PREPARED BY:

PND ENGINEERS, INC.

HAIGHT & ASSOCIATES
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PORT OF JUNEAU CRUISE SHIP BERTHS

SHORE TIE POWER STUDY

FEASIBILITY STUDY REPORT

NOVEMBER, 2016

PND No: 152054.01

Introduction

In 2004, a cruise ship electrical shore power facility was installed on the Franklin Dock. This provides power to cruise ships (primarily those operated by Princess Cruises) when they are in port, reducing the emissions of engine fumes into the downtown area. This also reduces the carbon footprint in Juneau by substituting hydro turbine generated electricity in lieu of diesel fired generation.

The new Port of Juneau Cruise Ship Berths are currently under construction. The South Berth was completed in May 2016. The North Berth will be completed in May 2017. This facility is designed with an allowance for future installation of components as required for cruise ship shore power. This report narrates the characteristics of the system and its components.

The team that is reviewing and providing the report for this installation includes:

- Carl Uchytil, P.E., CBJ Port Director
- Gary Gillette, AIA, CBJ Port Engineer
- Dick Somerville, P.E., PND, Principal Civil Engineer
- Brandon Ivanowicz, PND, Staff Engineer
- Ben Haight, P.E., Haight & Associates, Inc., Electrical Engineer

This report characterizes a concept design illustrating a probable system configuration and component features. With the initiation of a formal design, the concept will be used as a basis of design upon which detailed analyses, component definition, and final system configuration will be based. The report includes narration of the design along with a site map and marine facility schematics illustrating the probable layout. The report also includes an estimated budget for construction, design and project administration.

Electrical System

The electrical system will be powered from one of the existing 69KV transmission lines between the Thane Substation and the downtown substations. The system is constructed to feed power from this transmission line to the water side facility and will include several components. These are defined in sequence leading from the transmission line to the power connectors for the ships.

AEL&P Substation: A new substation will be located on the hillside southeast of the end of Gastineau Avenue. This site is located adjacent to the two existing 69KV transmission lines. The substation will consist of 69KV switchgear and protective relays, transformer(s), and secondary switches and protective relays. The substation will be adequately sized to power two cruise ships. The transformer(s) will be rated for ships, 15,000 KVA each, producing output voltages of 11.6KV and 6.2KV. All of this substation equipment is located on the ground with security fencing around the perimeter.

15KV feeder to South Franklin Street: The hillside from the substation to South Franklin Street is steep with areas of loose rock and overburden. It is a difficult area to trench. For each ship electrification facility, this portion of the system will include six 6-inch diameter conduits (12 total) installed above ground on structural stands, or potentially installed below ground if found possible. The conduits will include 15KV rated cables for power and fiberoptic cables for instrumentation and control. The conduits will terminate into a new vault at South Franklin Street on the uphill side.

15KV Feeder from South Franklin Street to Shore: Twelve 6-inch conduits are presently installed below grade from the location of the proposed new vault on the uphill side of South Franklin Street to an existing manhole near the shore adjacent to the Mt Roberts Tram. Twelve more conduits extend from this manhole beneath the shore to open under water at approximately -5 feet MLLW. This system of conduits and manholes provide allowance to install cables to power two ships. The existing conduits will be extended into the new vault as required. The 15KV cables identified earlier will extend to the existing manhole at the shore

where they will be terminated to a junction inside the manhole. The fiber optic cable(s) will extend to this same manhole and onto the ship power float.

15KV Submarine Cable to the Power Floats: Cables specifically designed for underwater conditions will be routed from the manhole on shore to the power float. They will be connected to the shore cables on 15KV terminals inside the manhole. The cables will be coiled on the sea bottom below the power float allowing it to move with tidal changes. These cables will be suspended to the float and supported on a structure specifically designed to support their weight. The cables will terminate in a 15KV switch located on the float.

Switchgear: The switchgear on the floats will be enclosed in a cabinet mounted to the float. The cabinet and enclosed equipment will be suitable for the corrosive marine environment. The switch will be used to synchronize and connect the cruise ship to the onshore power grid. The switch will be collaboratively controlled by the ship crew and AEL&P operators. An additional cabinet will enclose protective relays, control equipment, and data communications equipment. The switchgear will be approximately 20ft wide x 8ft deep x 7ft tall.

15KV Feeder to the Ship: Cables typically used in mines will be routed from the switchgear to the ship. The cables are quite flexible and include connectors on the ship's end. The cables will be installed in covered cable trays from the switchgear to a cable positioning device. The cable positioning device will support and move the cables to and from the ship as required to connect and disconnect shore power. This type of system as opposed to a festooning type of system as described below eases cable hand-off and reduces the need for cable attendance typical with tidal changes.

Marine Structures

The shore power system will be supported by a 36'x66' floating dock structure that will be accessed from a 50-ft long aluminum gangway mounted on the south approach dock. The floating dock would be of concrete pontoons or steel pipe construction and will be anchored in place with steel pipe piles and pile frames. The floating dock will offer cruise vessels a consistent level relative to the ships portal providing for improved handoff and retrieval of the shore power cables. The cable positioning device will have an extendable boom capable of providing a 30-ft range of reach and ability to accommodate vessels with varying portal configurations.

