working collaboratively, the team conceptualized time-saving strategies in design, such as anticipating material sourcing and/or fabrication times, utilizing FLAC analyses to avoid costly ground improvements, designing for early procurement, and more.

Furthermore, our team worked closely to innovate the MOF design to be resilient against tsunamis, seismic activity, strong waves, local tides up to 7-metres high, and a plethora of environmental conditions. Certainly, the robustness of the wharf is particularly noteworthy and can handle heavy SPMT train loading, concentrated strip loads from offloading ramps, and a 100kPa uniform surcharge. Additionally, the MOF was further designed by our structural team with a 25-year durability lifespan to allow for flexibility in future plant expansion phases, exceeding the originally prescribed 10-year lifespan.

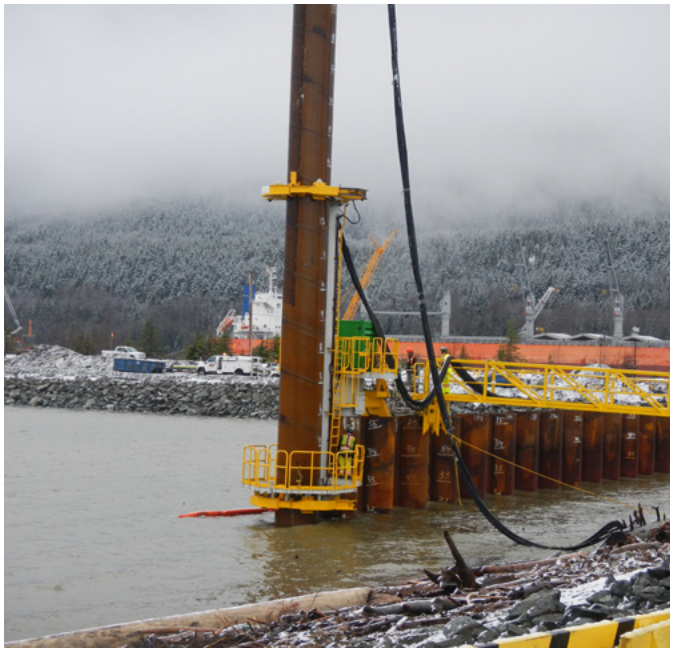
Installing infill sheet piles for the combi wall on South end of the West side of MOF

The design of the MOF distinguishes itself as BC's largest steel sheet pile combi-wall bulkhead. It is also the first delivered project in Canada designed in accordance with the new CSA EXP276.1 guidelines "Design Requirements for Marine Structures Associated with LNG Facilities".

The MOF design serves as a benchmark for future projects by demonstrating the successful application of an integrated design process under a compressed schedule. It exemplifies how innovative engineering solutions can be developed and implemented swiftly without compromising quality or safety. Furthermore, the project Engineer of Record wrote and published a paper about sheet pile combi-wall reinforcement plates, which further advances the state of practice and engineers' skills in the industry.

Installation of tie-rods on MOF West wall

Installation of first pipe piles on North wall



MOF in operation

Q.2 COMPLEXITY

The project included the following key challenges: an extremely compressed design schedule, as well as the unique issue of static liquefaction.

The Stantec team overcame Design-Build project time constraints and developed unique, value engineering solutions to help save project costs and achieve on-schedule delivery of the LNG modules. Bulkhead pipe piles were designed with reinforcing plates in high moment zones to allow for time to finalize pile design even after material stock ordering, which allowed for schedule flexibility because design changes after procurement could be mitigated by adjusting reinforcing plate size without affecting pipe size. This innovative design approach met project needs, while allowing for efficient use of steel and cost reductions through de-coupling procurement and design processes. Furthermore, concrete cope beams utilized the front face of the bulkhead as formwork by cutting off a portion at the top of the pipe piles which allowed the cope beams to be cast directly behind the bulkhead face—saving time and money on the project.

