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of Engineers

One Corps Serving the Army and the Nation

Greenup L&D

Rodney Cremeans, PE, PS
Project Manager/Structural Engineer



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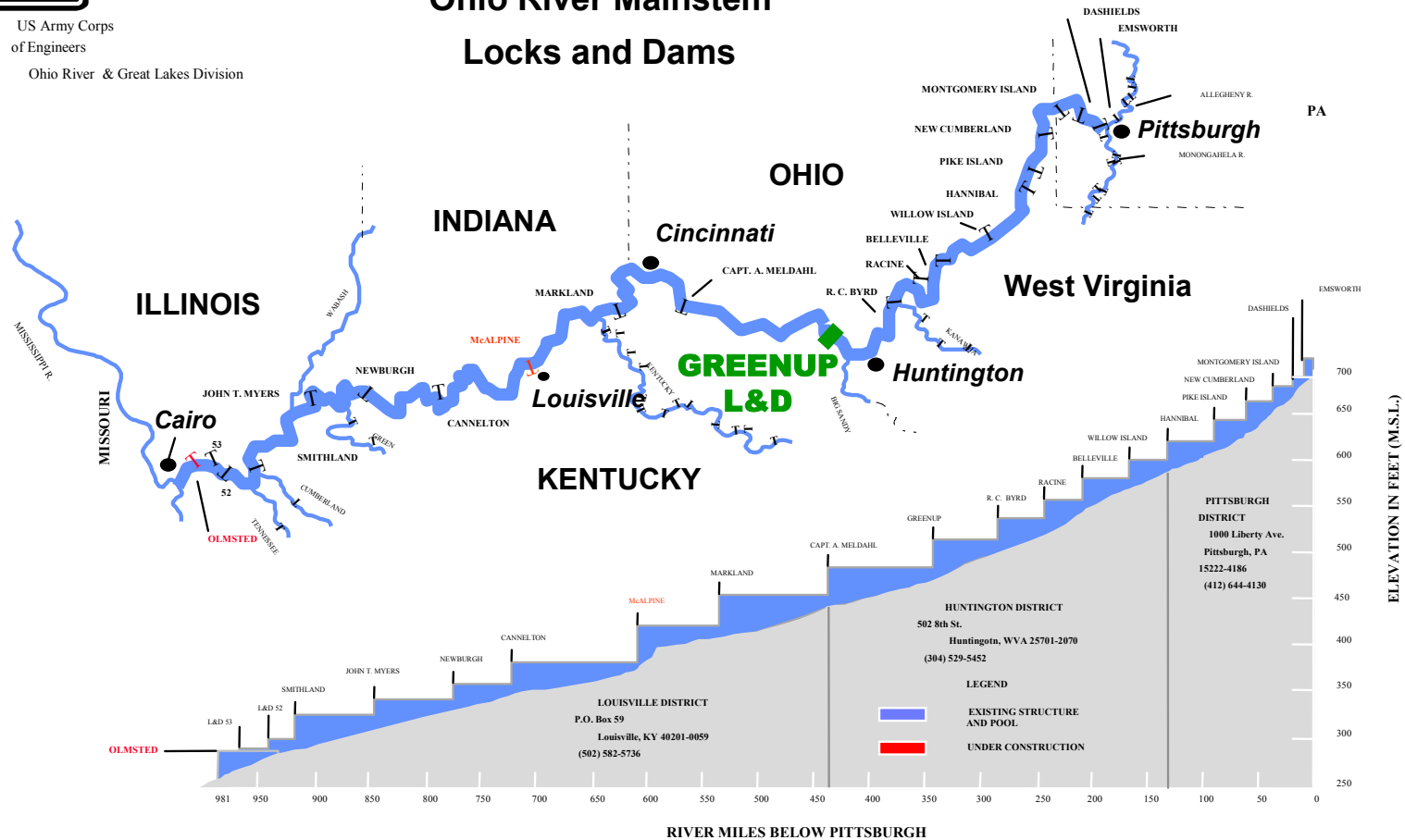
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US Army Corps
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Ohio River & Great Lakes Division

Ohio River Mainstem Locks and Dams





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Greenup L&D Statistics

◆ **Traffic**

- **8th Busiest Lock in United States**
- **1995 – 2004 Average Annual Tonnage = 71.1 Million Tons**
- **Projection – By 2050 tonnage = 71.9M to 118M**

◆ **Closures**

- **1991 - \$5.7M Transportation Delay Costs**
- **1998 - \$3.6M Transportation Delay Costs**
- **1999 - \$3.6M Transportation Delay Costs**
- **2003 - \$13.2M Transportation Delay Costs, \$28.6M+ End User Costs, \$1.5M O&M Costs, 546 tows affected**



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Greenup L&D Miter Gates





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Miter Gates

◆ **Present situation**

- **Miter gates for main lock chamber are significantly deteriorated**
- **Unscheduled outage in FY 03 revealed large cracks on the downstream miter gate – main chamber**
 - **Downstream middle wall leaf has extensive cracking around the pintle casting**
 - **Upstream river wall leaf had two cracks in the thrust diaphragm (steel member above pintle casting)**
- **Strain gauges have been installed to assist in monitoring the miter gates**
- **The gates have severely deteriorated and additional dewatering, inspection, and repair is anticipated**



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Greenup L&D Project Description

- ◆ **Project Authorized WRDA 2000**
- ◆ **Project Elements**
 - **Downstream Mooring Cells**
 - **Miter Gate Change-out System**
 - **R.C. Byrd Dry Dock**
 - **Extend Auxiliary Lock Downstream to 1200'**
 - **Environmental Mitigation**
 - **Rehabilitation of Main Lock & Dam Components**
- ◆ **Total Project Cost \$230.2 M**
 - **Excludes Rehab**

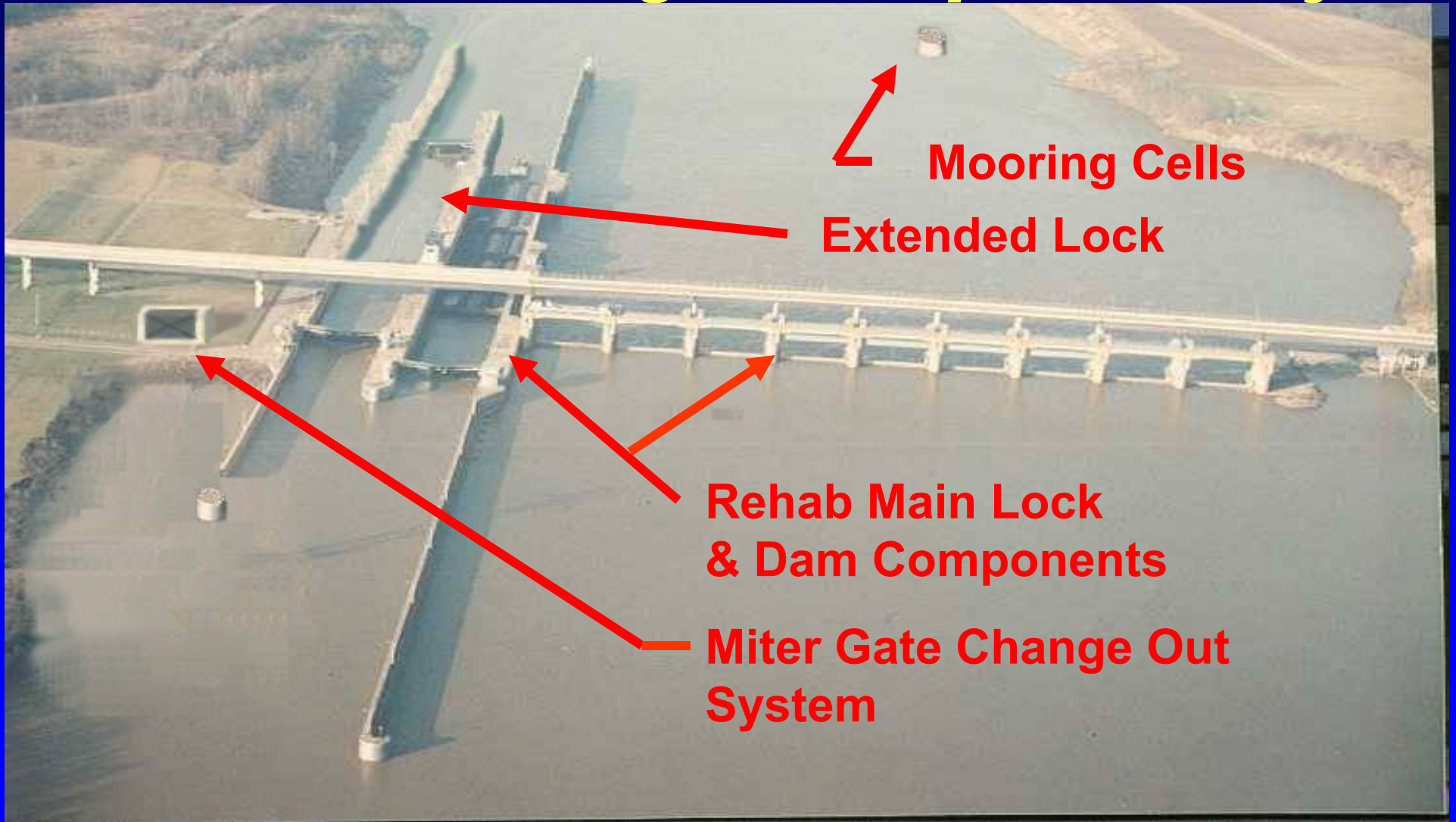


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Rendering of Completed Project



Mooring Cells
Extended Lock

Rehab Main Lock
& Dam Components

Miter Gate Change Out
System



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Greenup PED Project Status

- ◆ **Funding through FY05: \$7.8 M**
- ◆ **Pre-Construction Engineering and Design (PED) Activities**
 - **Mooring Cells P&S (100%)**
 - **Lock Extension DDR (10%)**
 - **Hydraulic Modeling (90%)**
 - **Drilling (100%)**
 - **Miter Gate Design (90%)**
 - **Conducted Preliminary Mitigation Modeling in FY 03**



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Mitigation Model Study



Filling & Emptying System Modeling



Navigation Approach Modeling

Tin Can
Mooring Cell

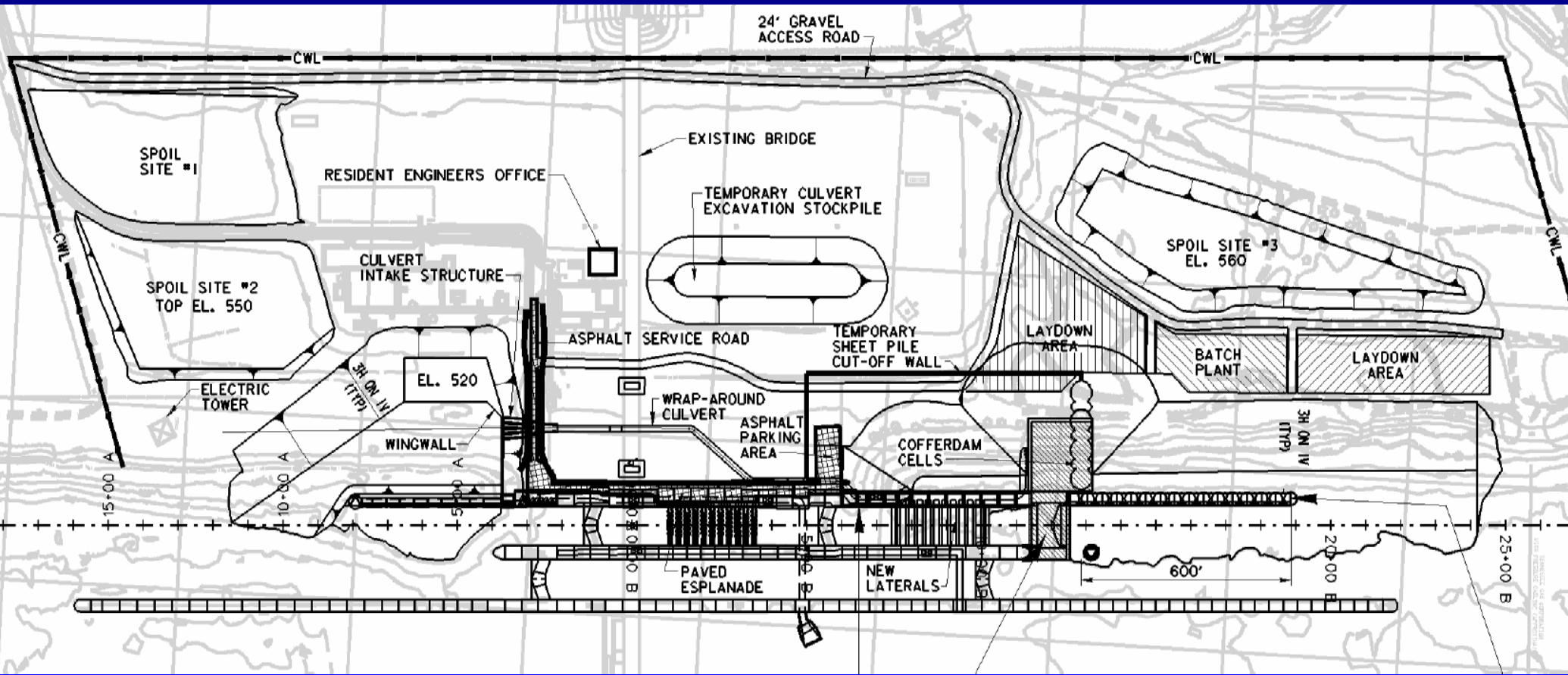




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Greenup L&D Mooring Cells





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**Concurrent
Navigation** →



1400 cy tremie, then pumped

Maximum 100 cy/hour

Approx. 20 hours to place concrete

24 hour navigation closure permitted to place concrete, but not used

Helper boat for 7 days for concrete strength gain period

Lock and Dam No. 24



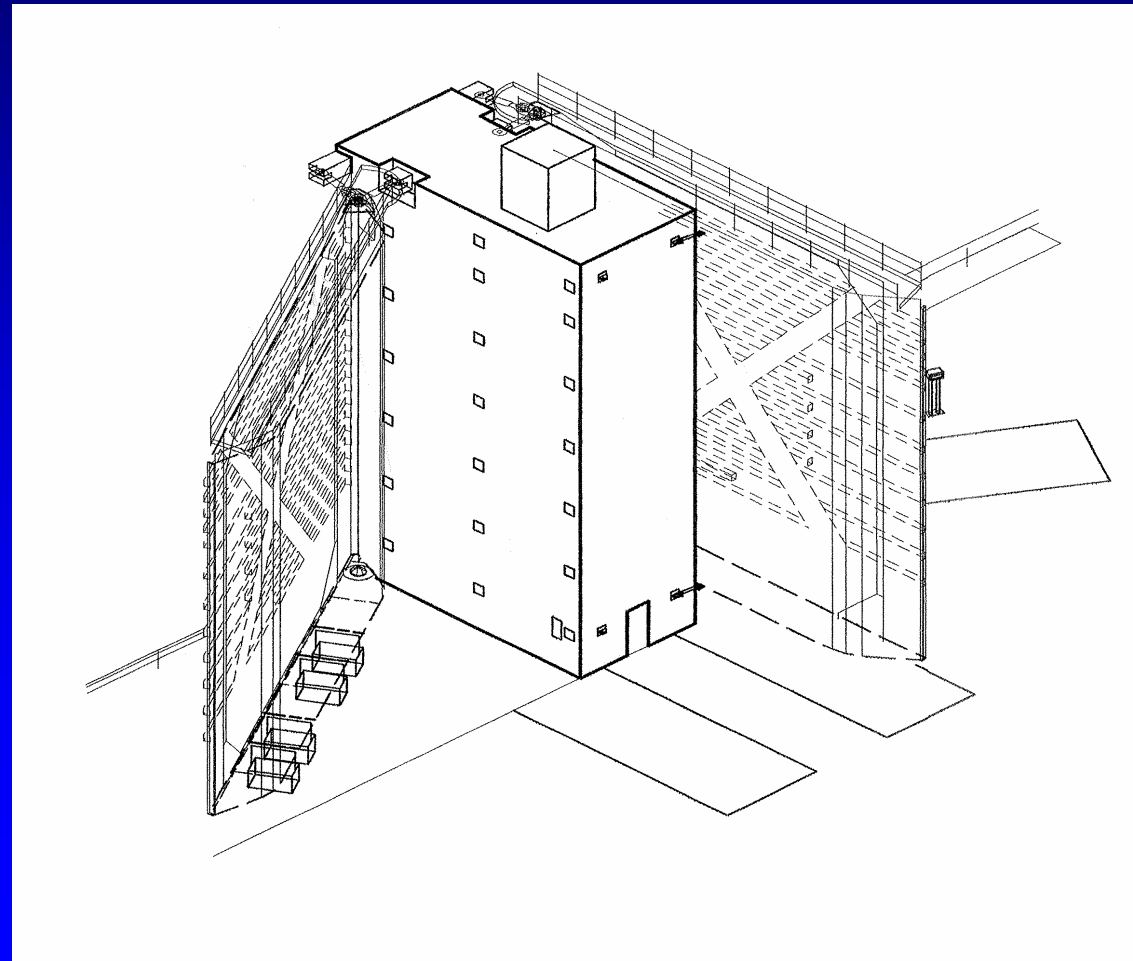
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Miter Gate Quick Change-out System

- 1. Assembly pier
(18' x 32' x 66')**
- 2. Features: Removable
Pintle Base, Miter Gate
Blocks, Jack Support
Slabs**





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Fixed Downstream Guide Wall

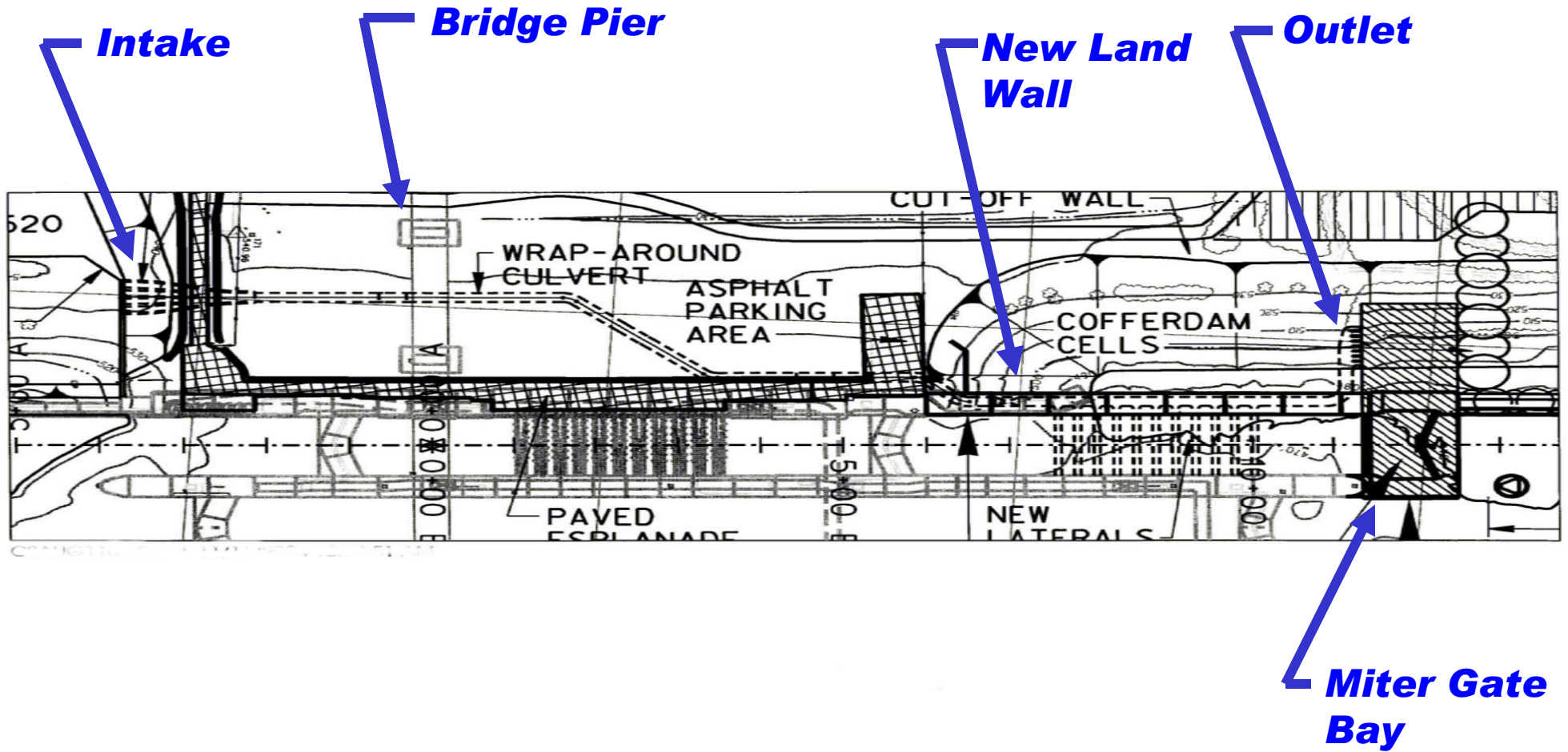




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Greenup L&D Supplemental F&E System