Low voltage power will be provided from the switchboard at the shore end of the new approach dock for the cable positioning device and power float lighting. This will involve a separate 480 volt feeder routed along the approach dock and down the gangway to the power float. Power will be distributed from a panel at the end of this feeder.

Options Considered

The system configuration and layout described above is one of several possible. Based on engineering experience and characteristics of the dock, this seems the most appropriate, however; with implementation of design, other options and sub-options should be considered. Options that were discussed while developing this configuration include the following:

- *Feeder route from shore to the floating dock:* As noted above the feeder is described to be routed directly to the sea bottom and then up to the power float. A route following the approach dock and down the transfer bridge to the main floating dock, and then following a structure to the power float is possible. With this route, the cables used will be the flexible mine type described above to allow for movement at both ends of the transfer bridge and on the transfer structure to the power float. This route is not favored at the South Berth due to the need to allow a portion of the approach trestle to be removable. This configuration will be an option for the North Berth.

- *Feeder Voltage:* AEL&P has presented thoughts using higher voltage service to the shore. With this option, the transformers reducing the voltage to that usable for the cruise ships will be located at the shore. This reduces the substation requirements on the hillside near Gastineau Avenue, and it reduces cable size and subsequent losses between the switchyard on the hillside and the shore. The conduits and manholes presently installed beneath South Franklin Street and the cruise ship uplands will allow for the higher voltage cables. Criteria that have to be addressed with this option will include the type of transformer used and its associated location. Per code and regulation, commonly used oil cooled transformers are not allowed over water. Thus, either the transformers used will have to be air cooled if over water, or space will have to be identified on shore. The air cooled transformers are quite large and will cause visual concerns.

- *Shore-tie Cable Deployment System:* The cable deployment system described above involves a crane style cable positioning device. This has become a preferred method of deployment at most ports along the west coast. Optionally, a festooning type system similar to the one installed at the Franklin Dock is possible. This involves additional stationary marine structures at the dolphins with the festooning system constructed above. It will also involve an extension of the approach dock to the dolphins as required to support the feeder cables. The required switchgear will be mounted to an extension of the approach dock. With this option, a power float is not required. This type of structure is anticipated to be more expensive and the cables require continual attendance while connected to the ship due to tide changes.

Cost of Construction

A budgetary estimate is attached with this report illustrating a probable cost of construction of $12.9 million based on the configuration illustrated above to facilitate shore power at the South Berth only. Installation costs of a similar configuration at the North Berth would also be similar. This estimate includes direct costs expected for the AEL&P substation, feeders, switchgear and devices all required for this installation. It does not include cost that might be borne by AEL&P to upgrade their infrastructure permitting this additional load to their plant.

Analyses

As stated above, the electrical and marine structure system narrated above defines a probable configuration and layout. Opportunities to enhance this configuration should be explored with the implementation of the design phase. Considerations to be included toward funding, design for cruise ship electrification, and impact to the community should include the following factors:

- *Docking:* Ships typically position their shore connection portals on their port side. Ships fitted to be connected from either side are unknown at this time. The cost to provide this type of configuration is expensive to the ship and captures valuable space. Most of the ships connecting to shore power will dock with their portside to shore, however based on past practice, the ships will dock stern to stern at the North and South Berths. The ship docked to the North Berth will be starboard side to the dock. Thus the scheme described above best facilitates the South Berth where the ship will dock portside to the dock.

- *Connection:* As part of connecting the cruise ships to shore power, they are required to synchronize to the AEL&P grid. This involves careful collaboration between the ship's crew and AEL&P's operators. Each ship has technical and operational characteristics that are specific to the ship. AEL&P is required to adapt to each ship. Technically, this involves differing power plant characteristics and operating parameters. Operationally, it can involve language or dialect differences. With short duration connections, and more ship connections, AEL&P operators

become more involved. This increases costs to AEL&P and challenges the sustainability of system operations to the community.

- *Opportunity to Deliver:* AEL&P currently connects and furnishes energy to approximately 60% of the vessel stops with shore power capability. Shore power is only available from the Franklin Dock. The remaining 40% of the shore power capable ships in port cannot receive energy from shore. The ships not receiving power are either docked at the other berths, or are anchored offshore in the harbor, or their longevity in port is brief, or they do not have an agreement to use the Franklin Dock. The Franklin Dock primarily serves Princess Cruise ships and the other cruise ship lines occupy the other berths. Of the remaining ships, some will dock at the South Berth, some at the North Berth, and some at the AJ Dock. All of the present shore power capable ships are fitted for connections on the port side. Thus, the North Berth does not facilitate shore power connection. Considering these factors, the opportunity to connect shore power capable ships is limited to something less than the remaining 40%. It appears that optimally, half of that number (20%) can be connected. Admittedly, this addresses connection opportunities only; it does not address the quantity of energy transferred to the ships.

- *Opportunity to Connect:* The time to connect and disconnect the ship to shore power is typically 1 to 1.5 hours each way. For a ship in port for 8 hours, approximately 5 hours are fully connected to shore power. Many of the ships are in port for less time. It is often not feasible to connect and disconnect with the limited time available.