With extremely heavy loads being placed on the MOF, static liquefaction of river sediments, as well as potential seismic activity, became a unique and extraordinary problem. Stantec's geotechnical team used FLAC software and detailed numerical modelling to provide a structural solution to the impacts of soil liquefaction both from seismic events and static liquefaction factors that could result from the large LNG module loads. This in-house analysis enabled Stantec to provide an innovative engineering solution that avoided costly and time-consuming ground improvement.

Q.3 SOCIAL AND ECONOMIC IMPACT

The construction of the LNG MOF has brought significant social and economic benefits to the local Kitimat community, while the LNG Canada export terminal's future operation will continue to provide long-term employment opportunities to the region, as well as additional government revenue from LNG exports.

For the local community, partnerships with people and organizations were created during construction. Teams of local labour forces were employed to execute the building of the MOF, while where possible, local suppliers were used as sources for various construction materials. All the project's required sand, gravel, and other granular material came from a quarry only a few kilometers from the project site via an open contract for this material. All concrete was delivered by a local provincially certified concrete supplier. Furthermore, local labour forces are provided with an opportunity for long-term employment in the operation of the export terminal. Engaging these local labour forces and materials suppliers has fostered skill development and economic growth within the community.

For the region, province, and nation, the project will contribute significant revenue increases for government at different levels. Over the life of the project, the facility is projected to generate approximately $23B in new government revenue. These funds will support public services such as health care, education, and more.

Additionally, as a spin-off benefit, the use of local resources and labour has minimized environmental impact. Furthermore, the project has set a precedent for future industrial development in the region, potentially leading to further infrastructure development and economic stimulation.

Tie rods and anchor wall intallation on North Wall

West bulkhead wall of MOF during construction

Q.4 ENVIRONMENTAL IMPACT

The LNG Canada MOF project addresses environmental and sustainability issues through several key initiatives.

Firstly, the MOF supports the export of LNG which provides a cleaner burning alternative to coal and contributes to reduced greenhouse gas emissions globally.

Secondly, the project itself employed local sourcing of materials where possible, significantly reducing transportation-related carbon emissions. For instance, granular materials were sourced from a nearby quarry, and concrete was supplied by a local provider, minimizing the environmental impact associated with long-distance transportation.

Furthermore, the MOF was constructed using a large amount of steel and concrete, materials known for their durability and longevity. With a design that allows for functional uses beyond its initial 10-year operational lifespan, sustainability and promotion of extended use is enhanced.

Thirdly, the use of predominantly local labour forces worked to reduce the project carbon footprint by avoiding the need to frequently move labour expertise in and out of the project site on rotation and provide new housing for working populations.

Finally, the design and construction of the MOF took into account the protection of local water systems and ecosystems. The geotechnical project team implemented a drilling program to understand soil conditions without disturbing the underwater environment excessively. Stantec's integrated environmental and engineering teams collaborated on the design of the MOF to prioritize environmental considerations during design development. Furthermore, the geotechnical team also provided engineering solutions to address challenges such as soft soil conditions and tidal action, which promoted stability and minimization of disturbances to the natural setting.