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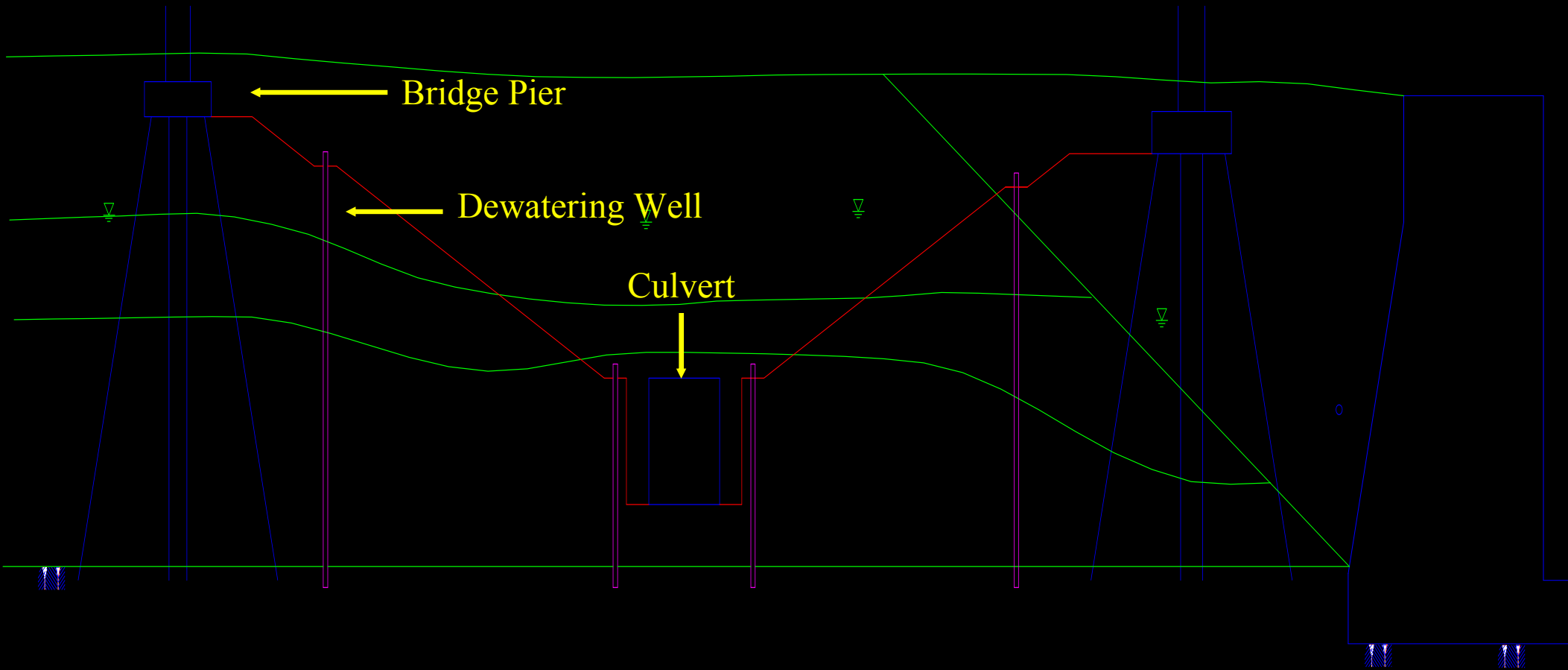
CIL of Culvert



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New Land Wall - Conventional



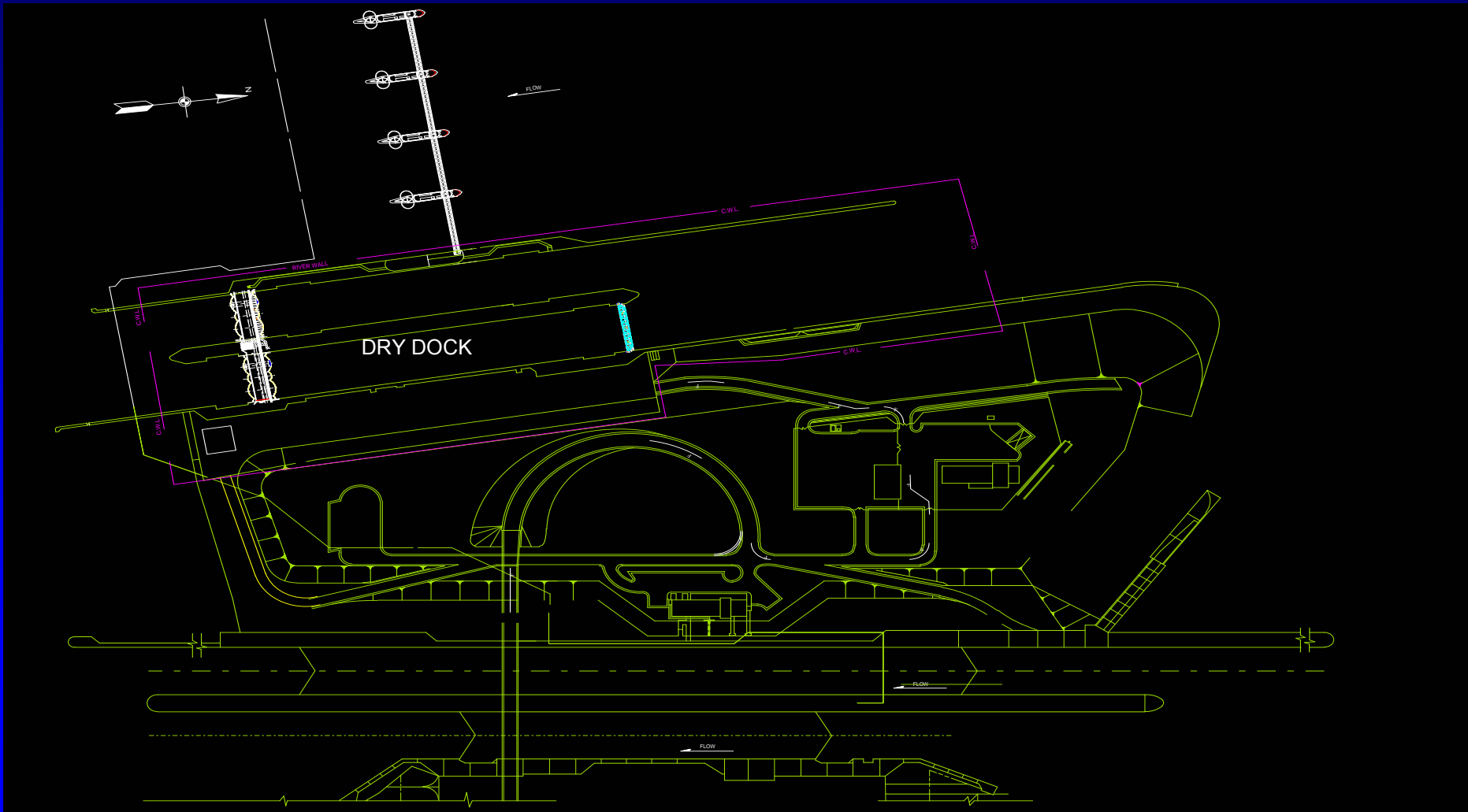


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Dry Dock at R.C. Byrd L&D



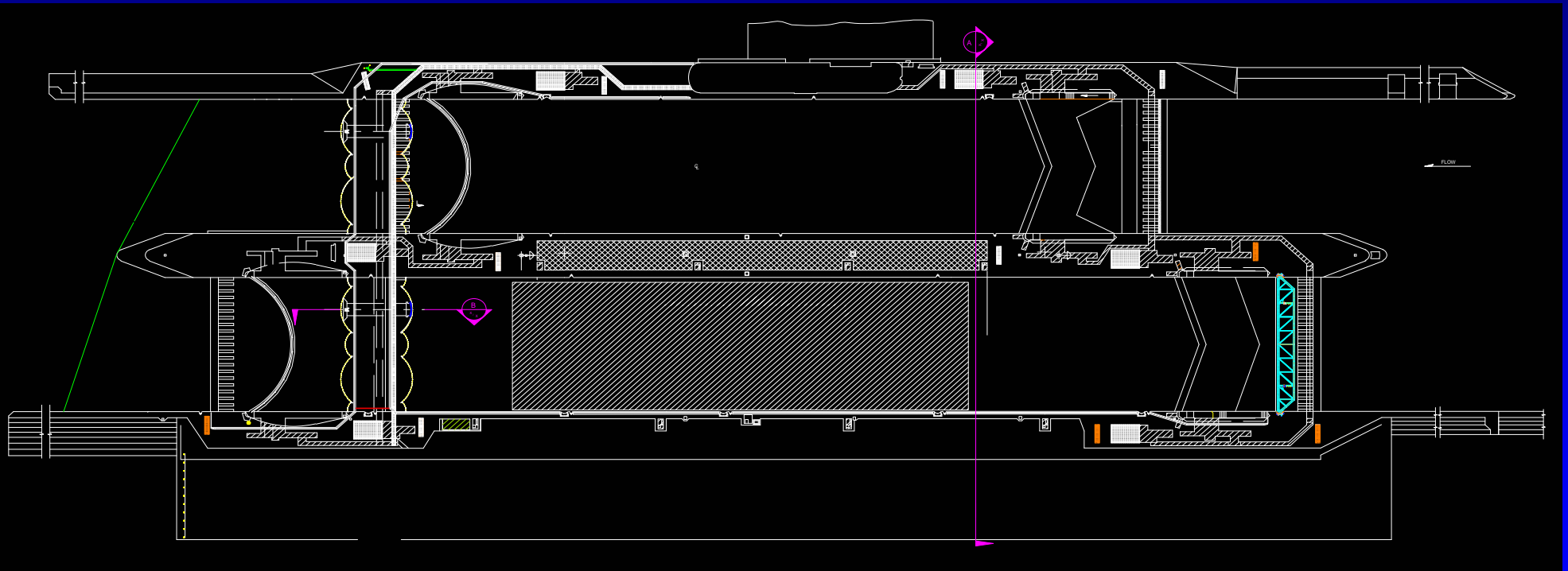


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Dry Dock at R.C. Byrd L&D





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Miter Gate Bay

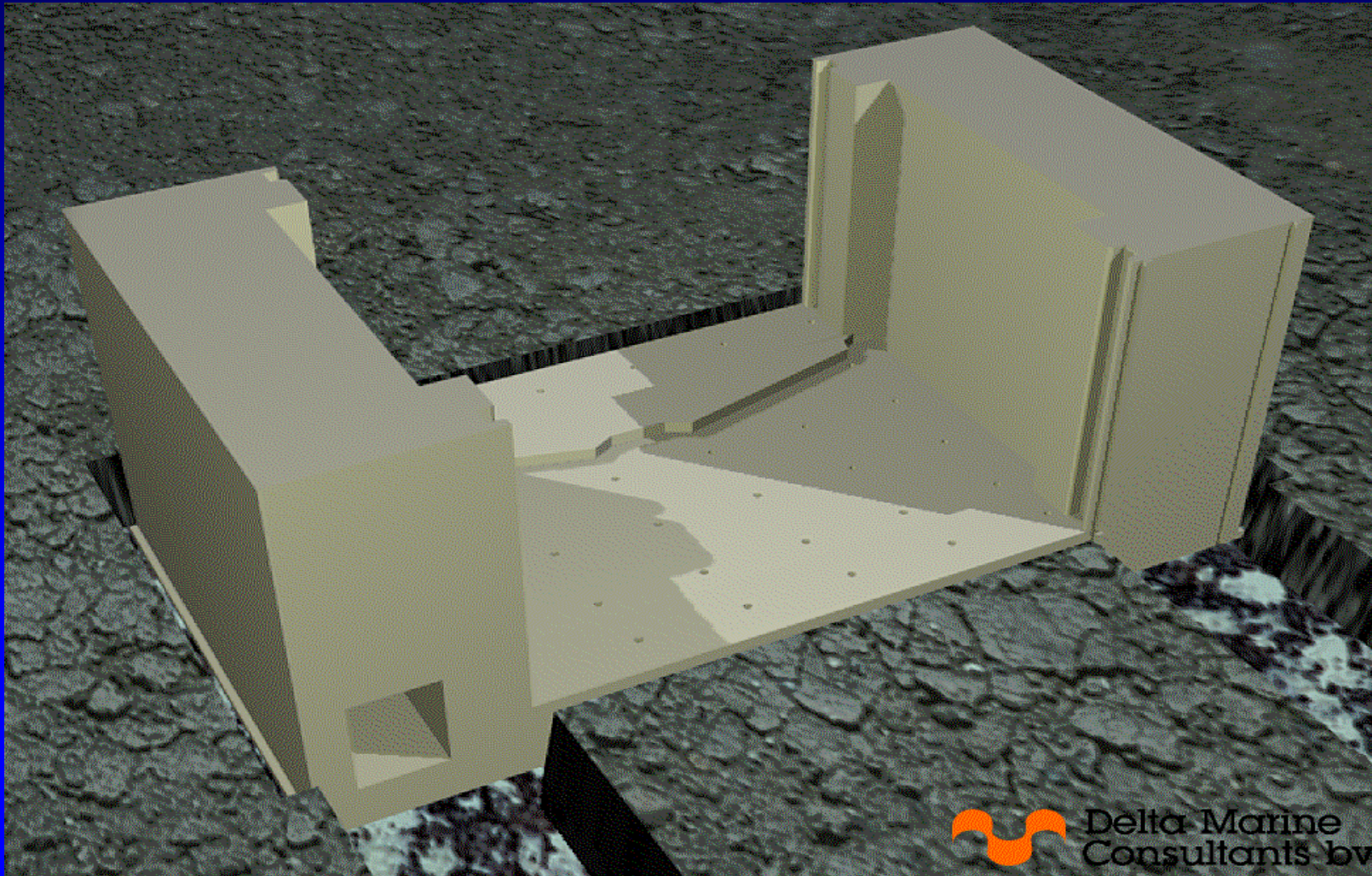
FLOAT-IN MITER GATE BAY
“INNOVATIVE TECHNIQUE”



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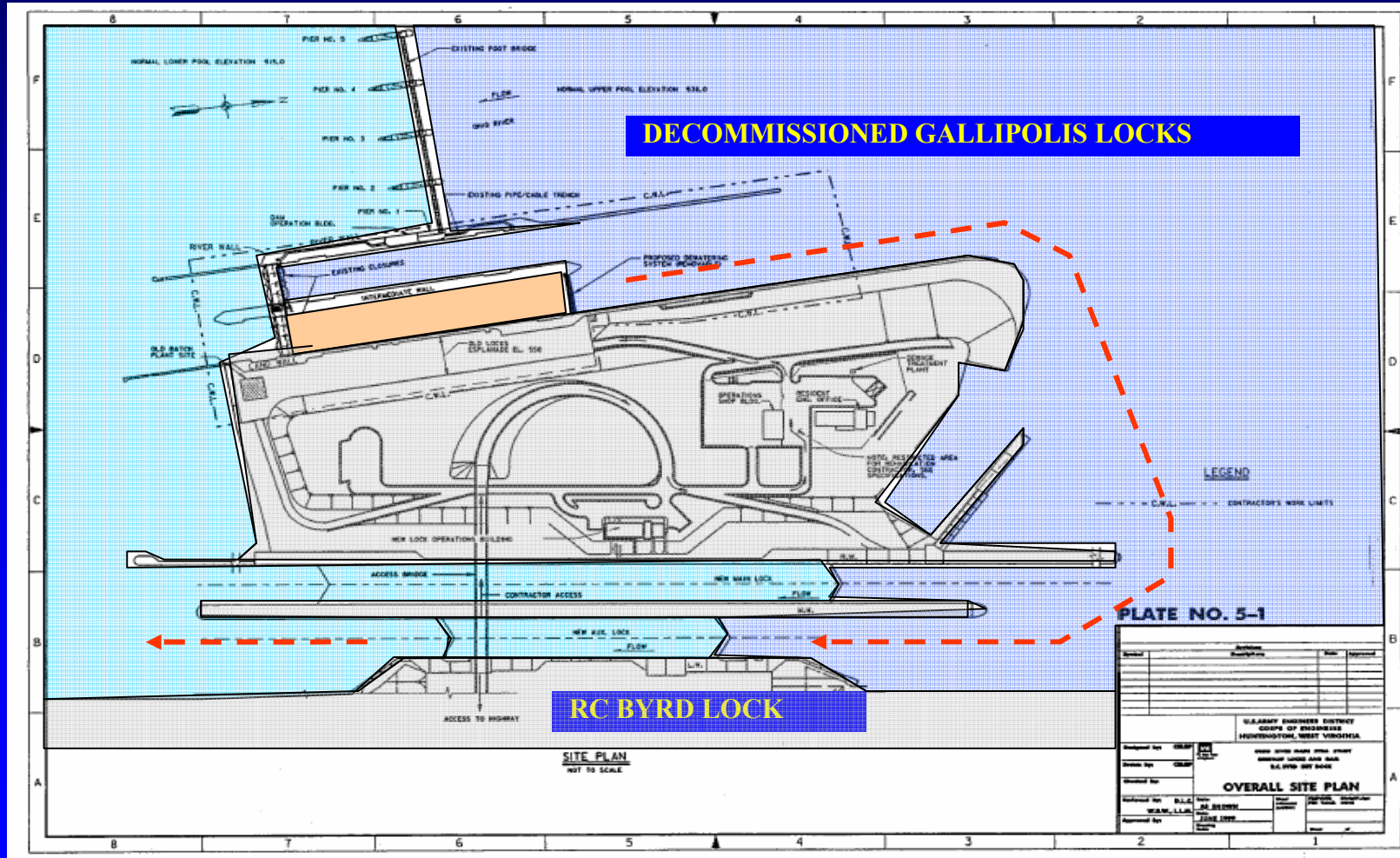
Delta Marine
Consultants bv



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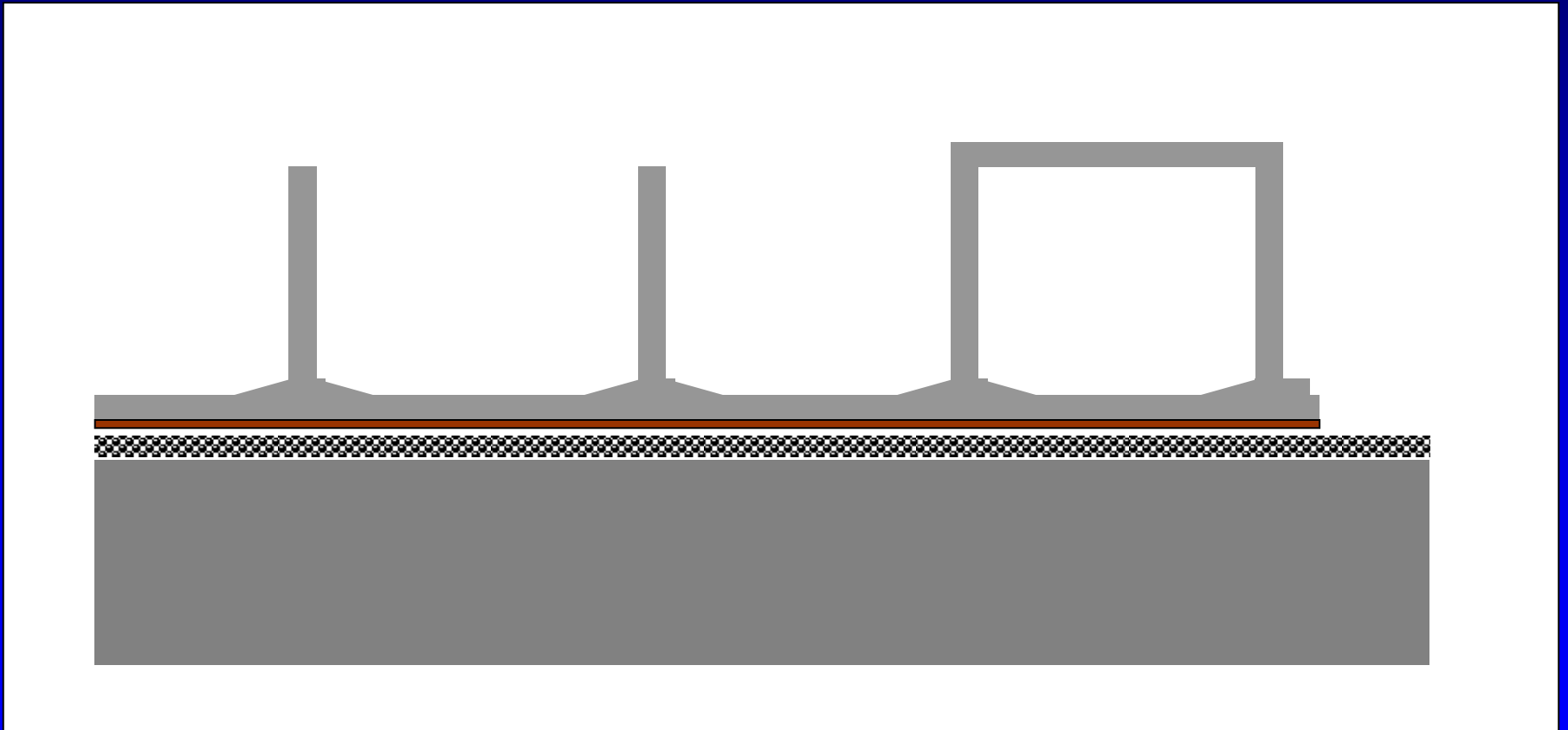