- *Hydro Capacity:* AEL&P reports that they occasionally have adequate capacity to deliver energy to more cruise ships. Their capacity for such is dependent on weather and water storage in the hydroplant dam impoundment. With a typical winter, snow melt supports good water storage in the summer when the energy is required. With the recent El Nino effects, the atmospheric temperatures are greater resulting in increased rainfall in the winter and summer. This supports water storage year-round. AEL&P also reports that they have the ability to construct additional generation facilities at Dorothy Lake and Sheep Creek which will ensure adequate capacity. Juneau Hydro Power also plans to develop Sweetheart Lake for additional capacity.

- *Transmission Line Capacity:* AEL&P operates and maintains a high voltage transmission line from Snettisham Hydroplant to Thane and two lower voltage lines from Thane into downtown Juneau. The loads on these lines are typically light during the summer, thus they have capacity for the additional load to deliver energy to the cruise ships.

- *Ranking of Customers Receiving "Interruptible" Energy:* AEL&P delivers "interruptible" energy to select customers based on its availability from their hydro generation sources. "Interruptible" energy is available to customers who have other sources of energy available to complete their energy requirements. In that the cruise ships typically generate their electricity using onboard generators, AEL&P is not obligated to provide additional fuel based standby generation at their Lemon Creek site. Thus, AEL&P offers energy to these customers at a reduced rate. AEL&P offers this rate to customers in a hierarchical fashion to those who obtained this rate first. Currently, customers with "dual fuel" heating systems have highest priority for interruptible energy. Those subsequently gaining similar agreements include Greens Creek Mine and the shore power facility at the Franklin Dock. New customers obtaining this service have a lower priority, and they receive this energy only if excess energy is available after the other customers are receiving theirs. When water resources are low, the new shore power facility is not likely to receive energy.

Conclusion

A configuration of the electrical system and the corresponding marine structural facility are described above. This described configuration is a probable one to meet the requirements for cruise ship electrification. It is intended only to illustrate features of a possible configuration that will meet the objectives. As additionally identified, there are other options available which may be considered. The design process should more carefully evaluate the presented configuration along with the options presented and any other options yet to be determined.

The facility described includes connection to the AEL&P transmission lines on Gastineau Avenue, a substation with feeder protection and voltage transformers, switchgear, and feeders to the ship portal. The configuration of the facility is based on application of submarine cables to a floating dock supporting a cable deployment system.

$12.9 million should be budgeted for the construction, engineering, and administration to install a facility for the South Berth. An additional $12.9 million should be budgeted to complete the same for the North Berth. These costs are itemized in the separately included estimate. Maintenance costs are not identified with this report, but they will primarily include the cable positioning device, the submarine cables, and the switchgear. Maintenance of the floating dock, gangway, and other ancillary features will be typical to all of the floating docks in Juneau. The operational costs are primarily those required to connect and disconnect the shore-tie cables and for the energy delivered.

There is no other known floating cable deployment system on the west coast. All of the known systems are located at stationary elevations on shore. Installing such a system on a floating dock reduces the constant manipulation of cables as required by the greater tidal changes that are experienced in Southeast Alaska. Development of this system will require additional engineering to address the associated risk.

At this time, the amount of energy that can be delivered to ships from a shore tie power facility at the South Berth is not specifically known. It is anticipated that service may be provided to approximately half of the remaining 40% of shore power capable ships not currently being serviced at the Franklin Dock. The economic advantage of the sales of this much energy versus the cost of installation are not evaluated under this report.

With this report, it is determined that a system can be constructed within the framework of the new marine structures serving the cruise ships. The structures and equipment can be constructed without major alterations to the newly constructed facilities.

AEL&P has not committed to providing energy to another dock. They presently maintain commitments to other non-firm loads with those customers having a higher priority to receive energy first. In the past, they have experienced seasons with inadequate water storage to generate energy for all of their non-firm loads, including the cruise ships. In order to ensure adequate capacity, the construction of additional hydro power generation facilities is required. To gain a reasonable return on investment, they need to see a requirement to support other new customers or customers with increased loads. They currently do not have an adequate demand to support such an investment.