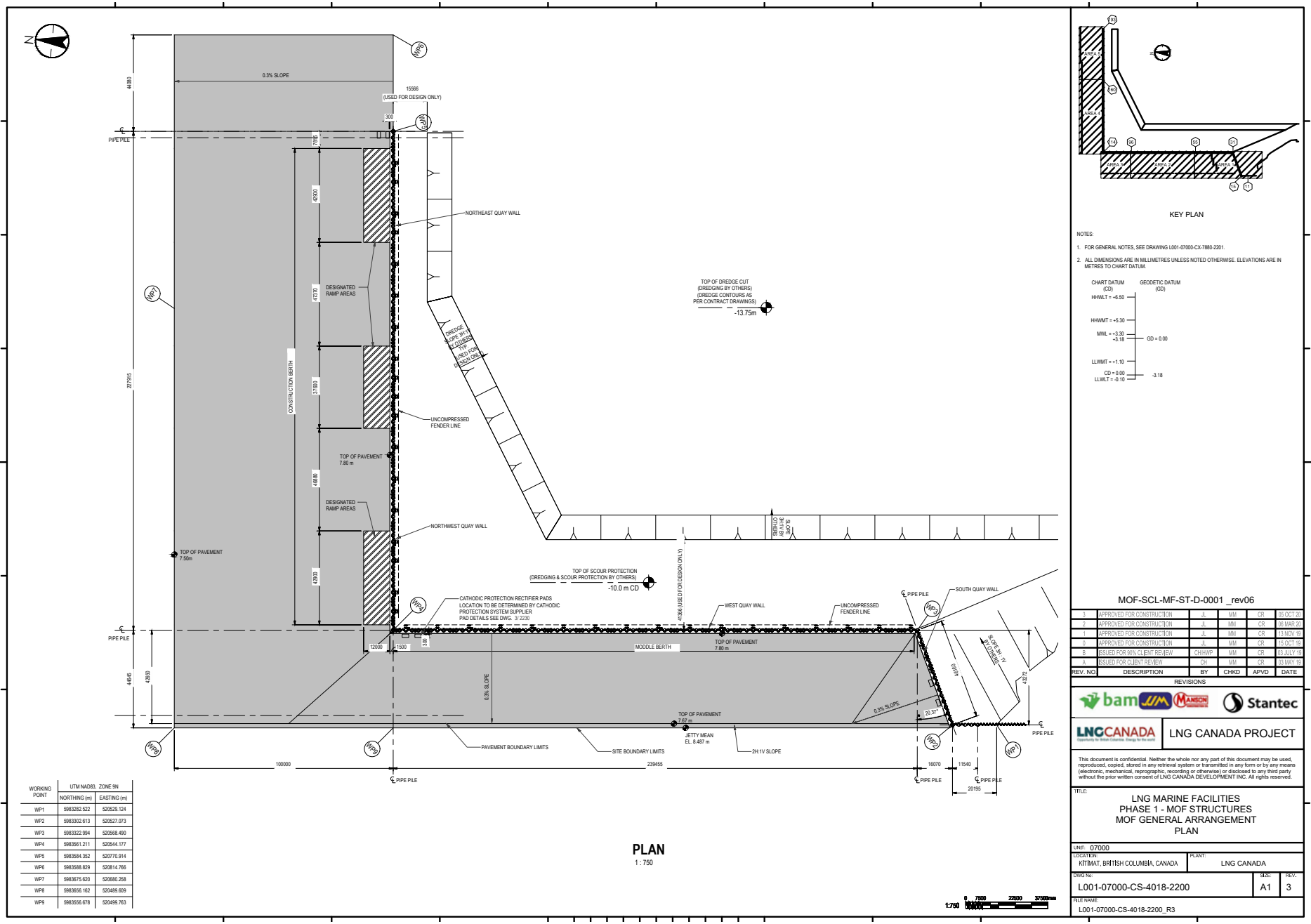
MOF North Wall with fender panels post construction (shown as upper bulkhead wall in image)

Q.5 MEETING AND EXCEEDING OWNER'S/CLIENT'S NEEDS

The main project goal for the LNGC MOF was to design a temporary port facility capable of offloading, staging, and storing 8,000-tonne modules and multiple construction materials. The project aimed to provide a cost-effective marine structure within a tight design schedule that could accommodate significant seismic loading. The design team aimed for substantial completion in time for scheduled module shipments, all while complying with environmental and regulatory approvals.

Stantec met these goals through an integrated multidisciplinary approach, leveraging local expertise in structural, geotechnical, civil, and electrical engineering. The team prioritized safety, durability, and strength in the design philosophy, and worked closely with client teams to develop innovative, time-reducing design decisions. One example of this is the structural team's use of early procurement of long lead items, such as with the bulkhead pipe piles, which were designed with reinforcing plates to allow for more time to finalize pile design even after plate stock ordering.

Economically, the project was a success and achieved an actual cost at completion that was in alignment with the initial budget estimates. The schedule was a key driver for the project because the LNG modules were ordered and enroute at project commencement. Client expectations on the design schedule were met, with all Phase 1 plant LNG modules and construction materials offloaded on time. This large Design-Build contract received a low number of RFI's and no major claims after construction completion, which exceeded client expectations, possibly due to the design team's focus on innovative, time-saving solutions.