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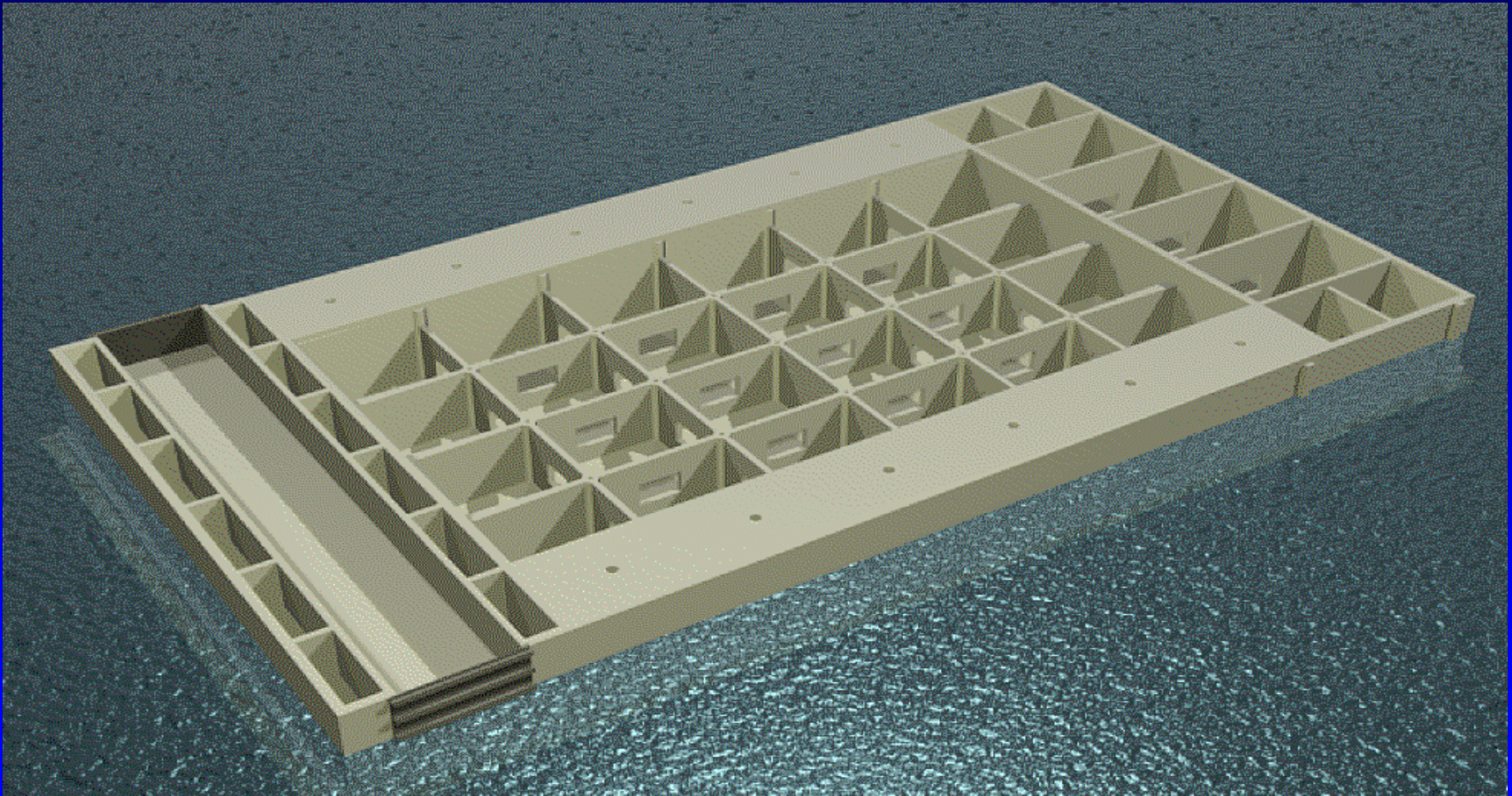
Casting of Miter Gate Bay



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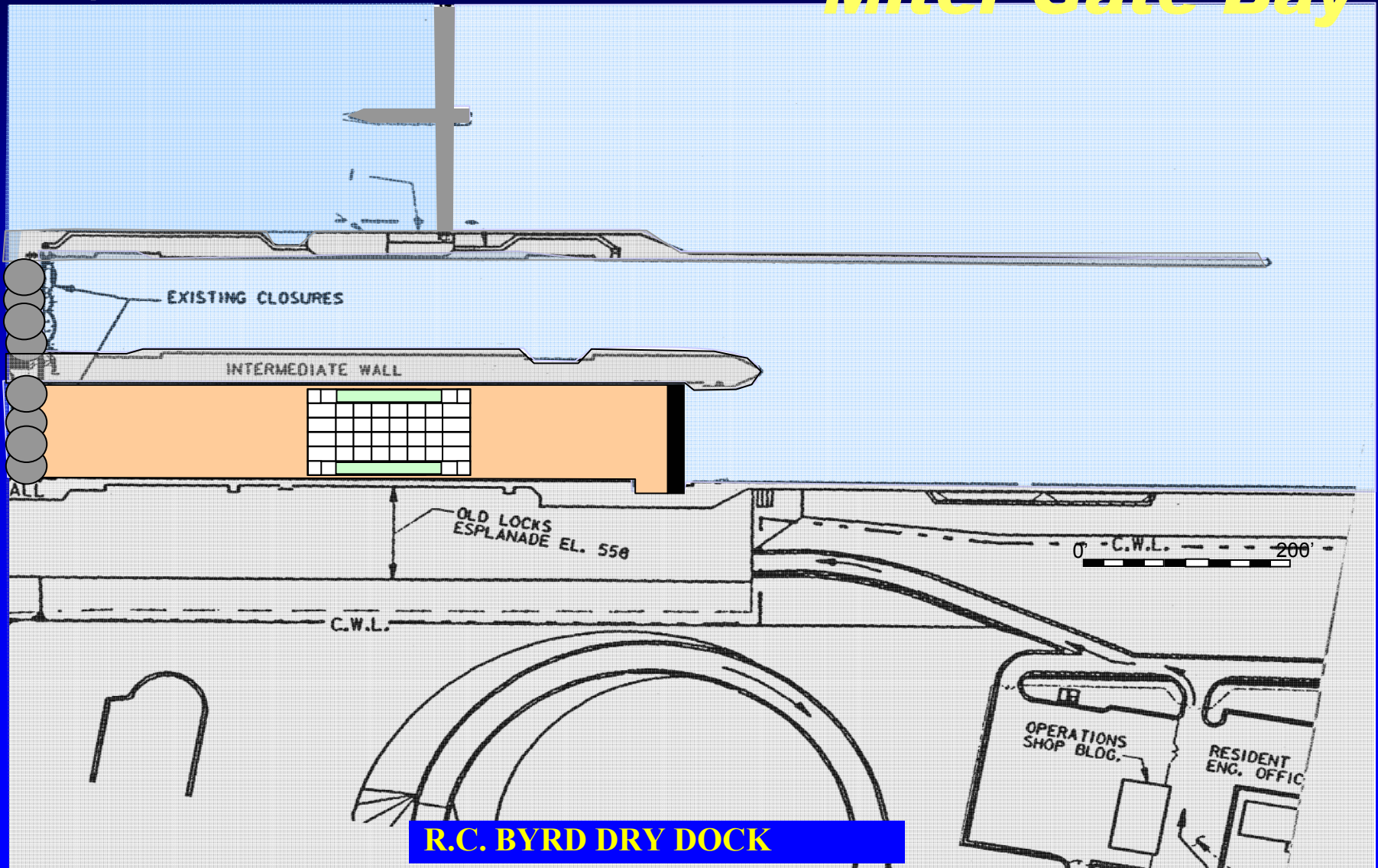




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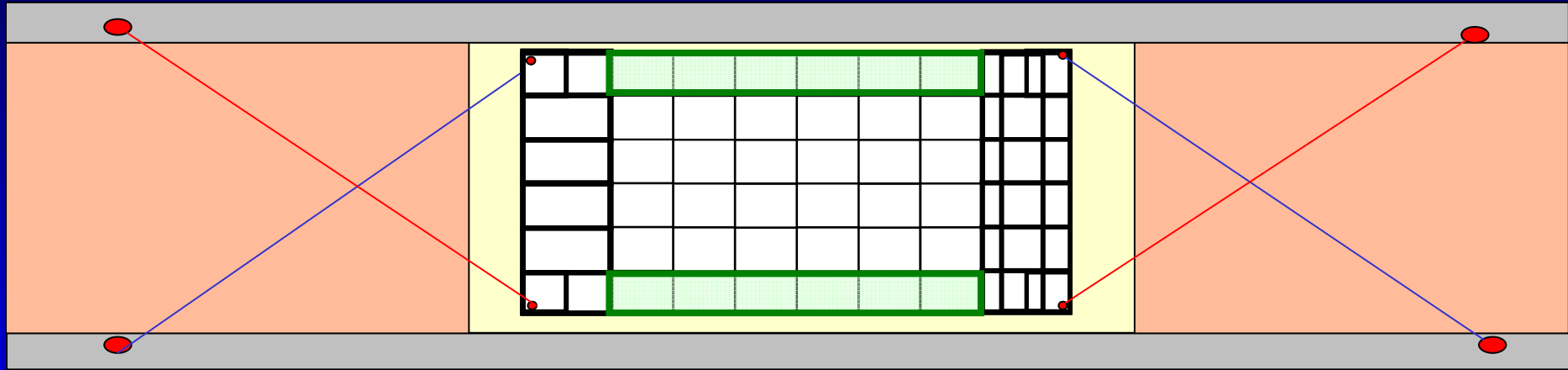


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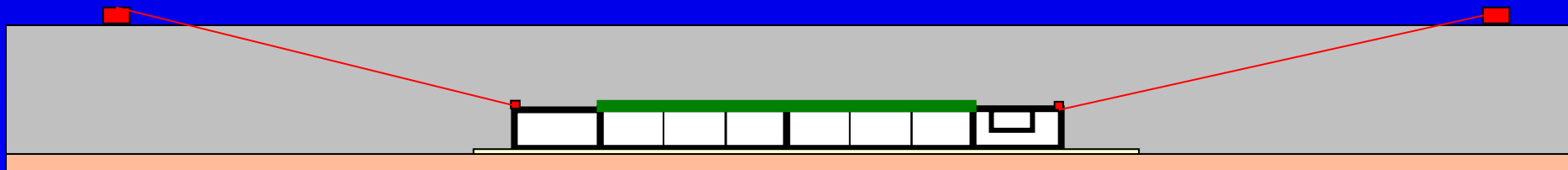


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PLAN



EL. 556

EL. 515

LONGITUDINAL CROSS SECTION
AT R.C. BYRD DRY DOCK

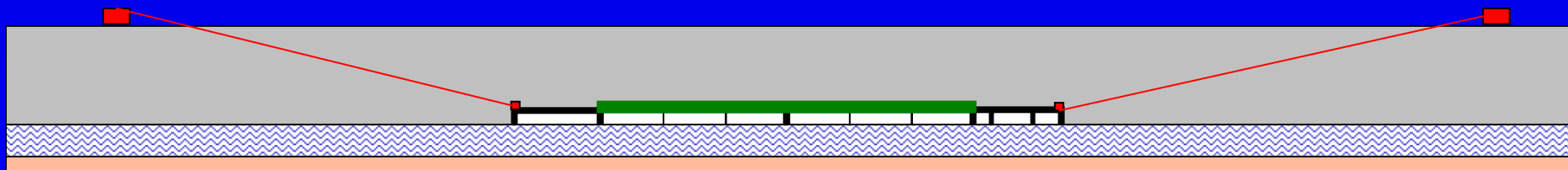
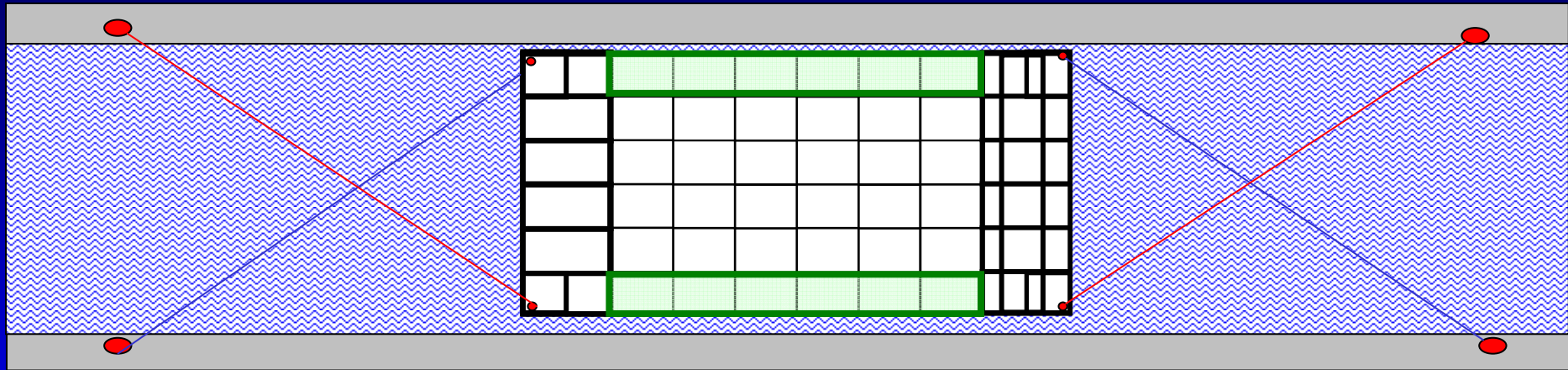


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EL. 556

EL. 515

AT R.C. BYRD DRY DOCK

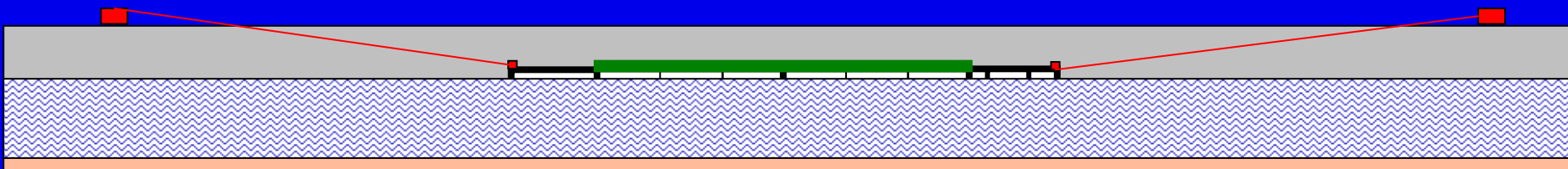
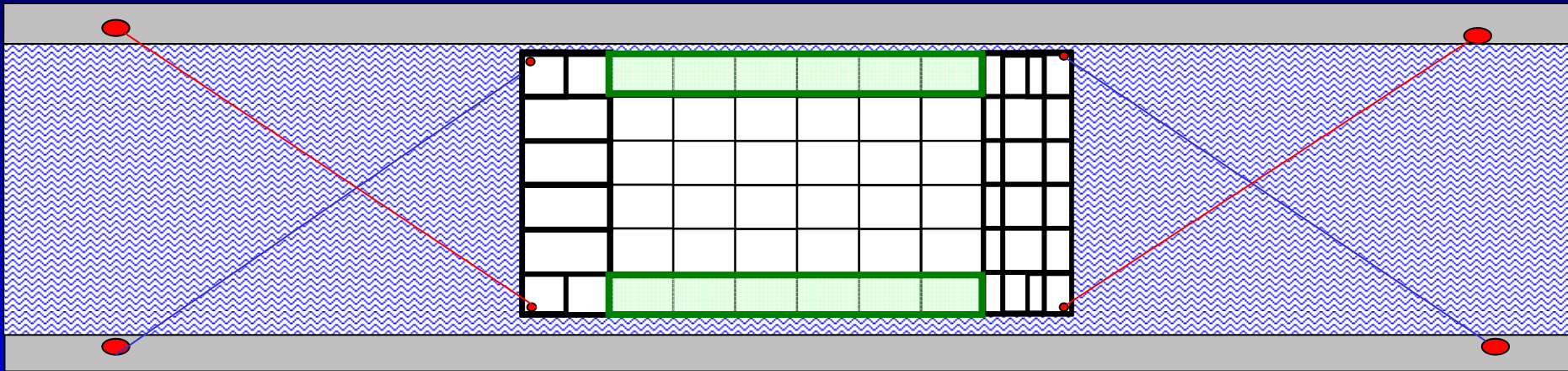


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EL. 556

EL. 538

EL. 515

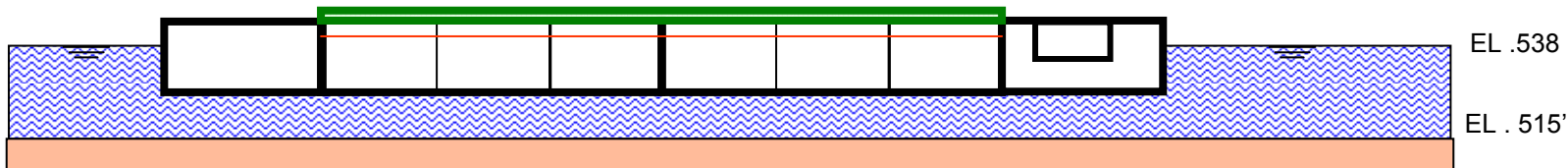
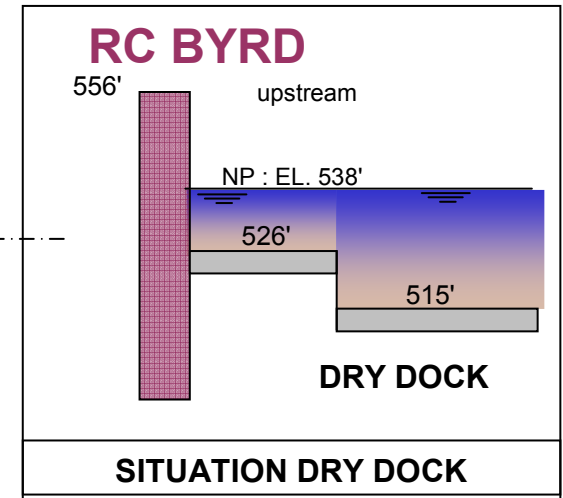
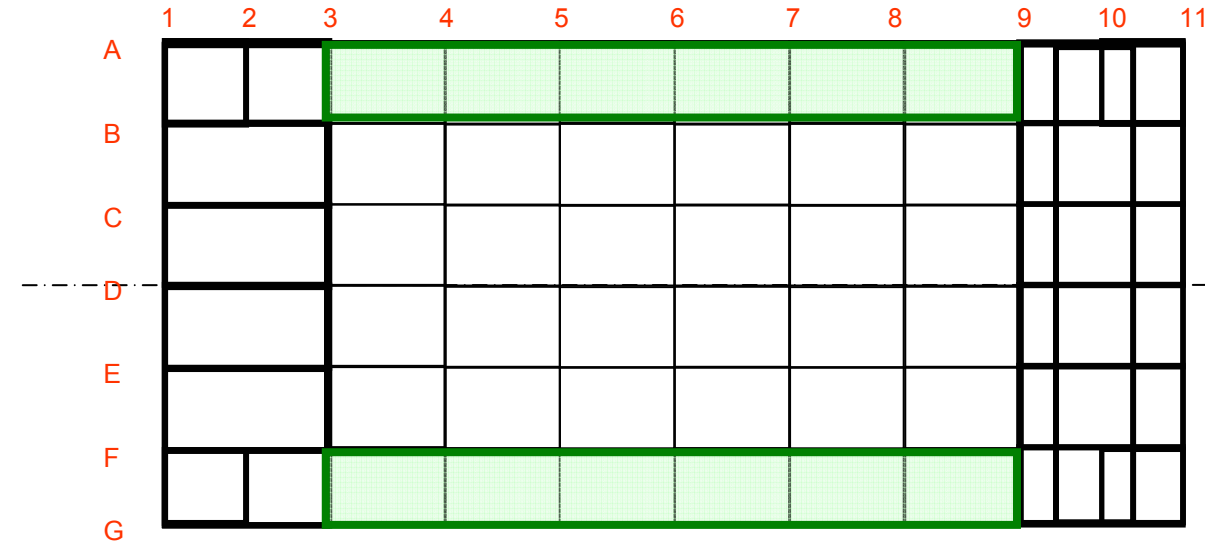
AT R.C. BYRD DRY DOCK



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Remarks :

1. Case 1: Spec. weight concrete 157.9 pcf
Spec. weight water 62.4 pcf
2. Case 2: Spec. weight concrete 150.7 pcf
Spec. weight water 63.7 pcf

Phase 1.B: Floating

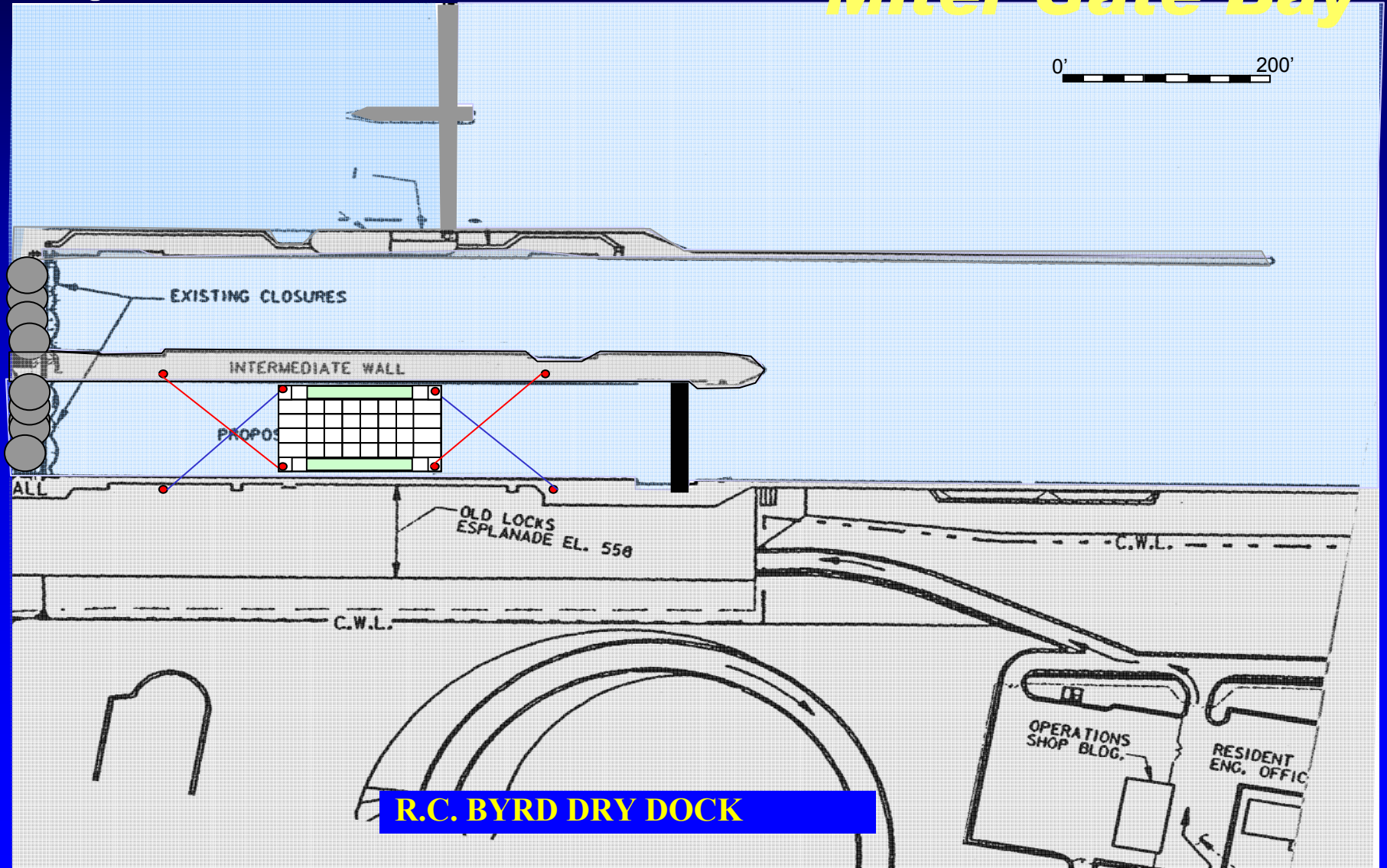
DRAFT	9.8 ft
FREEBOARD	6.2 ft
KEELCLEARANCE	13.2ft