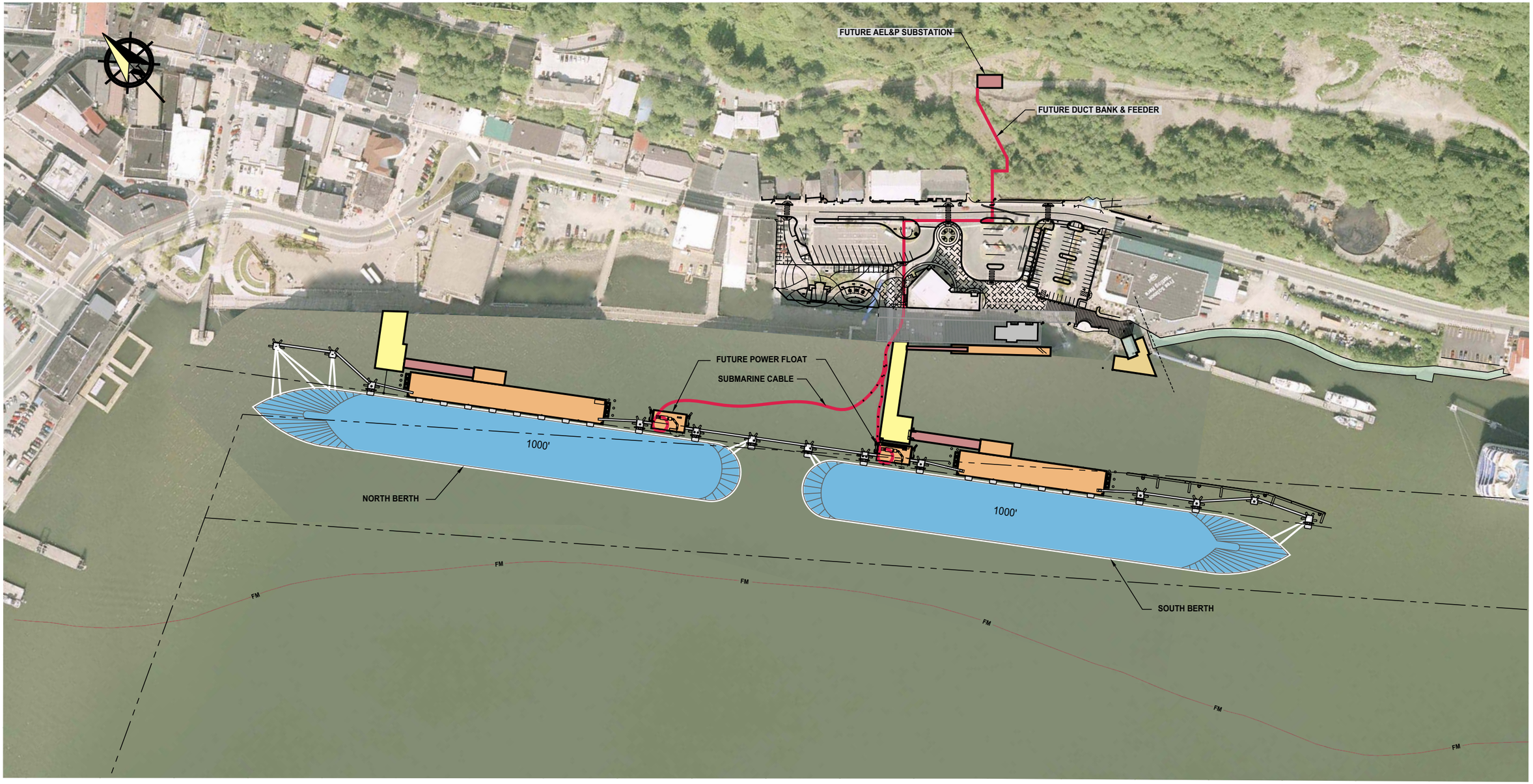
The revenue from the sale of energy to cruise ships goes to AEL&P. The City & Borough of Juneau only receives the sales tax benefit of these sales. This revenue is small compared to the cost of construction of additional cruise ship electrification facilities. The rate of return on investment is therefore not considered reasonable for a public agency.

Attachments: *Budget Level Engineer's Estimate, POJ Cruise Ship Berths Shore Tie Power Study Concept Plans*

PORT OF JUNEAU CRUISE SHIP BERTHS
SHORE TIE POWER STUDY
BUDGET LEVEL ESTIMATE - SOUTH BERTH
Prepared by: PND ENGINEERS, INC.
November, 2016

Item	Item Description	Units	Quantity	Unit Cost	Amount
1505.1	Mobilization	LS	All Req'd	10%	$824,660
2702.1	Construction Surveying	LS	All Req'd	$75,000	$75,000
2894.1	50-ft Aluminum Gangway	LS	All Req'd	$60,000	$60,000
2895.1	Floating Dock, 36'x66'	SF	2,376	$350	$831,600
2896.1	Furnish 36-Inch dia. Steel Pipe Pile	LF	1,200	$250	$300,000
2896.2	Install 36 -Inch dia. Steel Pipe Vertical Pile	EA	4	$15,000	$60,000
2896.3	Install 36 -Inch dia. Steel Pipe Batter Pile	EA	2	$20,000	$40,000
2896.4	Furnish and Install Pile Frames	LS	All Req'd	$200,000	$200,000
2897.1	Cantilevered Approach Dock Extension	LS	All Req'd	$100,000	$100,000
2899.1	Supply and Install Pile Anodes	LS	All Req'd	$40,000	$40,000
5120.1	Electrical Support Assemblies	LS	All Req'd	$40,000	$40,000
11000.1	Cable Positioning Device w/ Extendable Boom	LS	All Req'd	$250,000	$250,000
16000.1	Electrical Substation	LS	All Req'd	$825,000	$825,000
16000.2	Feeder to Shore	LS	All Req'd	$3,500,000	$3,500,000
16000.3	Submarine Cable & Support Structure	LS	All Req'd	$1,550,000	$1,550,000
16000.4	Power on Float	LS	All Req'd	$375,000	$375,000
	ESTIMATED CONSTRUCTION COST				**$9,071,260**
	CONTINGENCY (20%)				**$1,814,252**
	PERMIT APPLICATIONS				**$20,000**
	FINAL DESIGN & CONTRACT DOCUMENTS (10%)				**$1,088,551**
	CONTRACT ADMINISTRATION & CONSTRUCTION INSPECTION (8%)				**$870,841**
	TOTAL RECOMMENDED PROJECT BUDGET				**$12,864,904**

Note: This estimate provides costs for South Berth shore power only. North Berth shore power costs anticipated to be similar.