PLAN
1 : 750

WORKING POINT	UTM NAD83, ZONE 9N	
	NORTHING (m)	EASTING (m)
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WP2	5983302.613	520527.073
WP3	5983322.994	520568.490
WP4	5983561.211	520544.177
WP5	5983584.352	520770.914
WP6	5983588.829	520814.766
WP7	5983675.620	520680.258
WP8	5983656.162	520489.609
WP9	5983566.678	520499.763

KEY PLAN

NOTES:

1. FOR GENERAL NOTES, SEE DRAWING L001-07000-CX-7880-2201.
2. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE. ELEVATIONS ARE IN METRES TO CHART DATUM.

MOF-SCL-MF-ST-D-0001 _rev06

REV. NO	DESCRIPTION	BY	CHKD	APVD	DATE
3	APPROVED FOR CONSTRUCTION	JL	MM	CR	05 OCT 20
2	APPROVED FOR CONSTRUCTION	JL	MM	CR	06 MAR 20
1	APPROVED FOR CONSTRUCTION	JL	MM	CR	13 NOV 19
0	APPROVED FOR CONSTRUCTION	JL	MM	CR	15 OCT 19
B	ISSUED FOR 90% CLIENT REVIEW	CH/HWP	MM	CR	03 JULY 19
A	ISSUED FOR CLIENT REVIEW	CH	MM	CR	03 MAY 19