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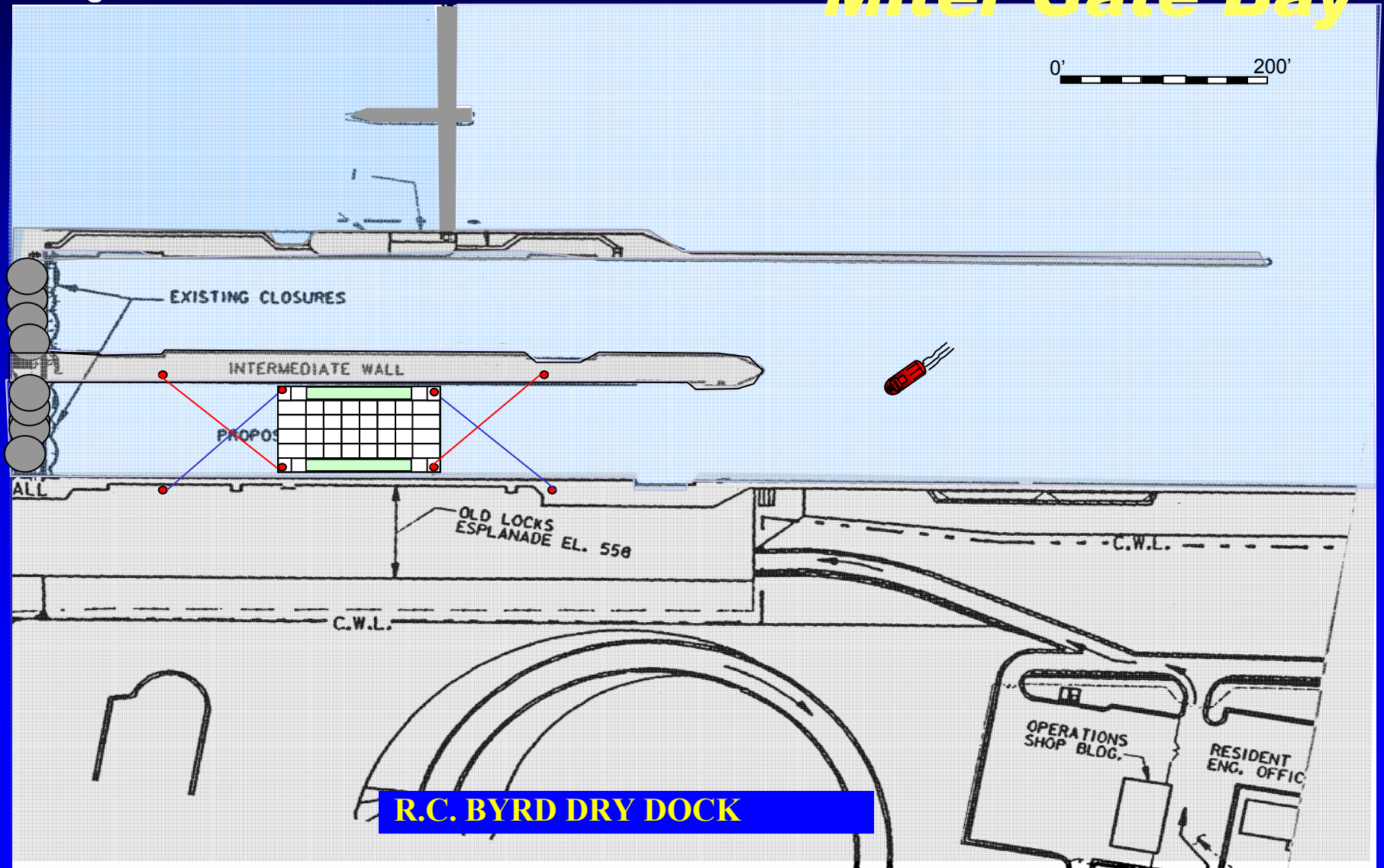




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Environmental Conditions for Marine Operations

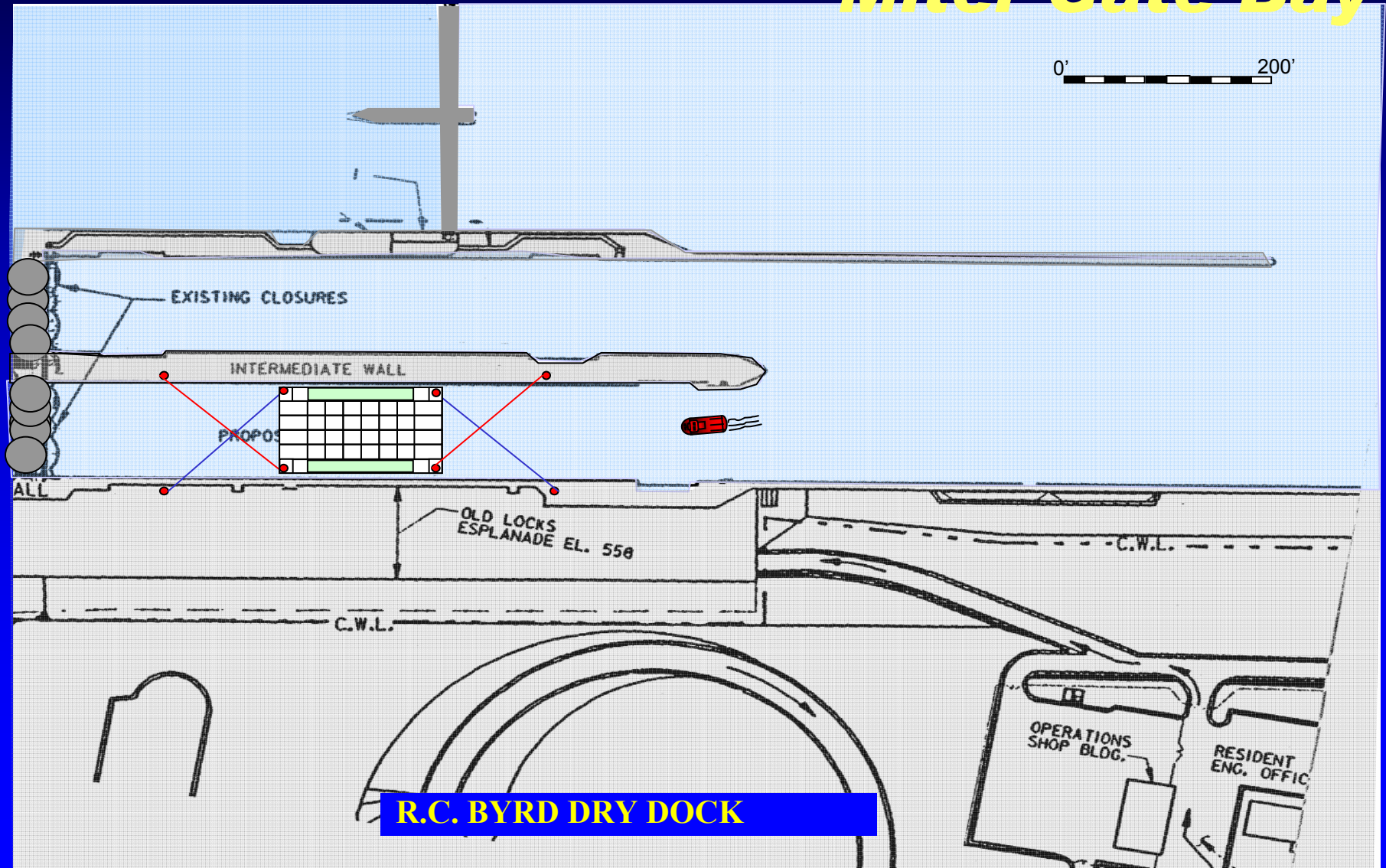
- ***Mean wind speed below 35 mph***
- ***Temperature above 35°F***
- ***No fog***
- ***Water velocity considerations***
- ***Water level considerations***



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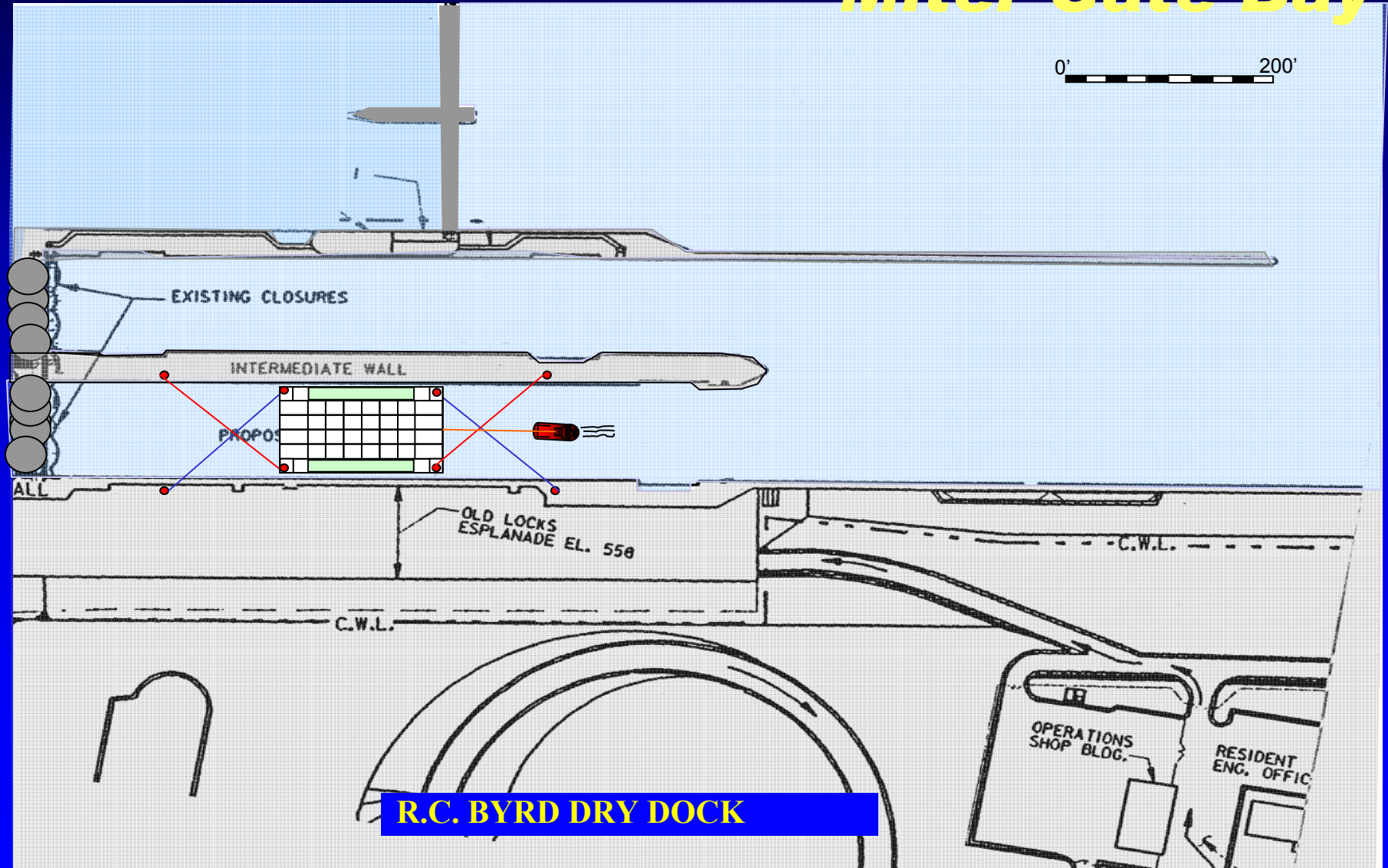




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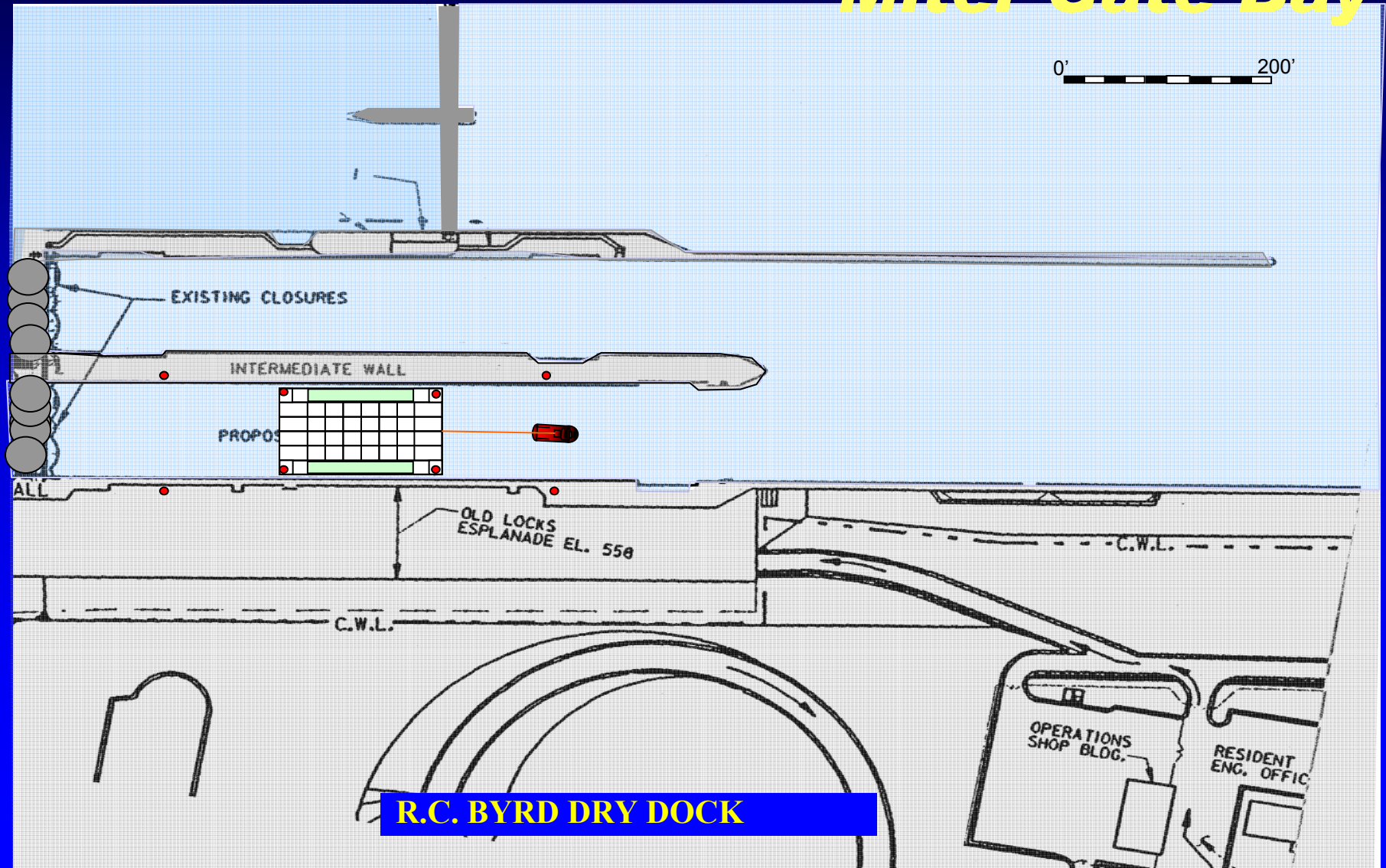




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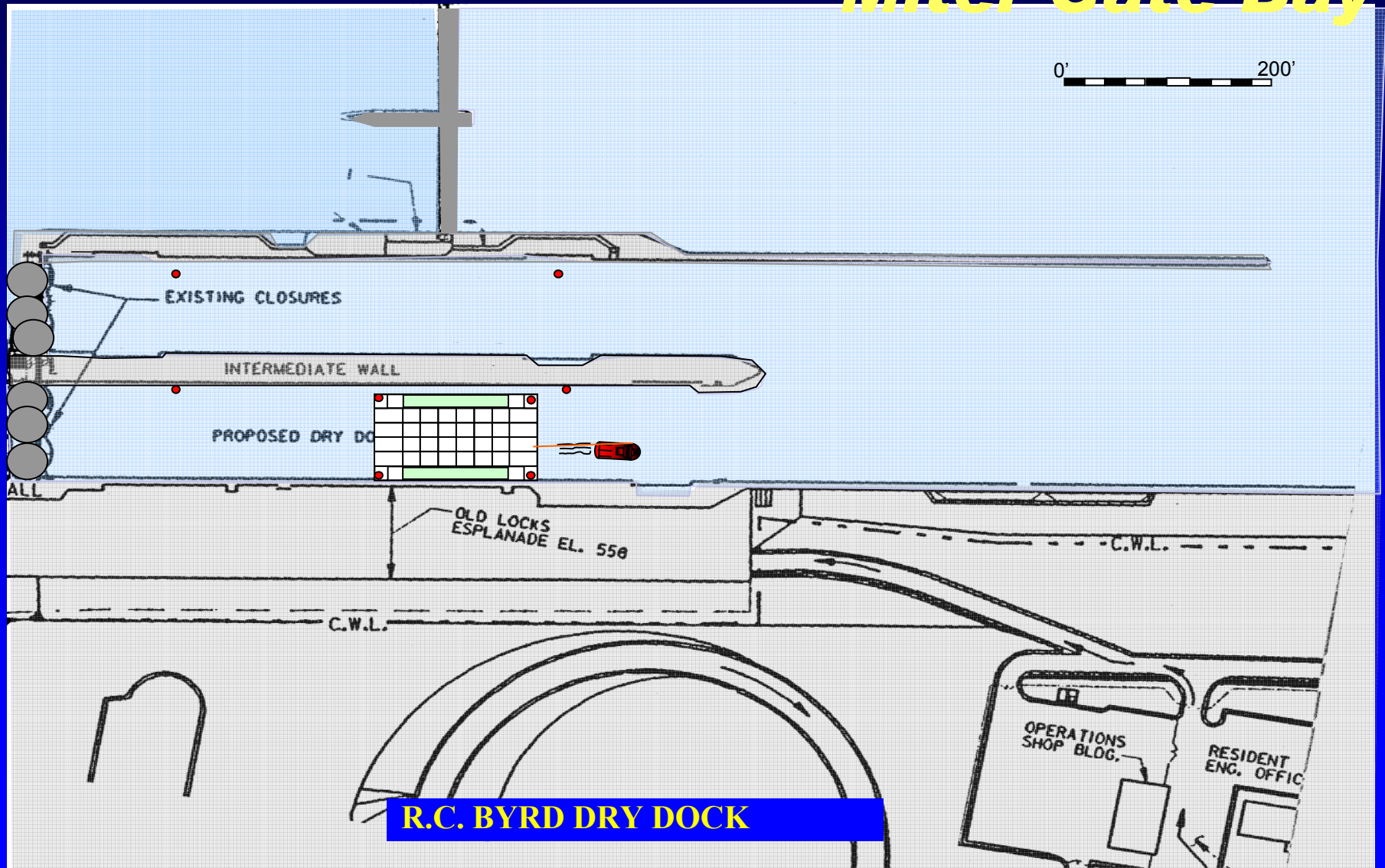




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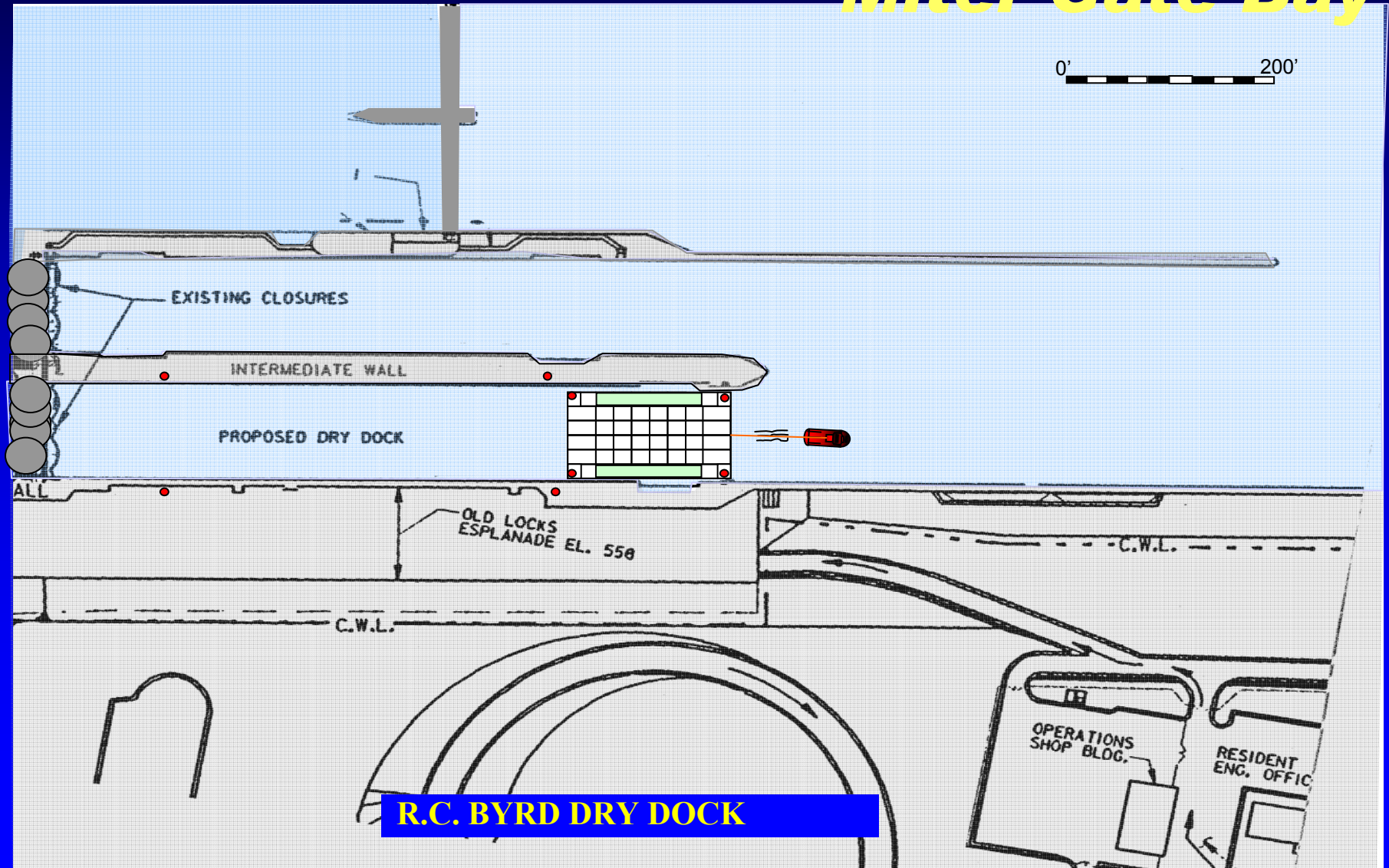