OVERALL SITE PLAN

CONCEPT

CITY & BOROUGH OF JUNEAU — DOCKS & HARBORS

REVISIONS

REV.	DATE	DESCRIPTION	DWN.	CKD.	APP.

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Phone: 907-586-2093
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www.pndengineers.com

DESIGN: PJD CHECKED: JLD
DRAWN: PJD APPROVED: CRS
SCALE: SCALE IN FEET 0 100 200 FT.
DATE: 10/19/16

PORT OF JUNEAU CRUISE SHIP BERTHS SHORE TIE POWER STUDY
CONTRACT NO. XX-XXXX

SHEET TITLE: OVERALL SITE PLAN
PND PROJECT NO.: 152054

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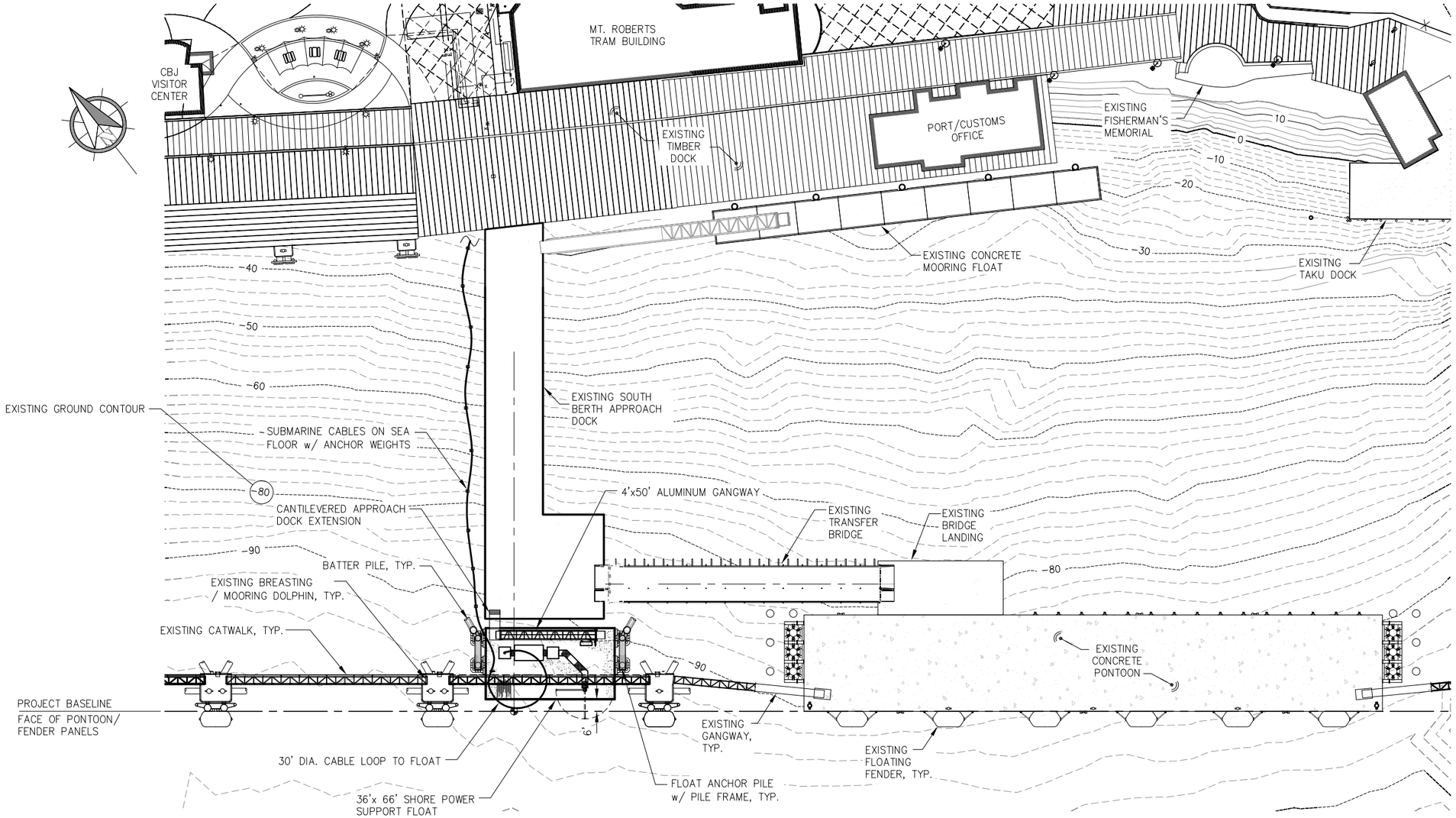

OVERALL SITE PLAN

NOTE: NORTH BERTH INSTALLATION SIMILAR.