REVISIONS

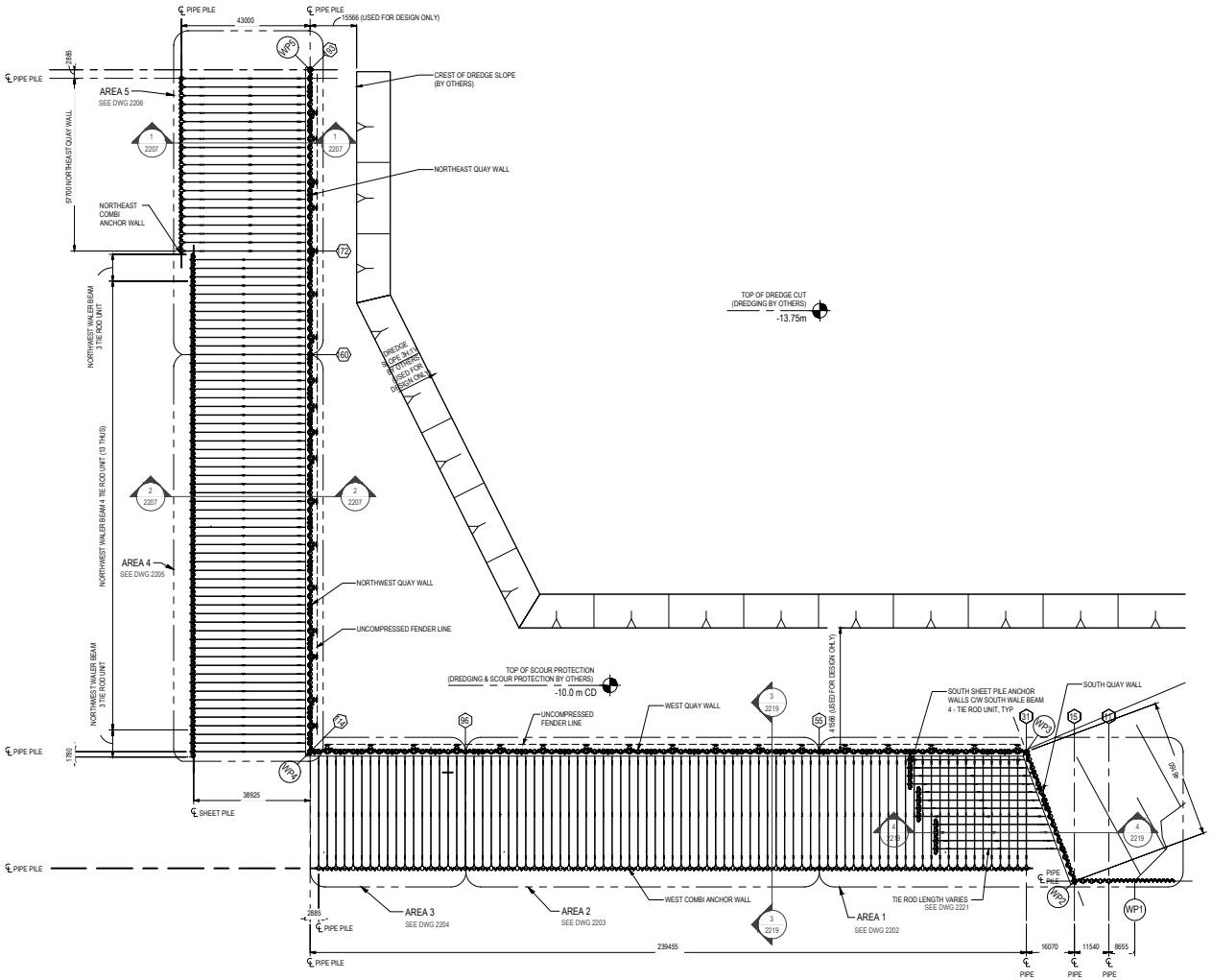
bam JJM Manson Construction Stantec

LNGCANADA Opportunity for British Columbia. Energy for the world.

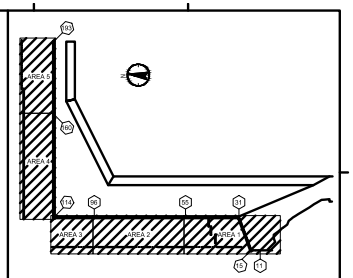
LNG CANADA PROJECT

TITLE:
LNG MARINE FACILITIES
PHASE 1 - MOF STRUCTURES
MOF GENERAL ARRANGEMENT
PLAN

UNIT: 07000
LOCATION: KITIMAT, BRITISH COLUMBIA, CANADA
PLANT: LNG CANADA
DWG No: L001-07000-CS-4018-2200
SIZE: A1
REV: 3
FILE NAME: L001-07000-CS-4018-2200_R3



PLAN
1 : 750



KEY PLAN

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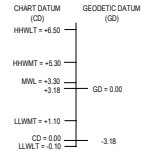
2. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE. ELEVATIONS ARE IN METRES TO CHART DATUM.
3. FOR WORK POINT COORDINATES, SEE DRAWING L-0001-07000-CS-4018-2200.
4. FOR MARINE HARDWARE LAYOUT, SEE DRAWING L-0001-07000-CS-4018-2214.
5. FOR PIPE PILE, SHEET PILE, TIE ROD SCHEDULES, SEE DRAWING L-0001-07000-CS-4018-2221.
6. FOR CORROSION PROTECTION REQUIREMENTS SEE SPECIFICATIONS L001-07000-CX-7880-4010 AND L001-07000-CX-8380-1903.



MOF-SCL-MF-ST-D-0002 _rev06

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1	APPROVED FOR CONSTRUCTION	JL	MM	CR	13 NOV 19
0	APPROVED FOR CONSTRUCTION	JL	MM	CR	15 OCT 19
B	ISSUED FOR 90% CLIENT REVIEW	CH/HWP	MM	CR	03 JULY 19
A	ISSUED FOR CLIENT REVIEW	CH	MM	CR	03 MAY 19

REVISIONS

LNG CANADA PROJECT

TITLE:
LNG MARINE FACILITIES
PHASE 1 - MOF STRUCTURES
SHEET PILE AND TIE ROD
OVERALL PLAN

UNIT: 07000
LOCATION: KITIMAT, BRITISH COLUMBIA, CANADA
PLANT: LNG CANADA
DWG No: L001-07000-CS-4018-2201
SIZE: A1
REV.: 2
FILE NAME: L001-07000-CS-4018-2201_R2