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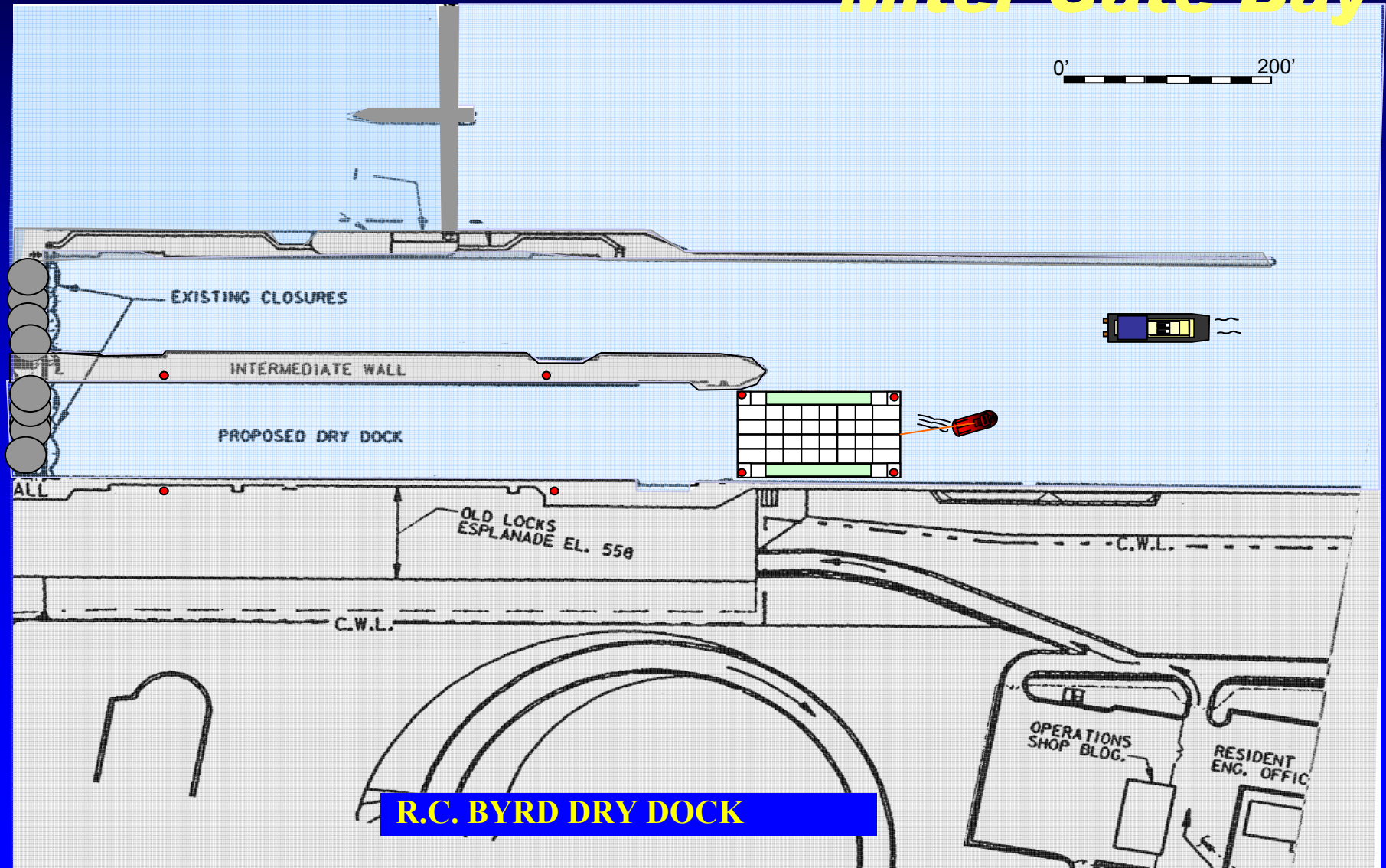




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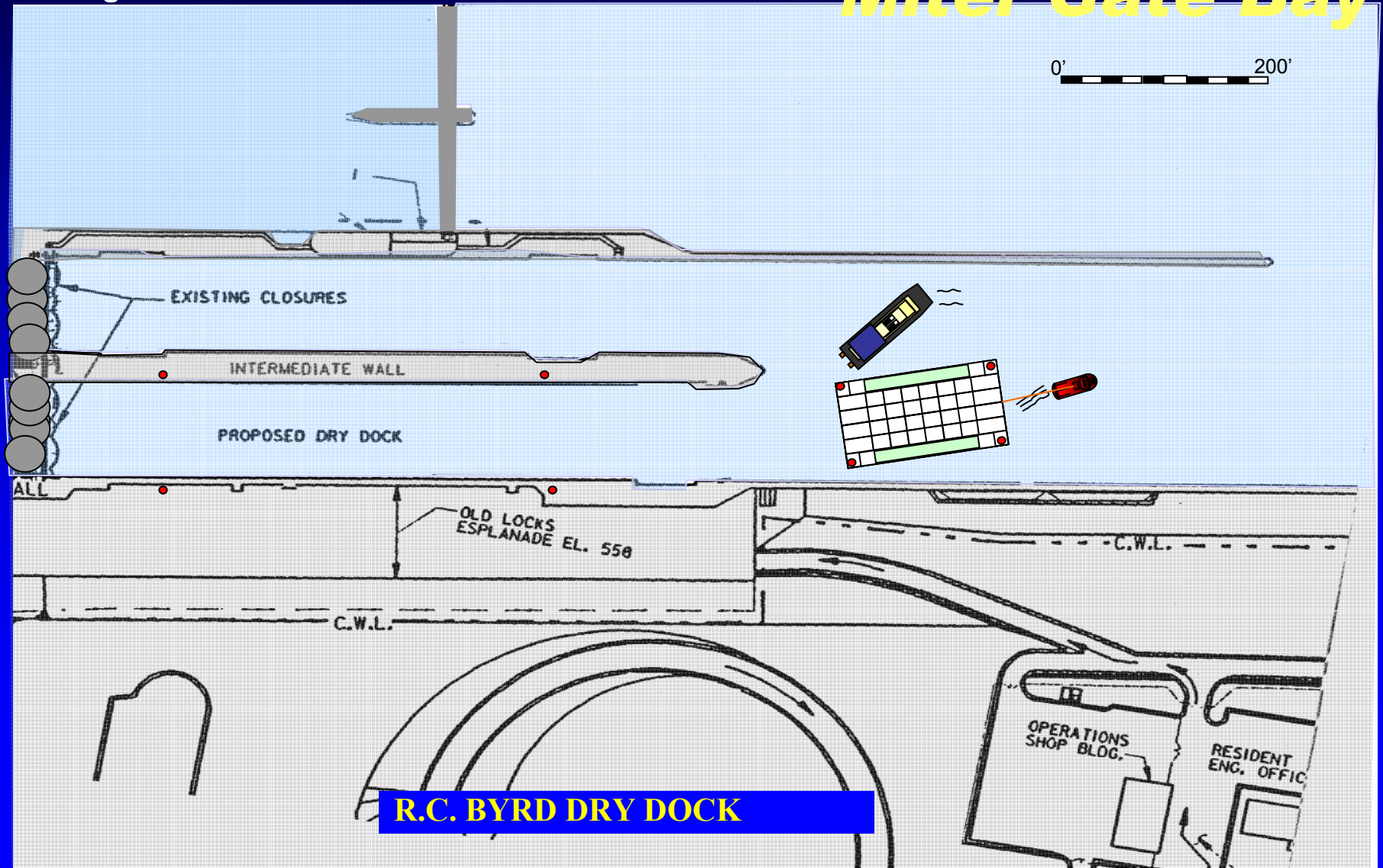




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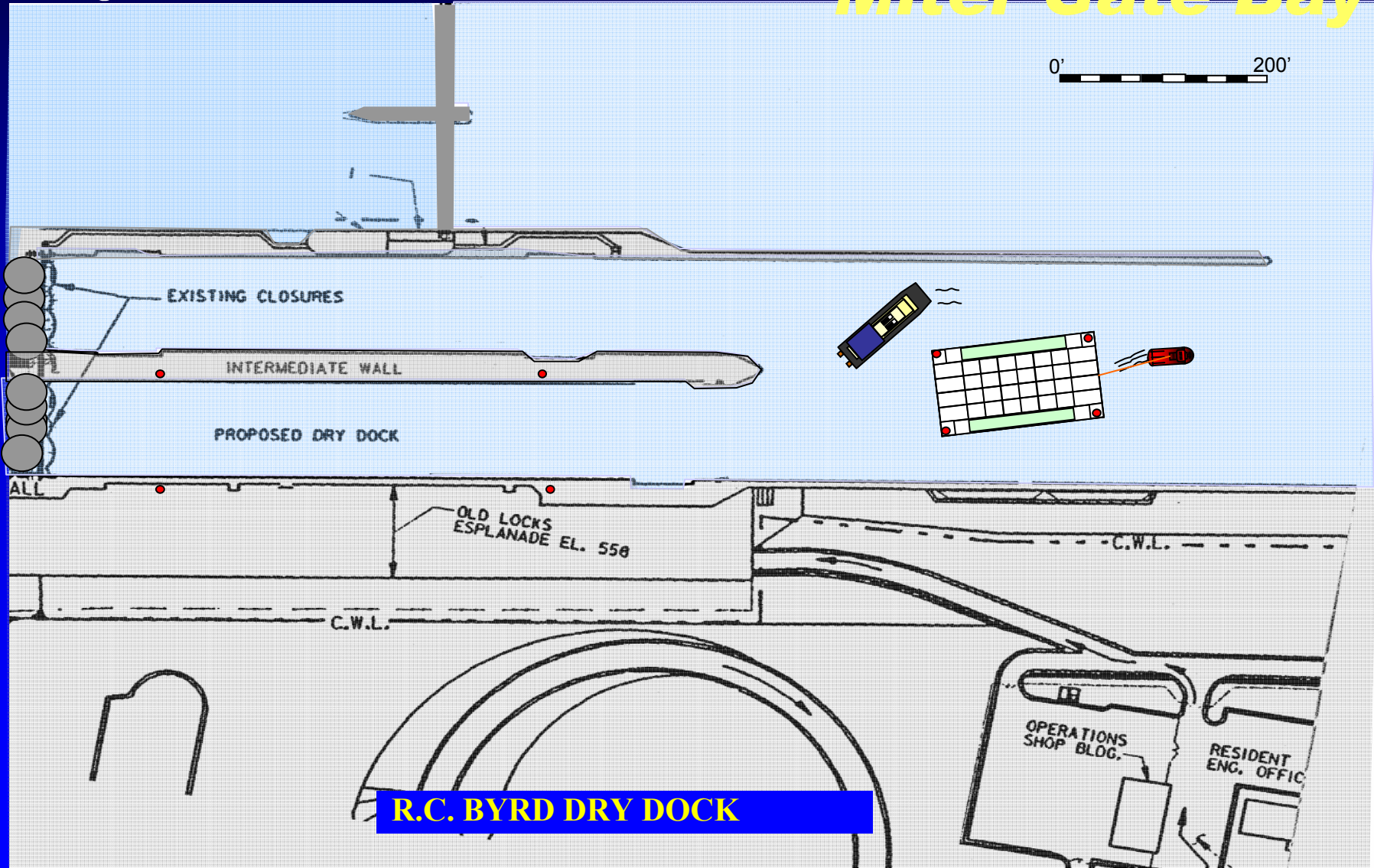


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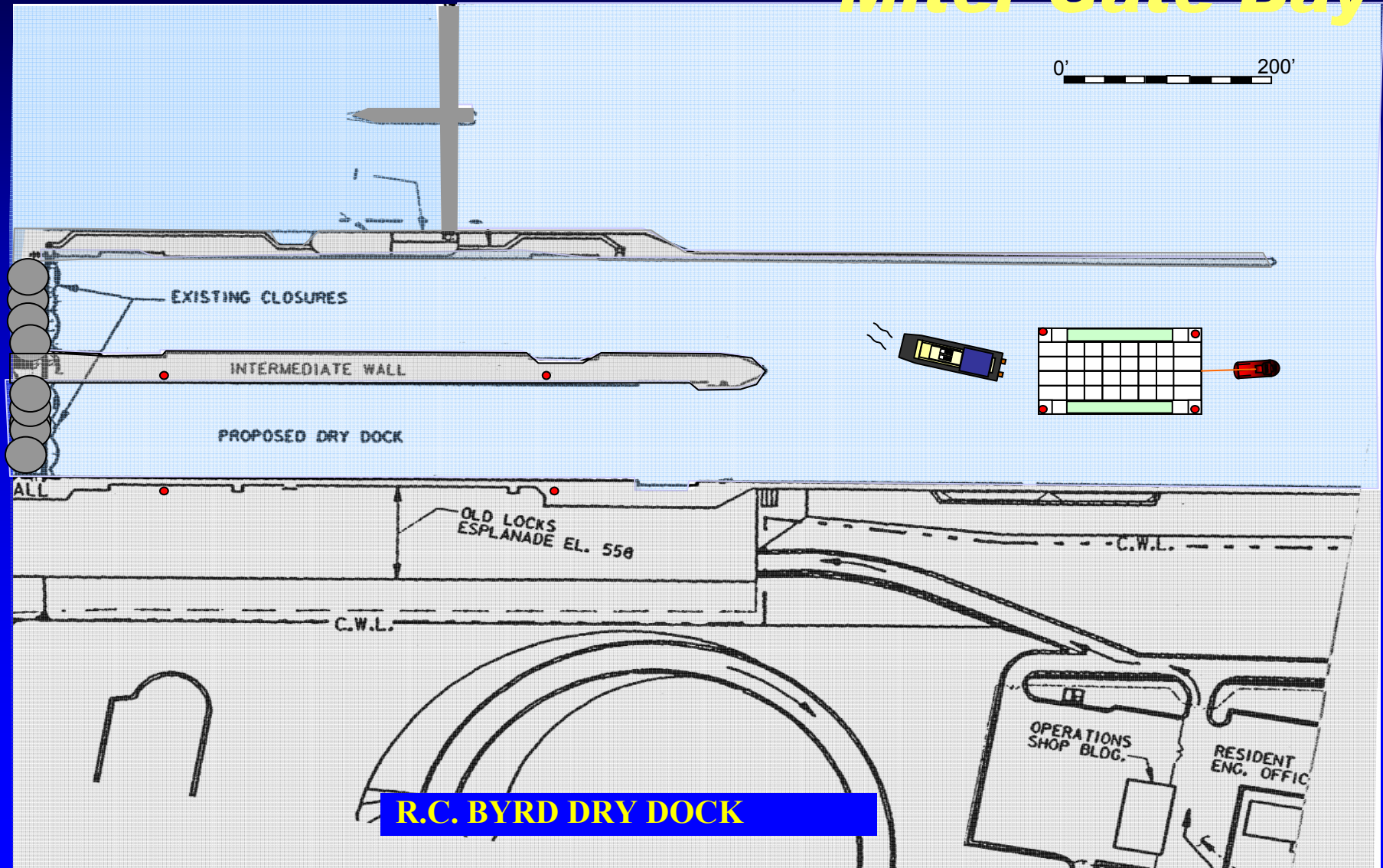




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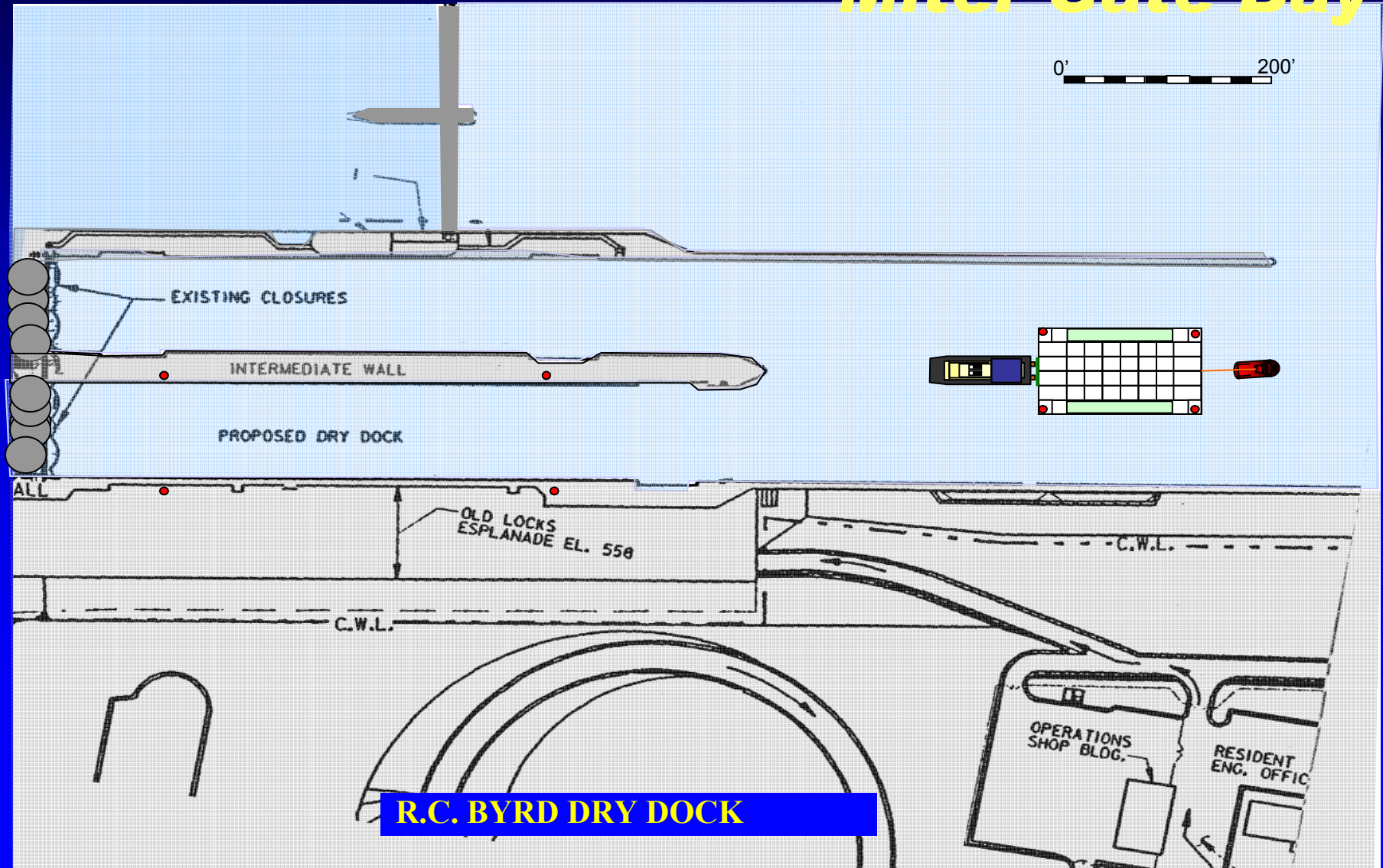


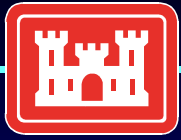


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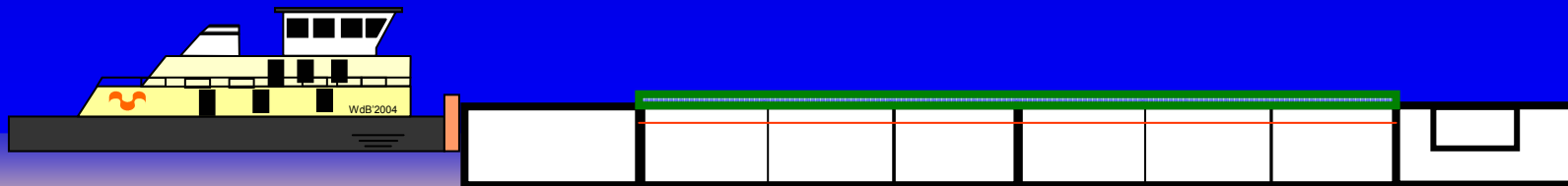
Greenup L&D Miter Gate Bay

Braddock Dam TOWBOAT

- Capacity 2100 – 2600 hp
- Similar to 35 short ton BP tug

VESSEL DIMENSIONS

- Braddock = 104' X 333'
- Greenup = 105' X 188'