CONCEPT

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DESIGN: BMI CHECKED: JLD
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DATE: 10/19/16

PORT OF JUNEAU CRUISE SHIP BERTHS SHORE TIE POWER STUDY
CONTRACT NO. XX-XXXX

SHEET TITLE: **OVERALL SITE PLAN - SOUTH BERTH**

PND PROJECT NO.: 152054

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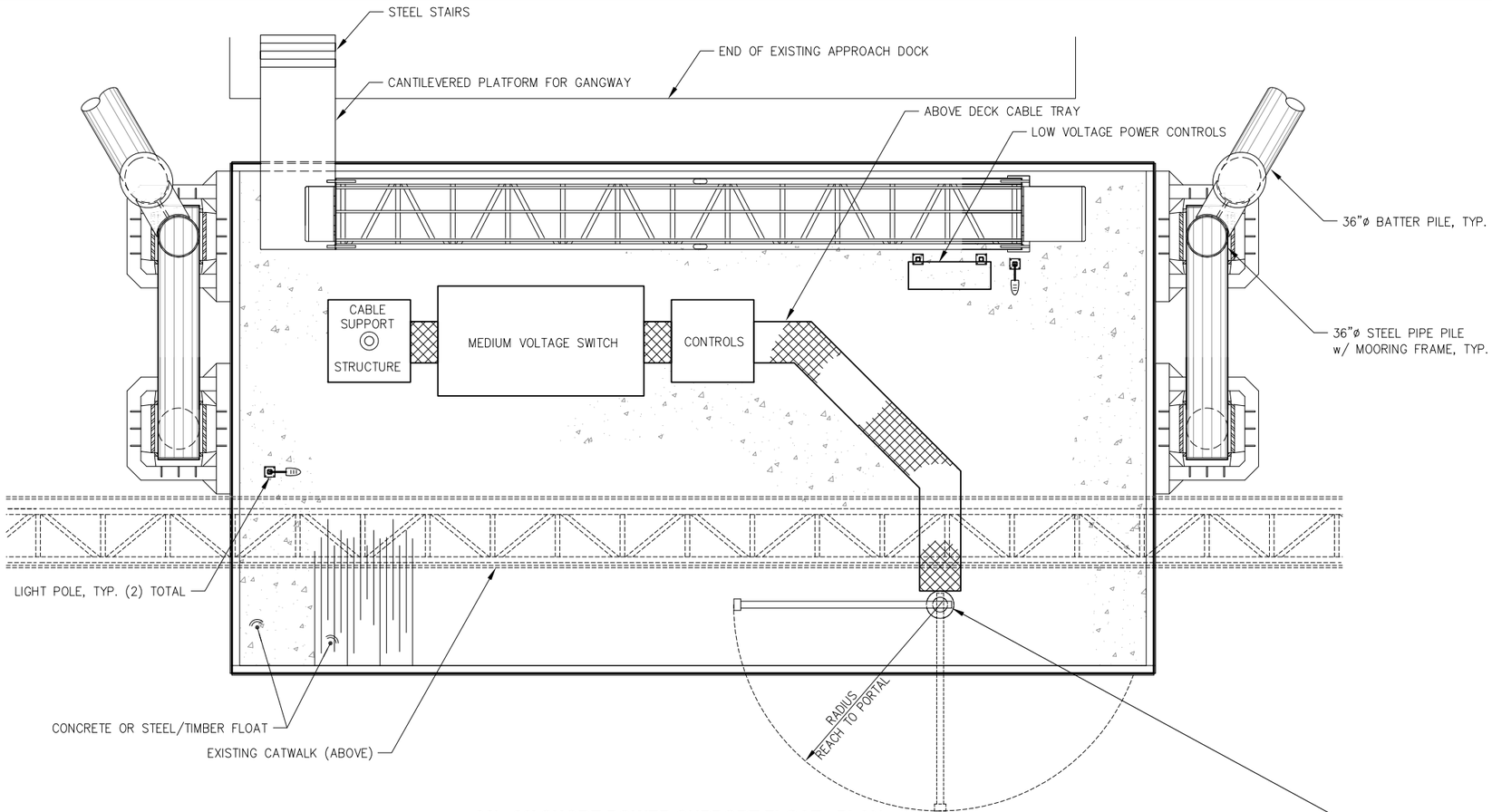
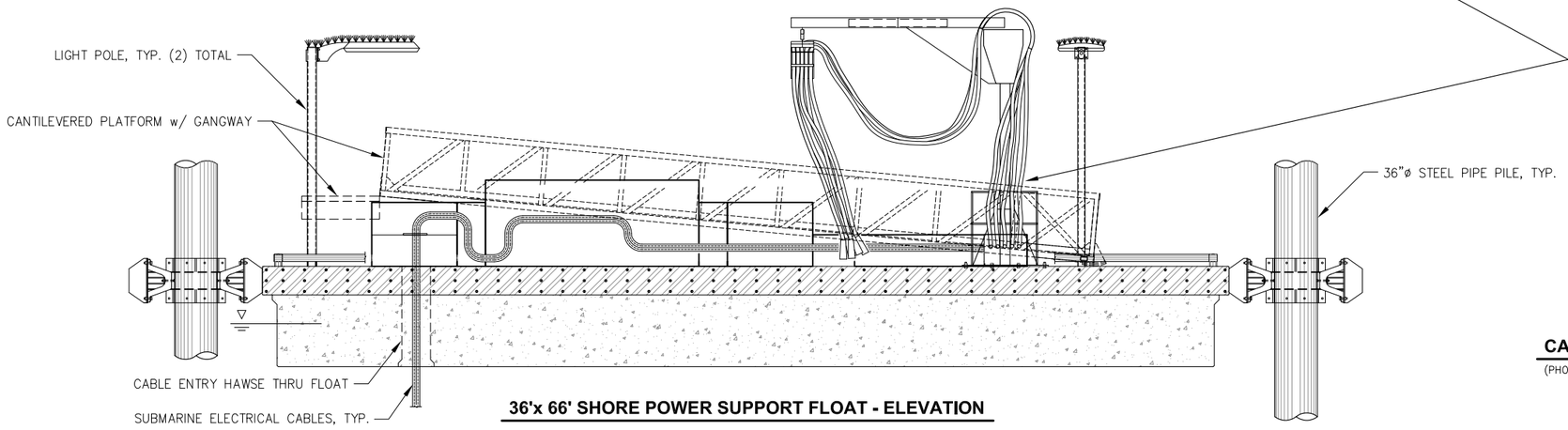