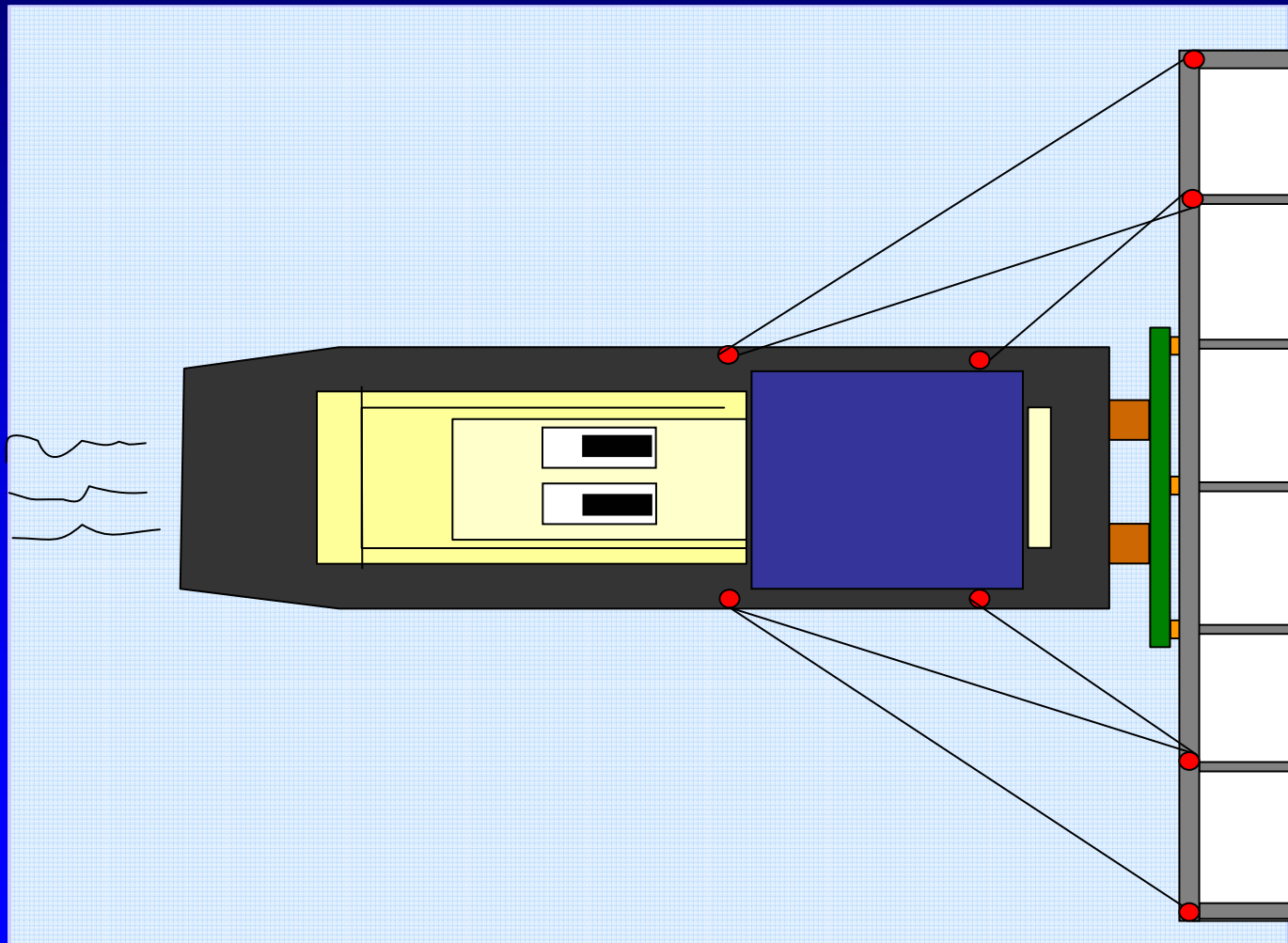




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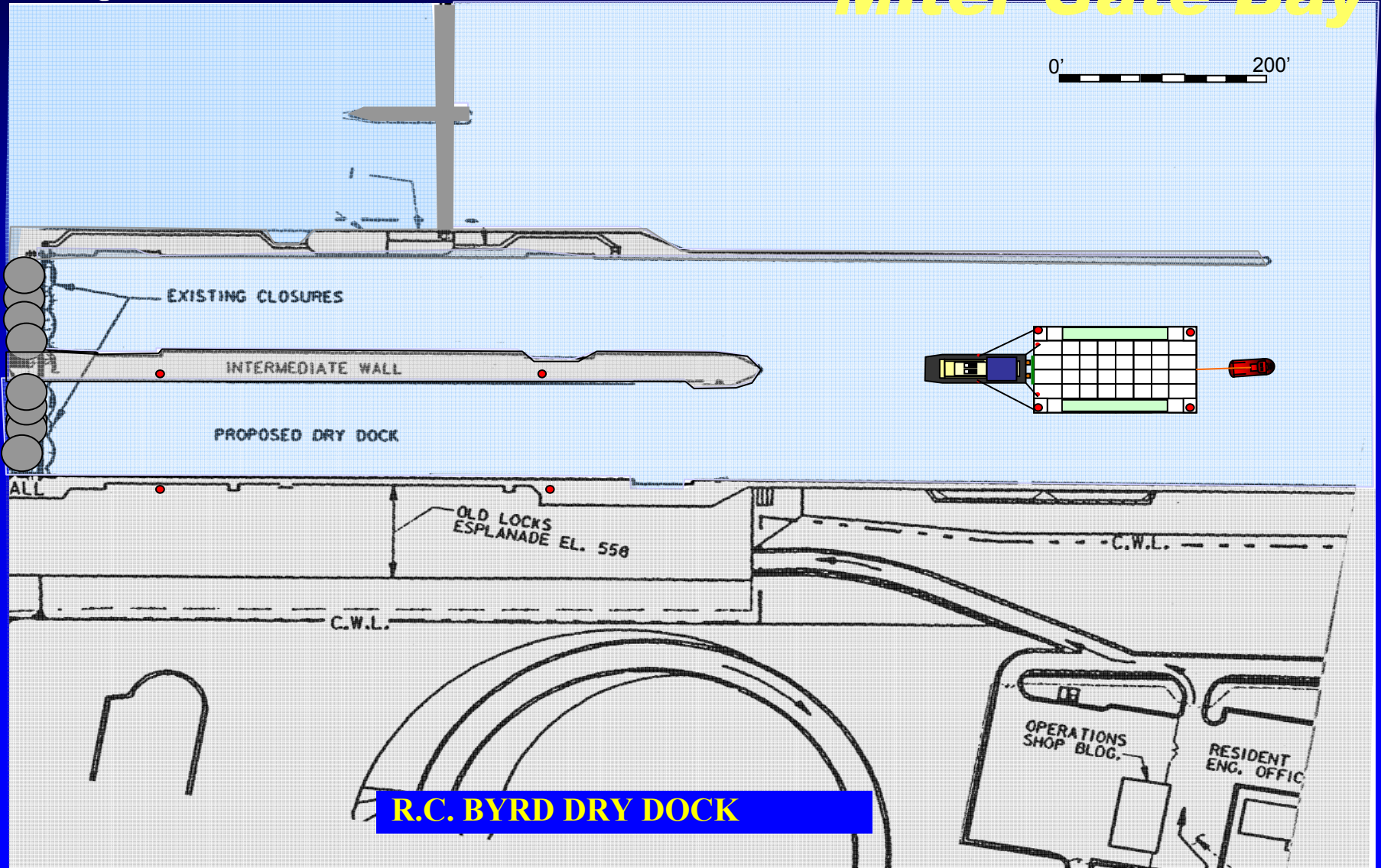




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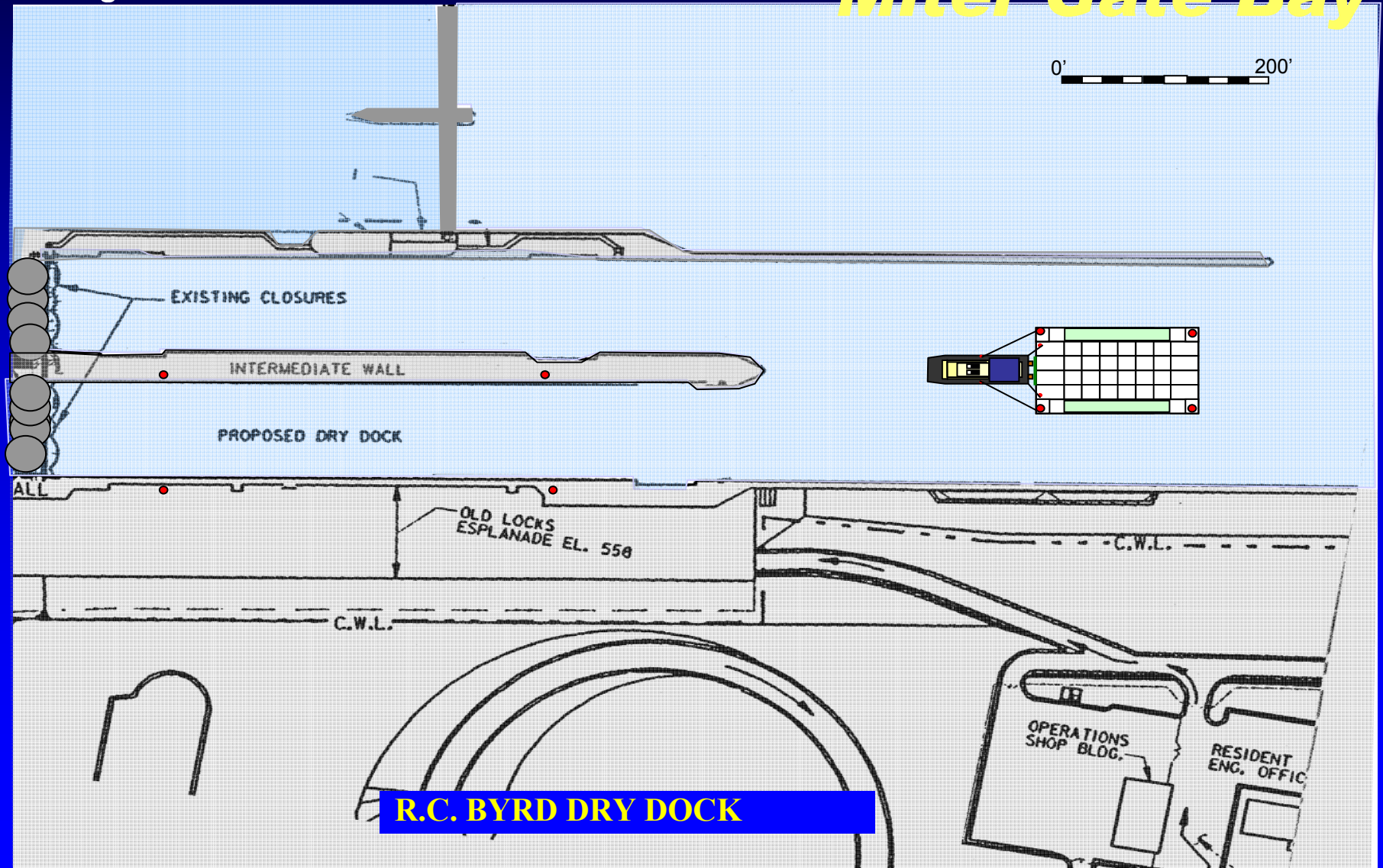


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0' 200'

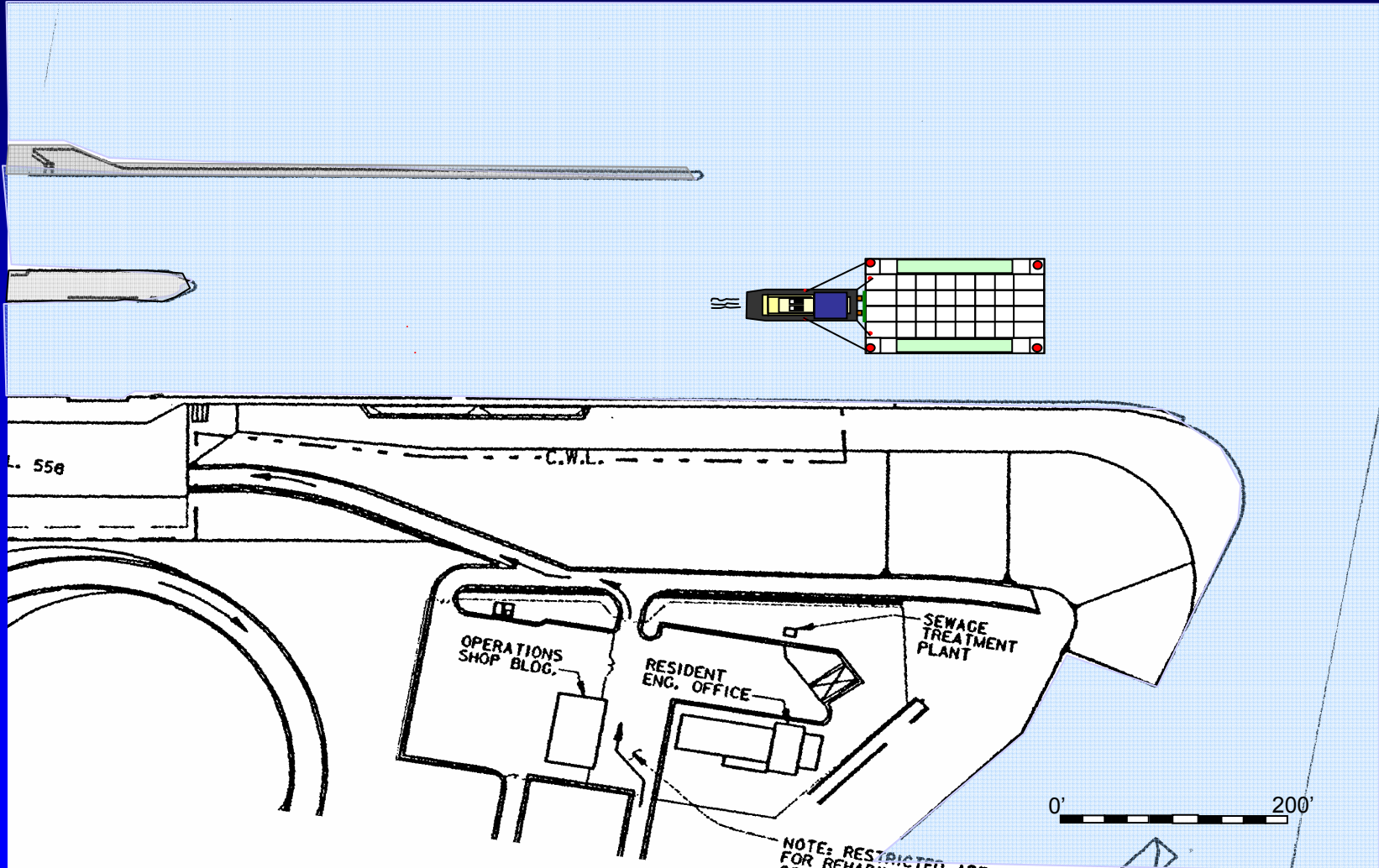




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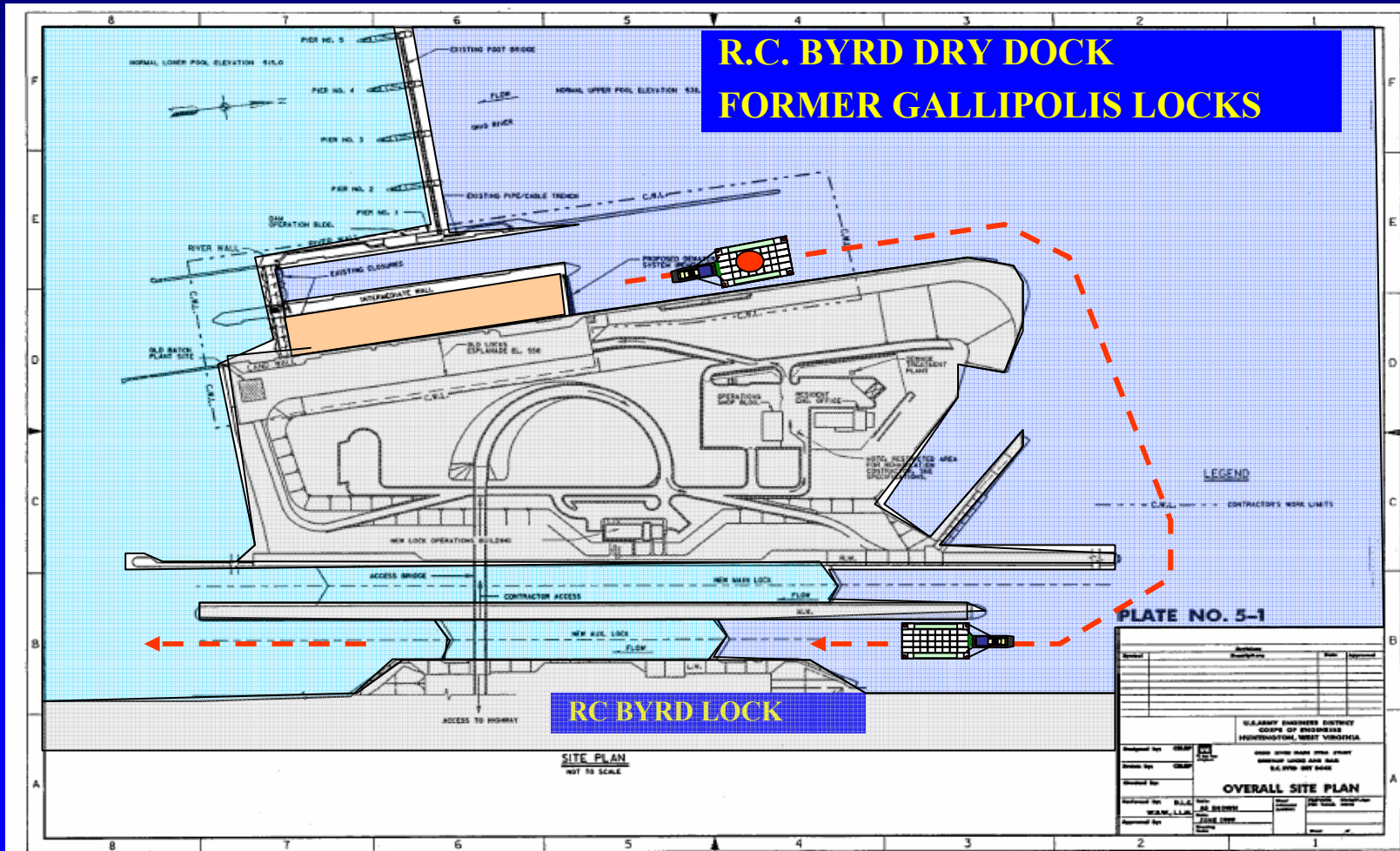
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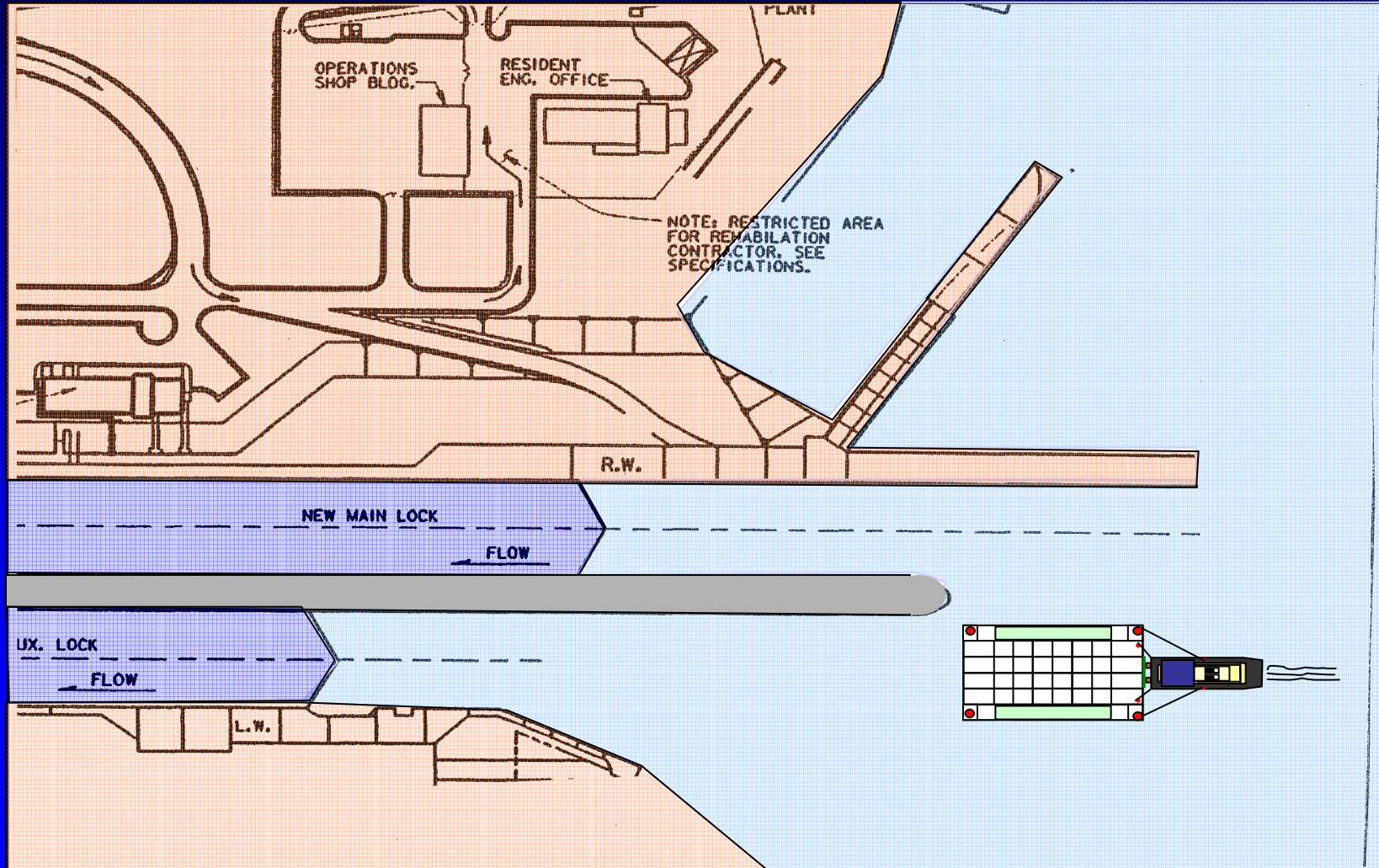




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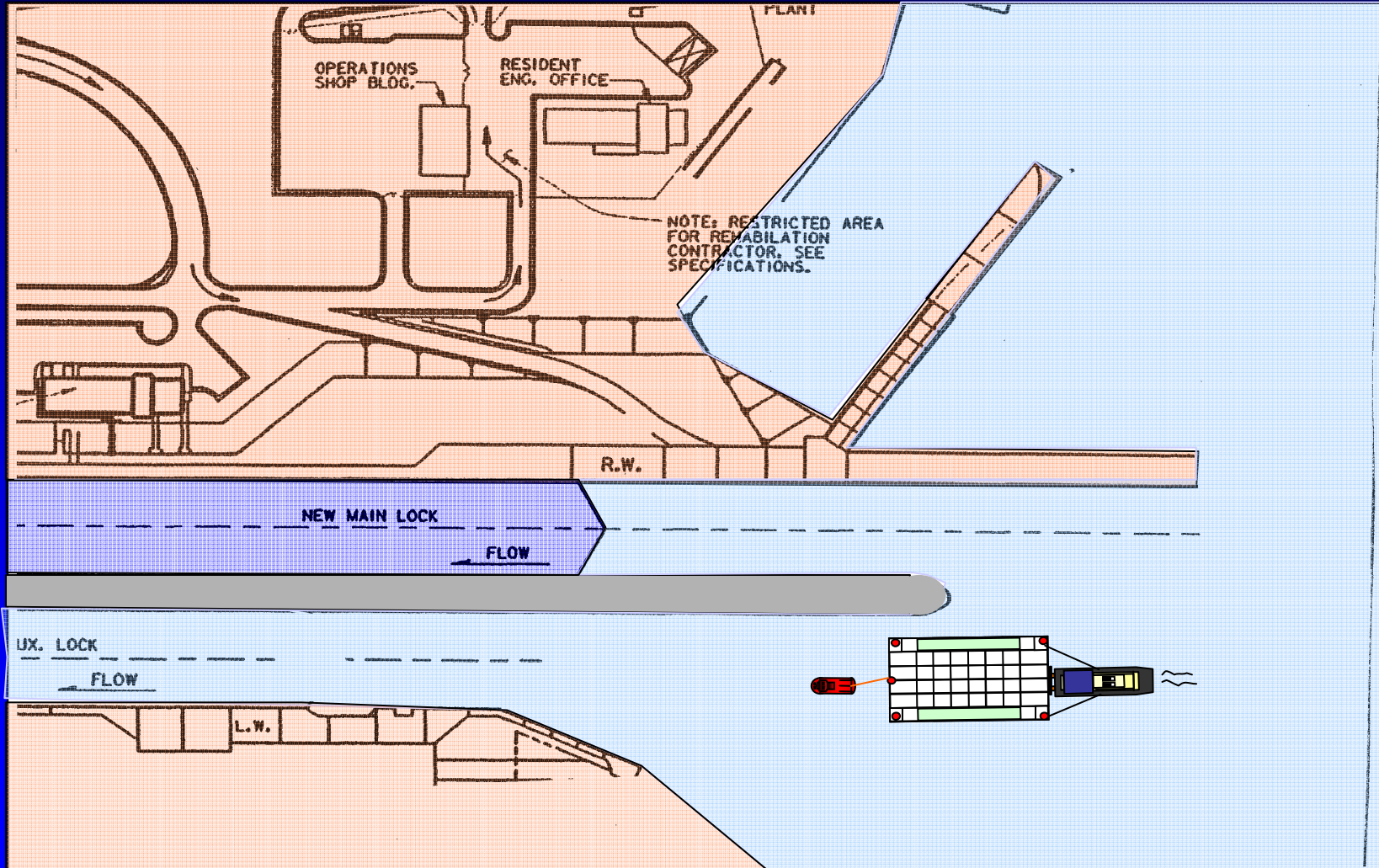
R.C. BYRD LOCKS AND DAM



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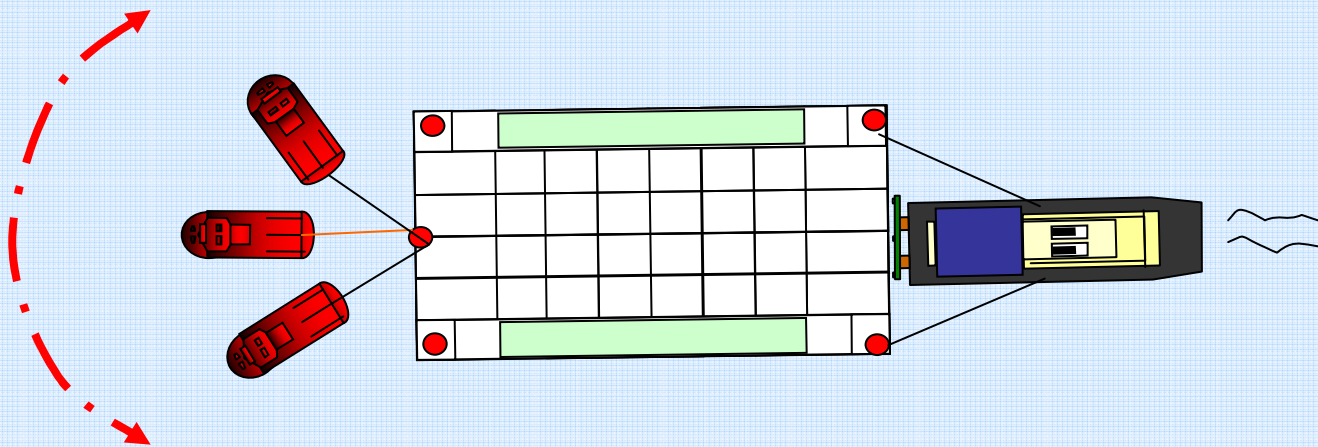
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Correction of direction (short lines)

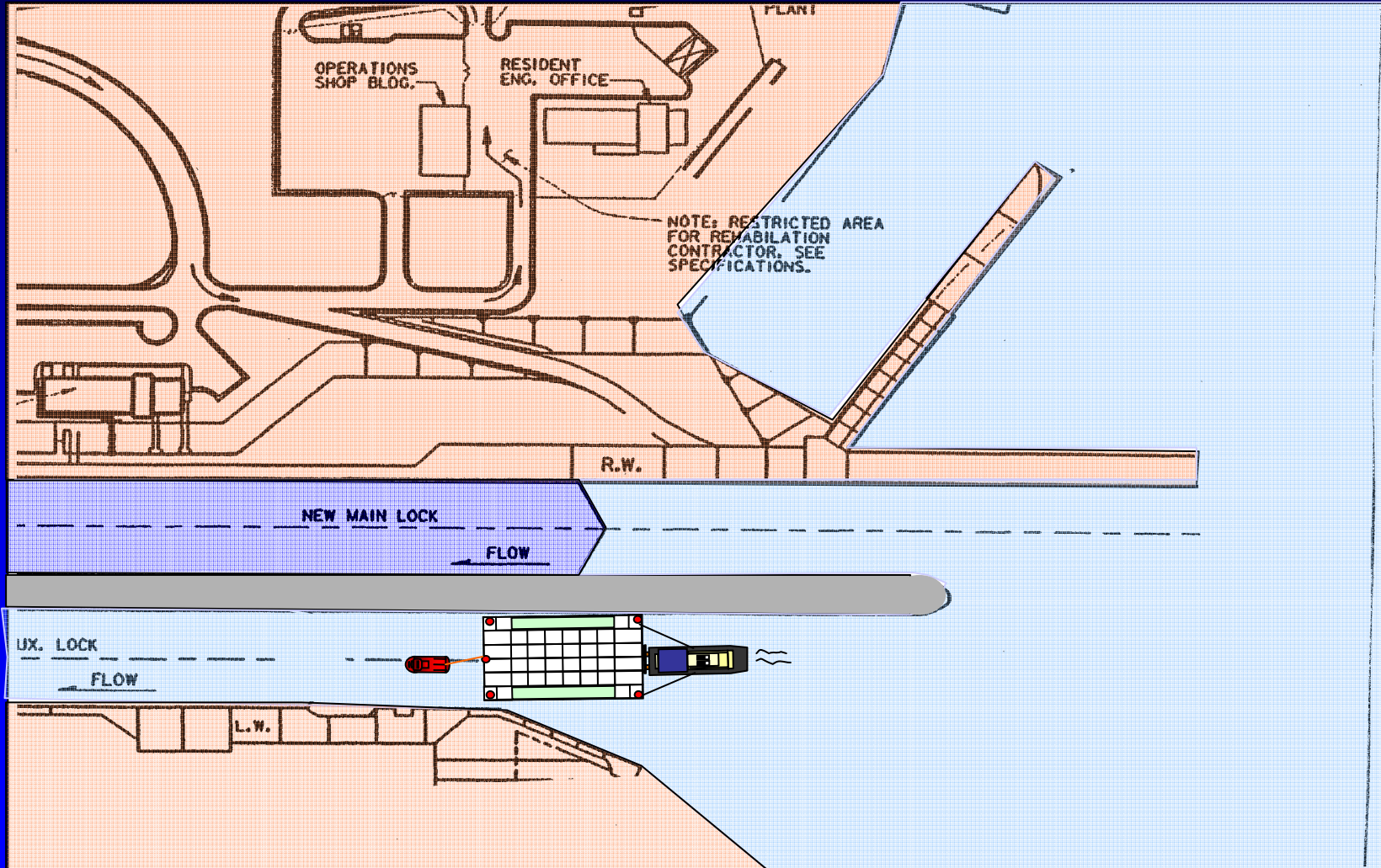
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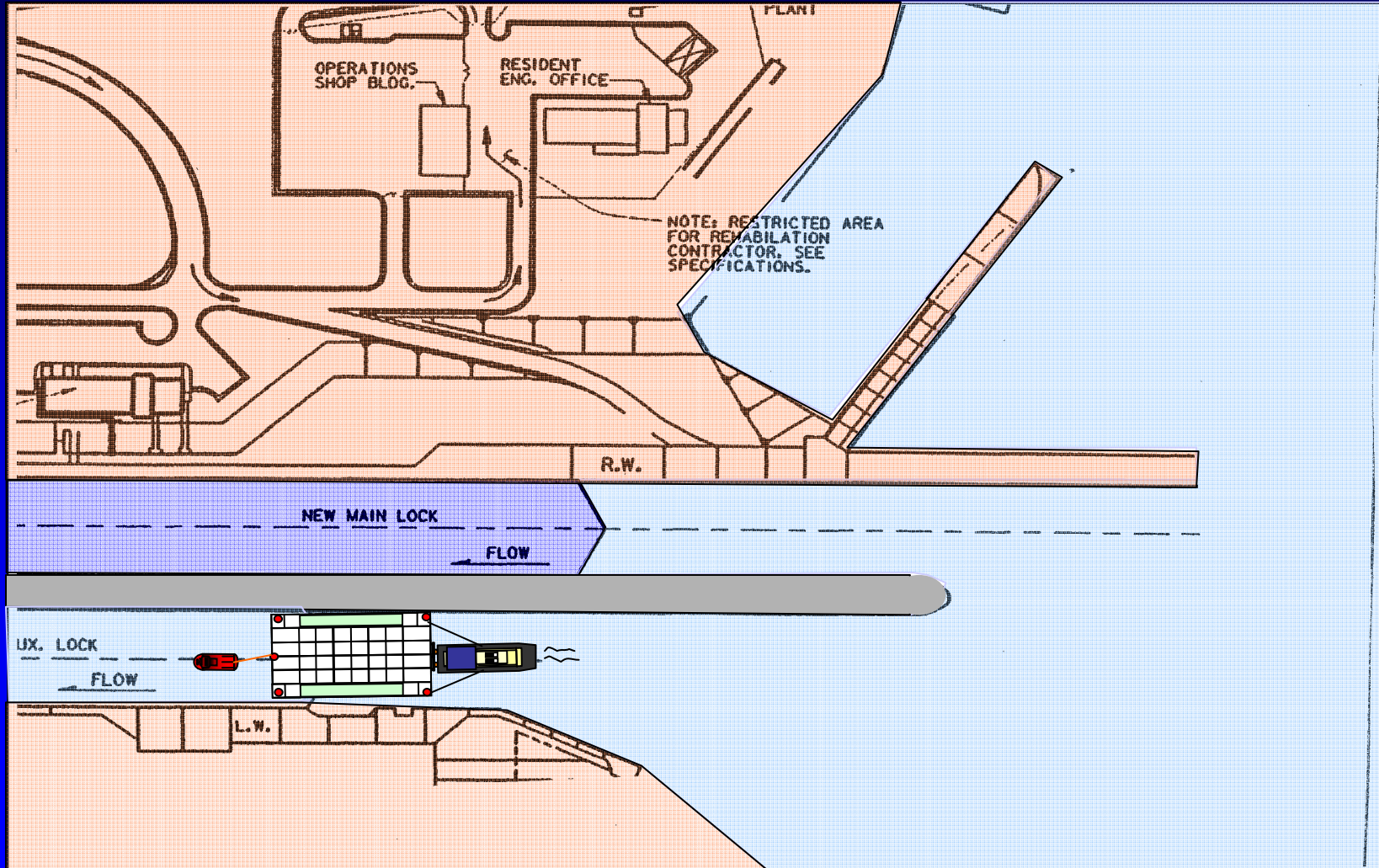
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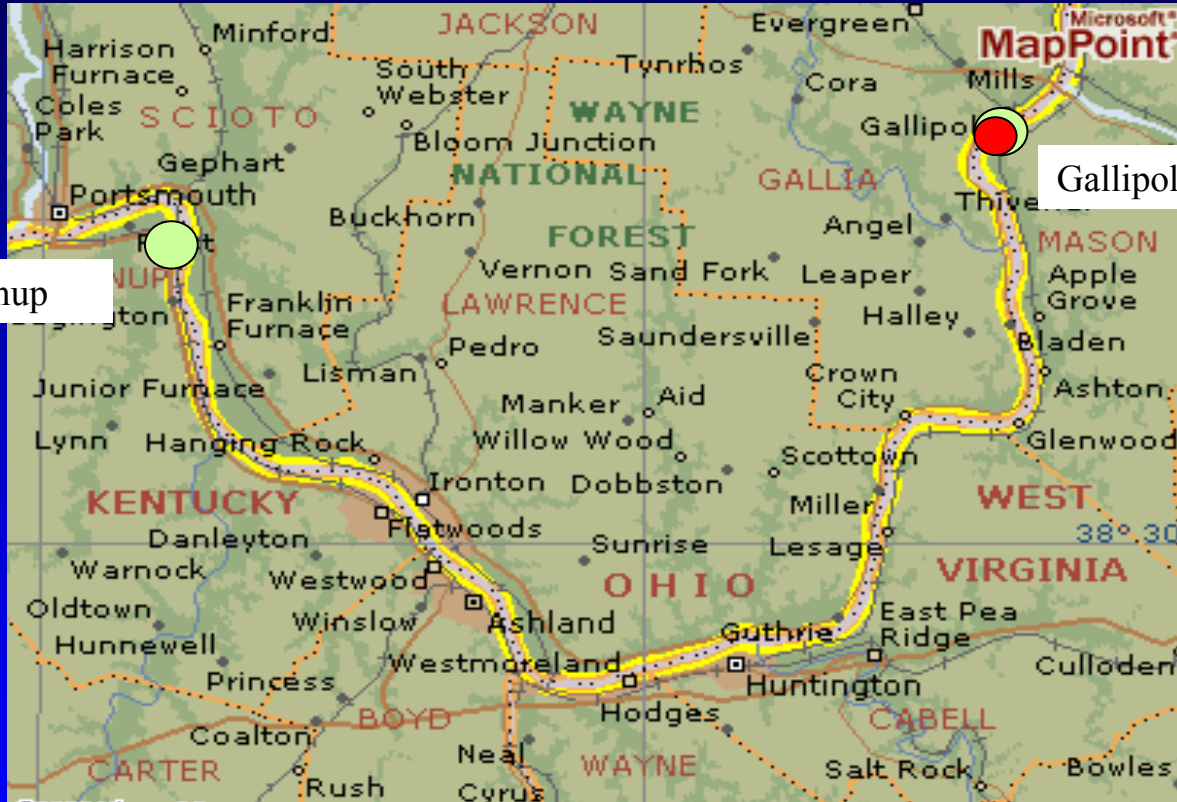
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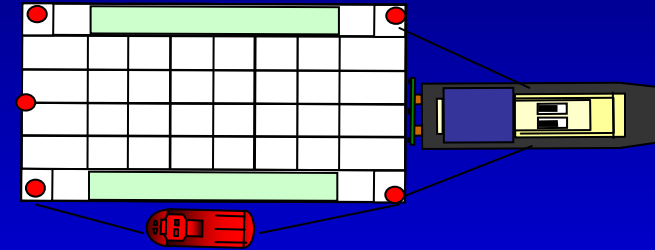
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Greenup

Gallipolis



RIVER TOW	
•Distance	60 miles (52 nautical miles)
•Average speed	5 to 6 mph
•Duration	12 to 16 hours (schedule 24 hrs)

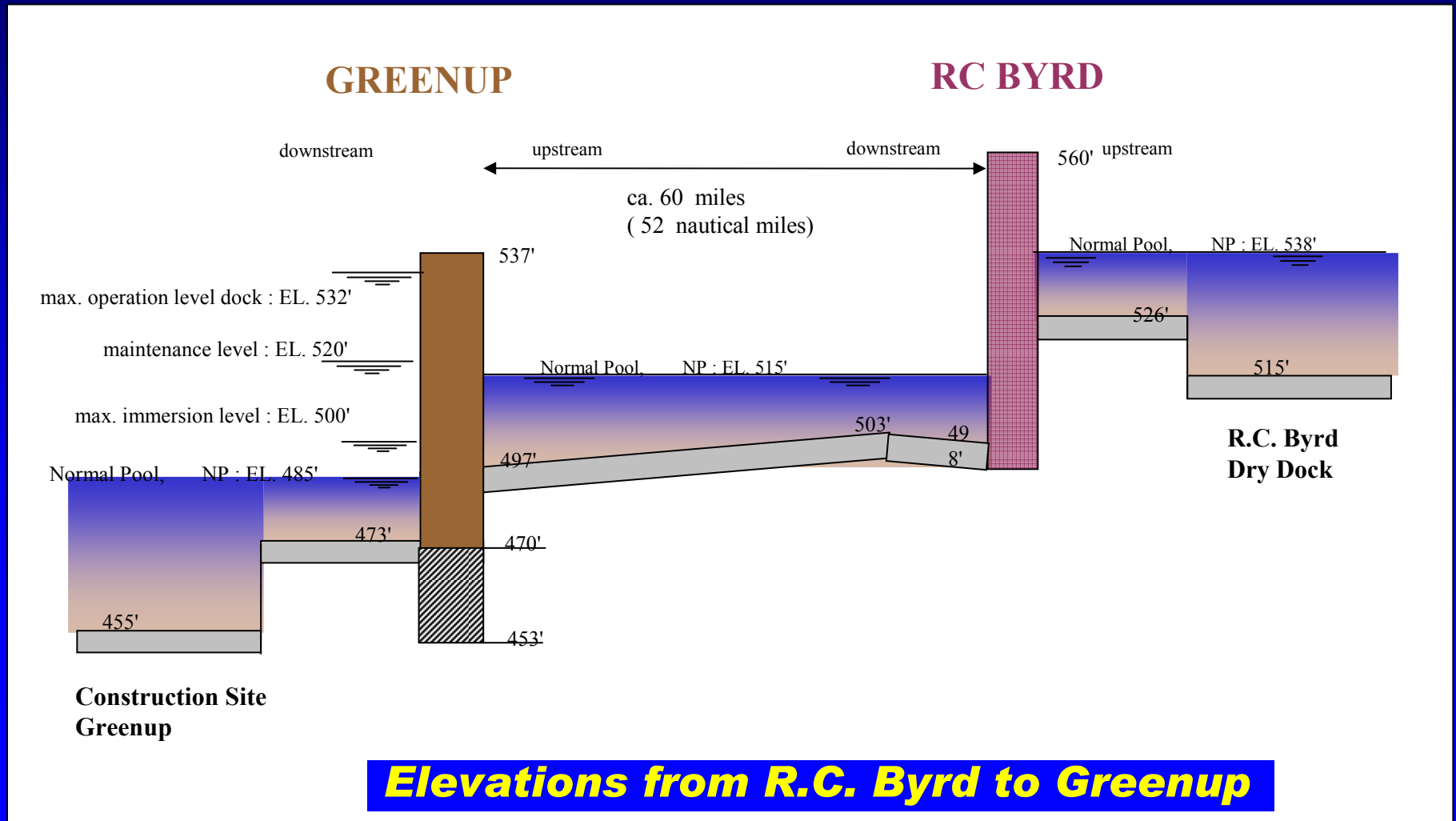
**Ohio River: R.C. Byrd
to Greenup**

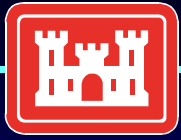


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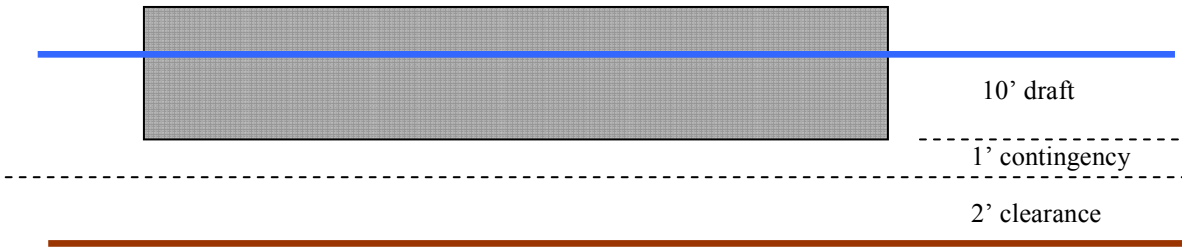




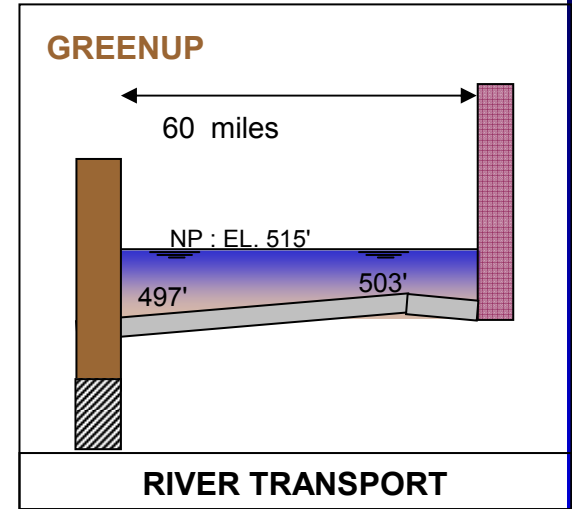
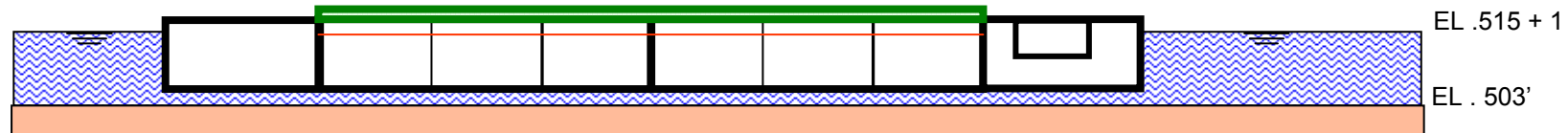
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**Dredge 1ft
or tow at normal pool +1ft**