36'x 66' SHORE POWER SUPPORT FLOAT - PLAN



36'x 66' SHORE POWER SUPPORT FLOAT - ELEVATION

CABLE POSITIONING DEVICE w/ 15' EXTENDABLE BOOM

(PHOTO USED WITH PERMISSION FROM COCHRAN MARINE.)

CONCEPT

CITY & BOROUGH OF JUNEAU — DOCKS & HARBORS

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PORT OF JUNEAU CRUISE SHIP BERTHS
SHORE TIE POWER STUDY
CONTRACT NO. XX-XXXX

SHEET TITLE:
SHORE POWER SUPPORT FLOAT PLAN AND ELEVATION

PND PROJECT NO.: 152054

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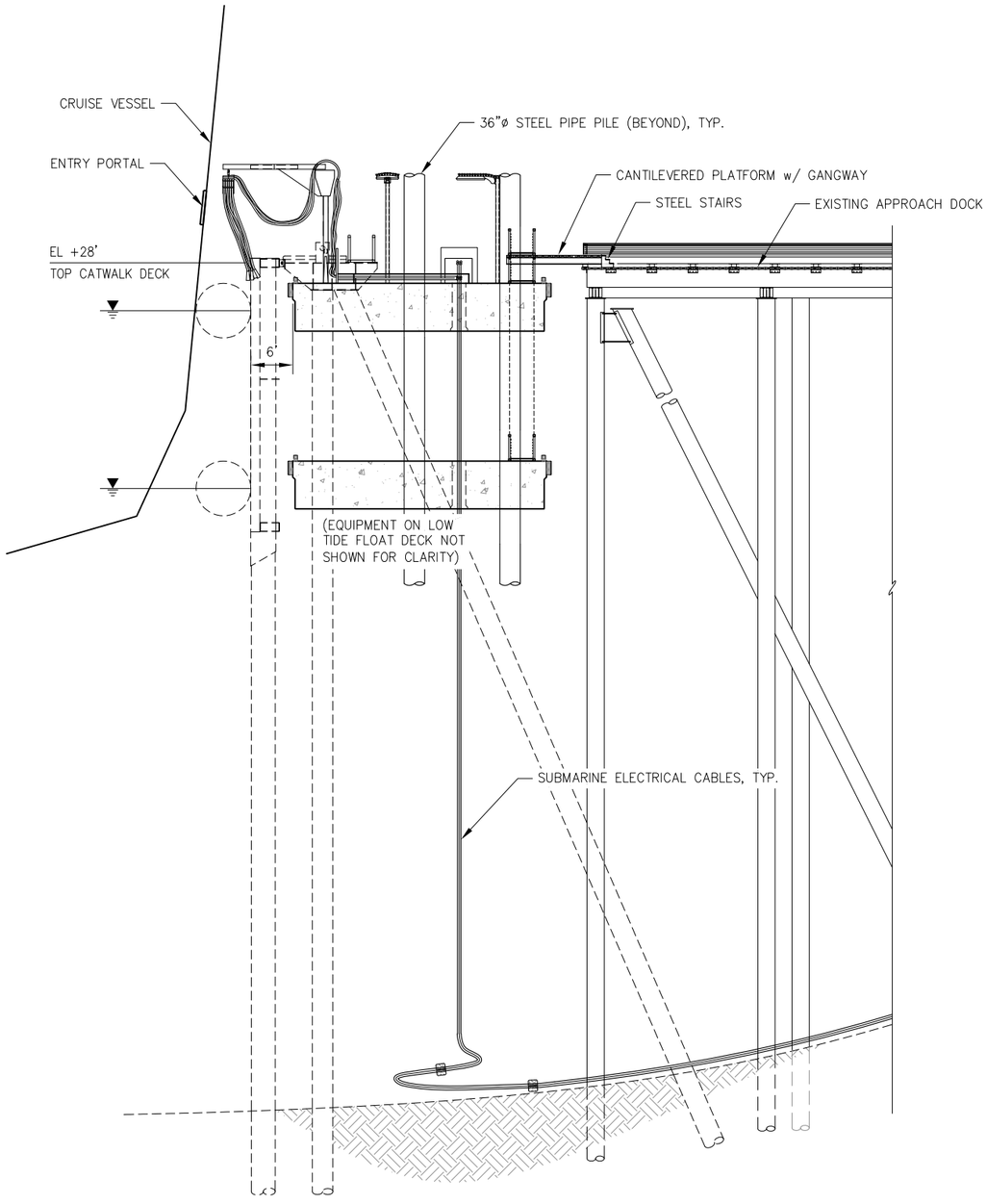

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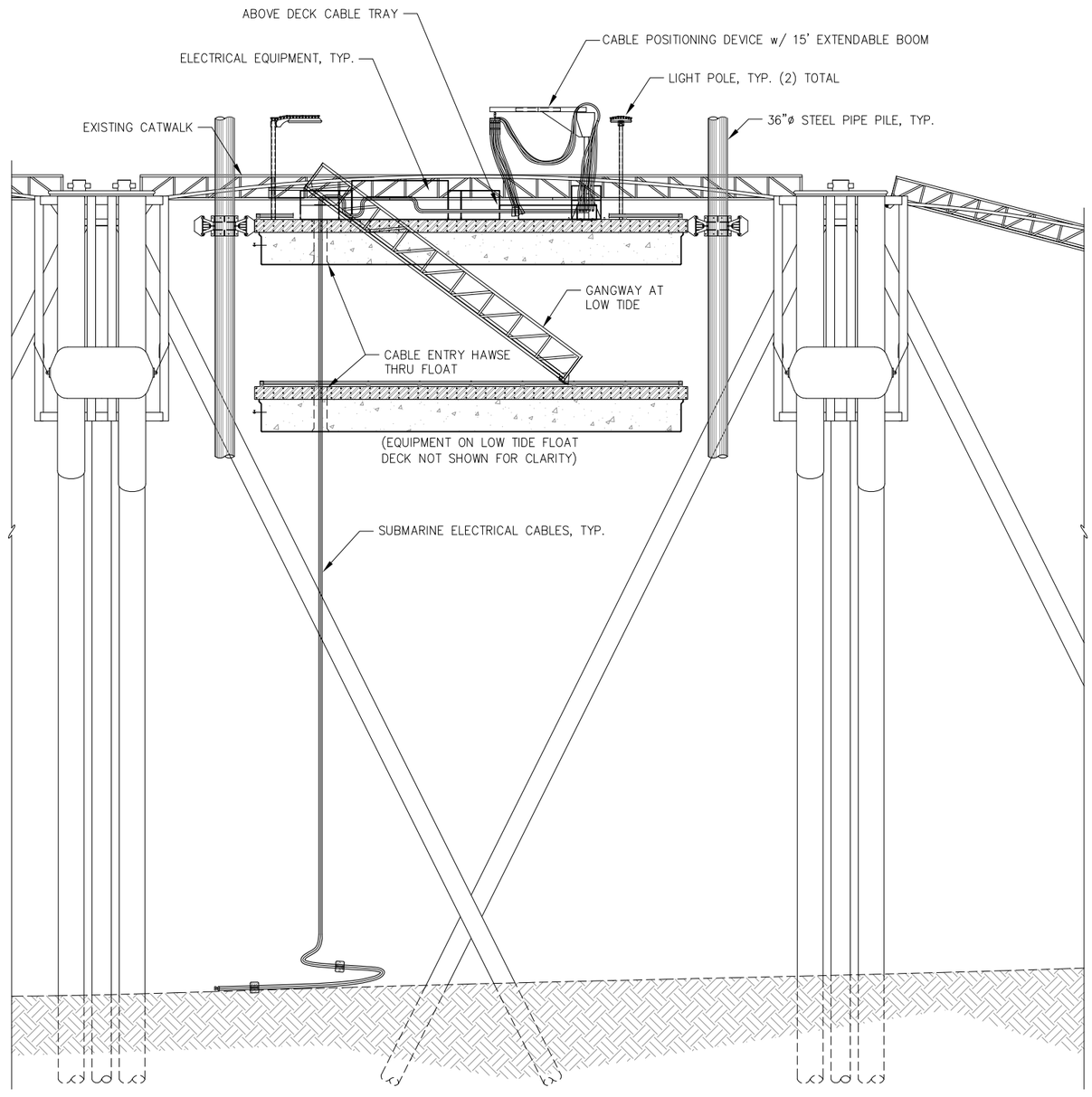

ELEVATION

CONCEPT

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PORT OF JUNEAU CRUISE SHIP BERTHS
SHORE TIE POWER STUDY
CONTRACT NO. XX-XXXX

SHEET TITLE: **SITE ELEVATIONS**

PND PROJECT NO.: 152054

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