DRAFT	10.0 ft
FREEBOARD	6.0 ft
KEELCLEARANCE	3.0 ft

Phase 2: River Transport



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Cofferdam & Nose Cell Constructed

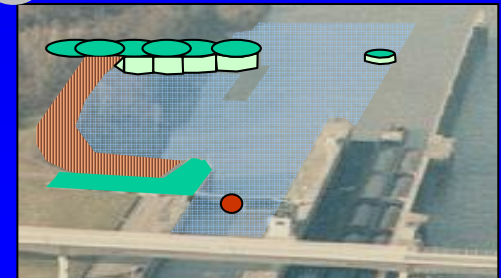
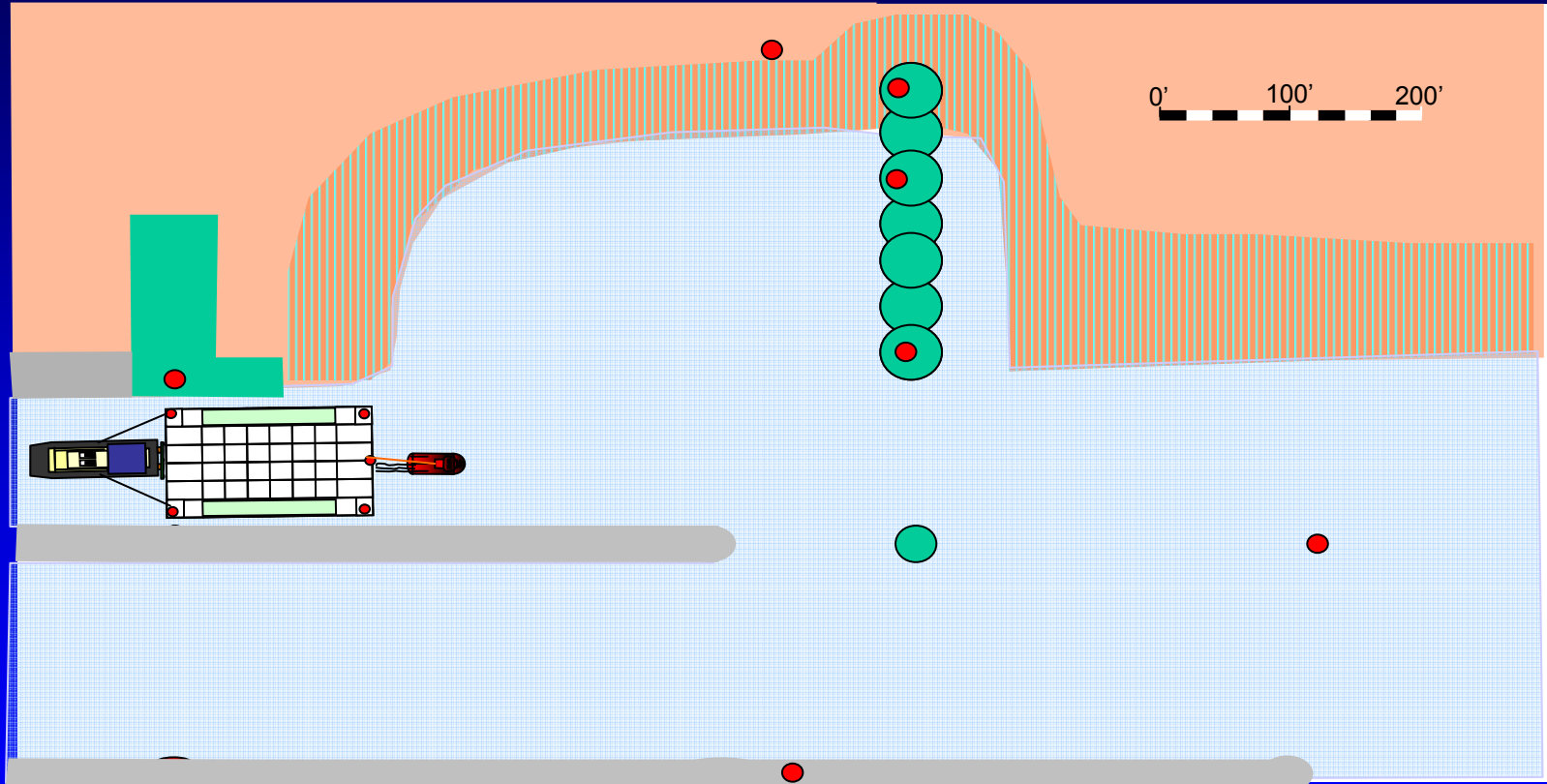


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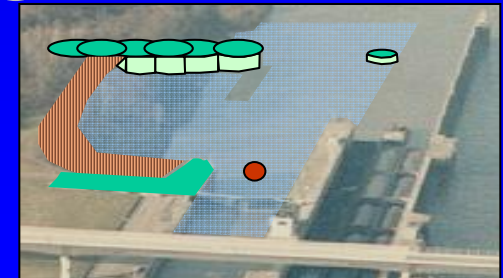
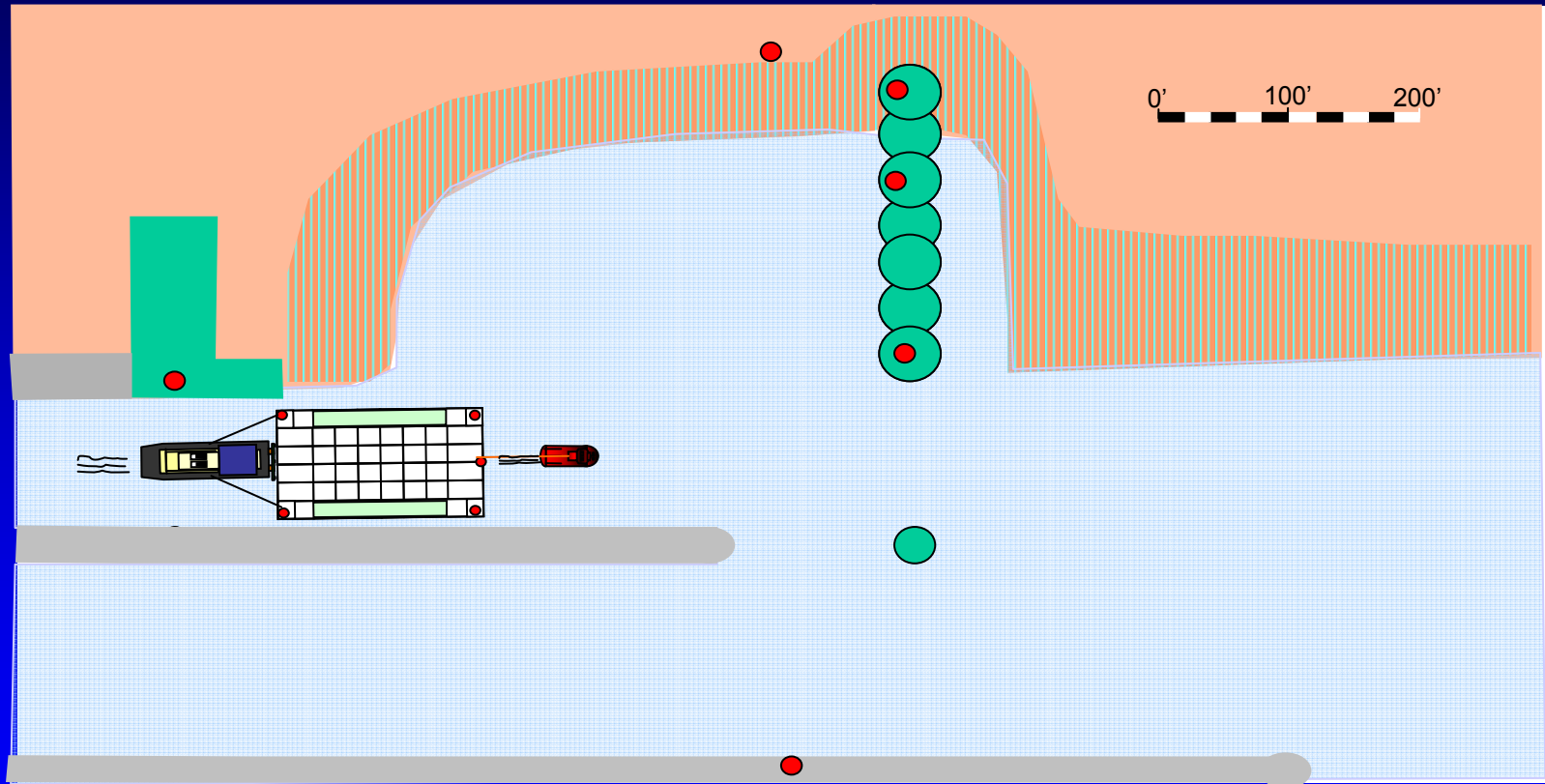


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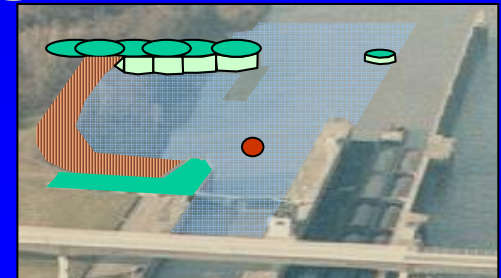
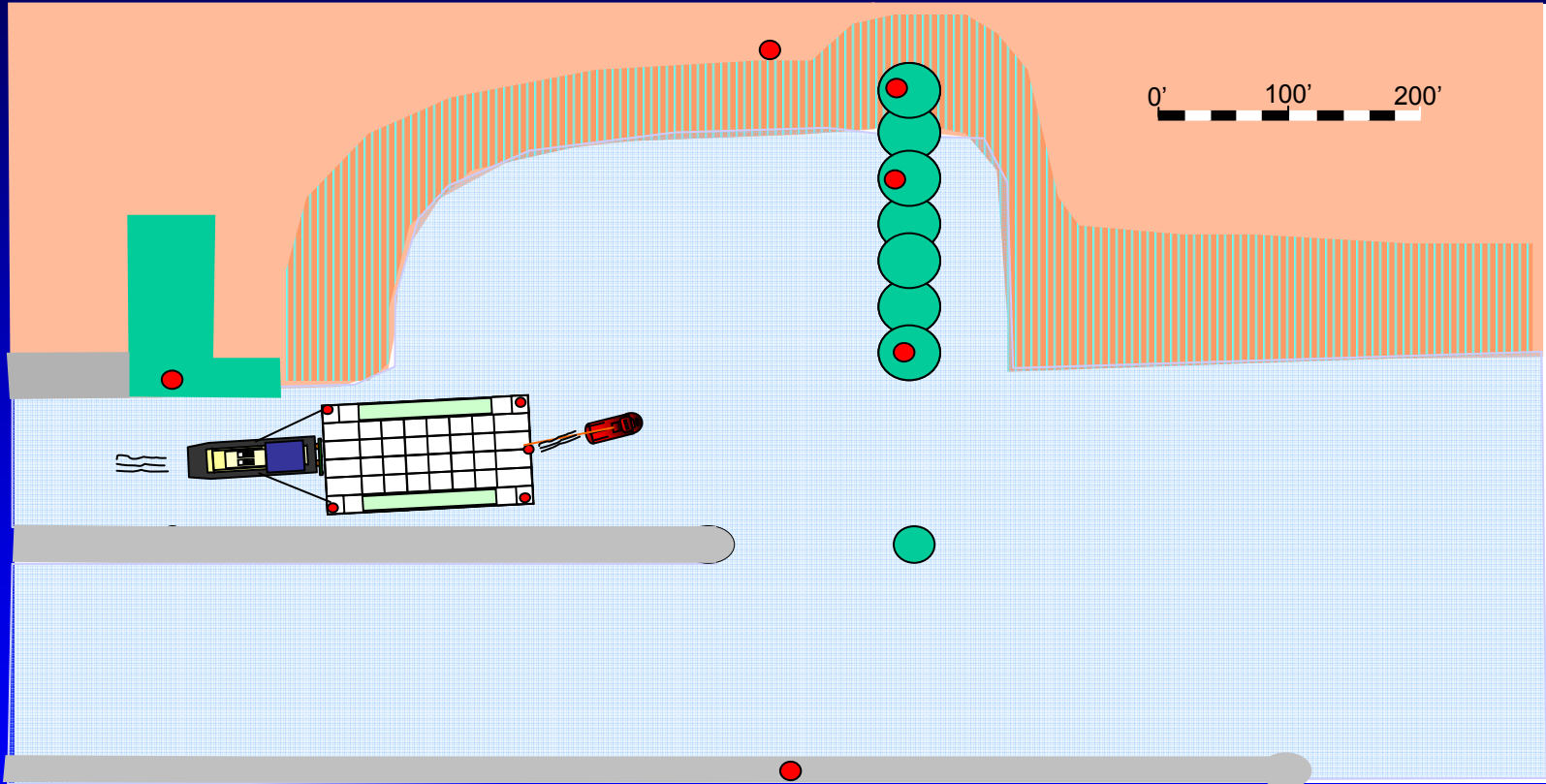


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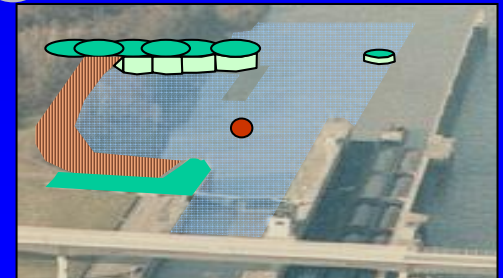
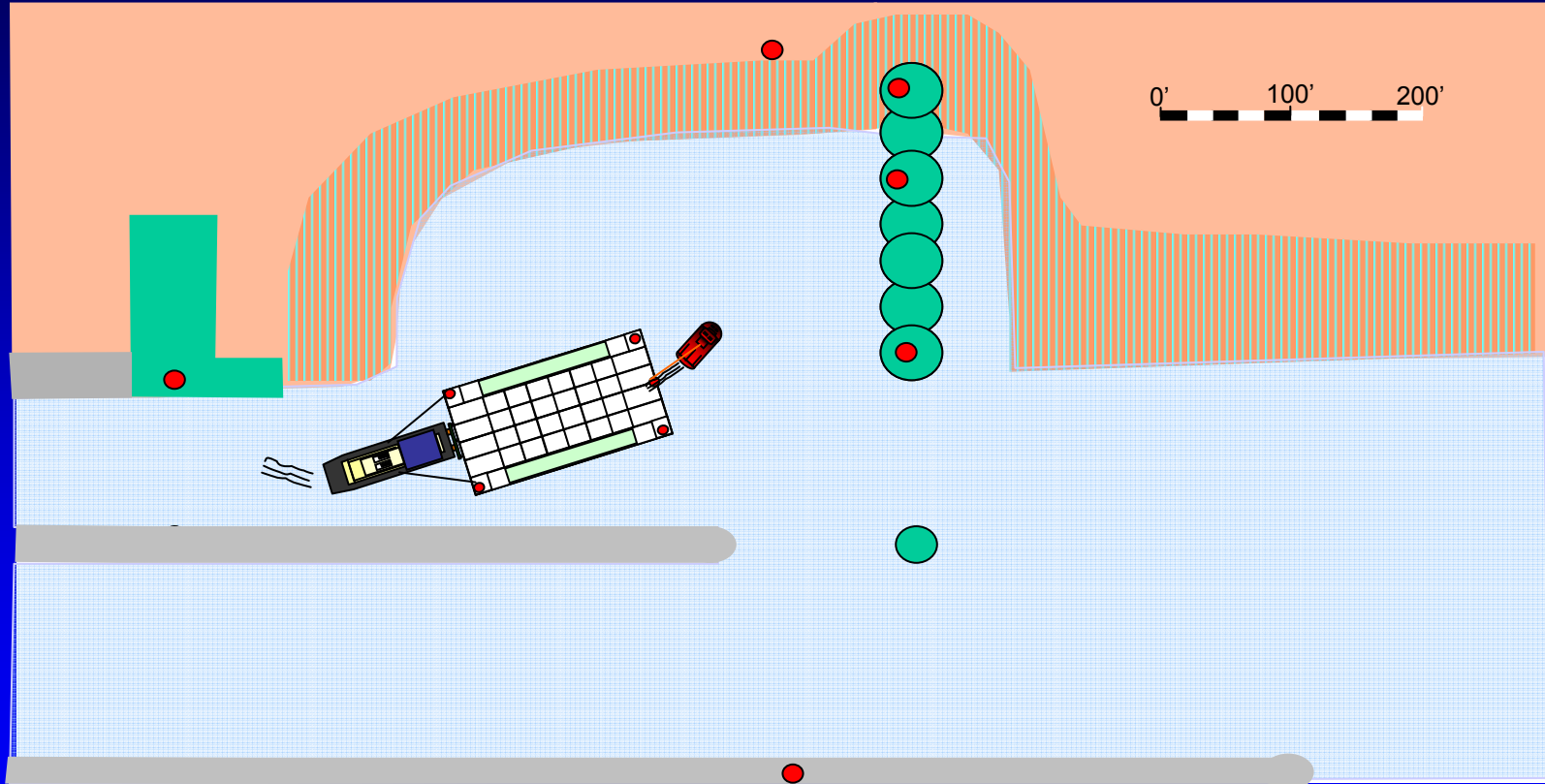


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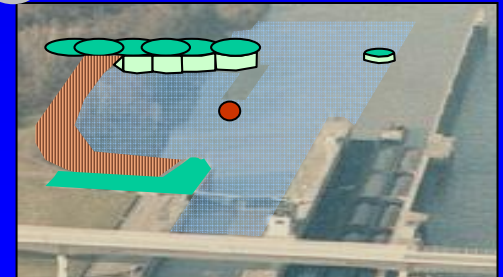
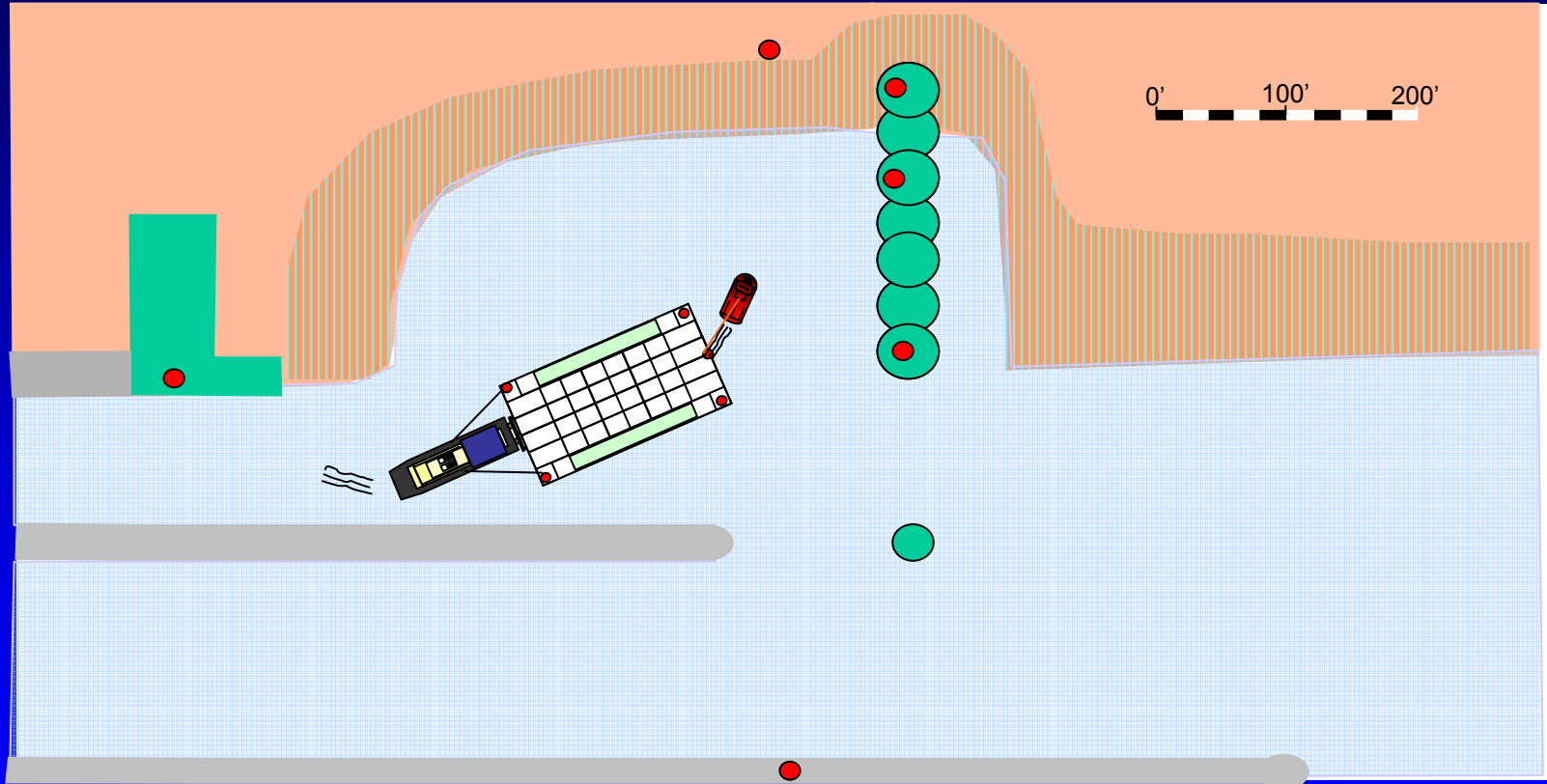


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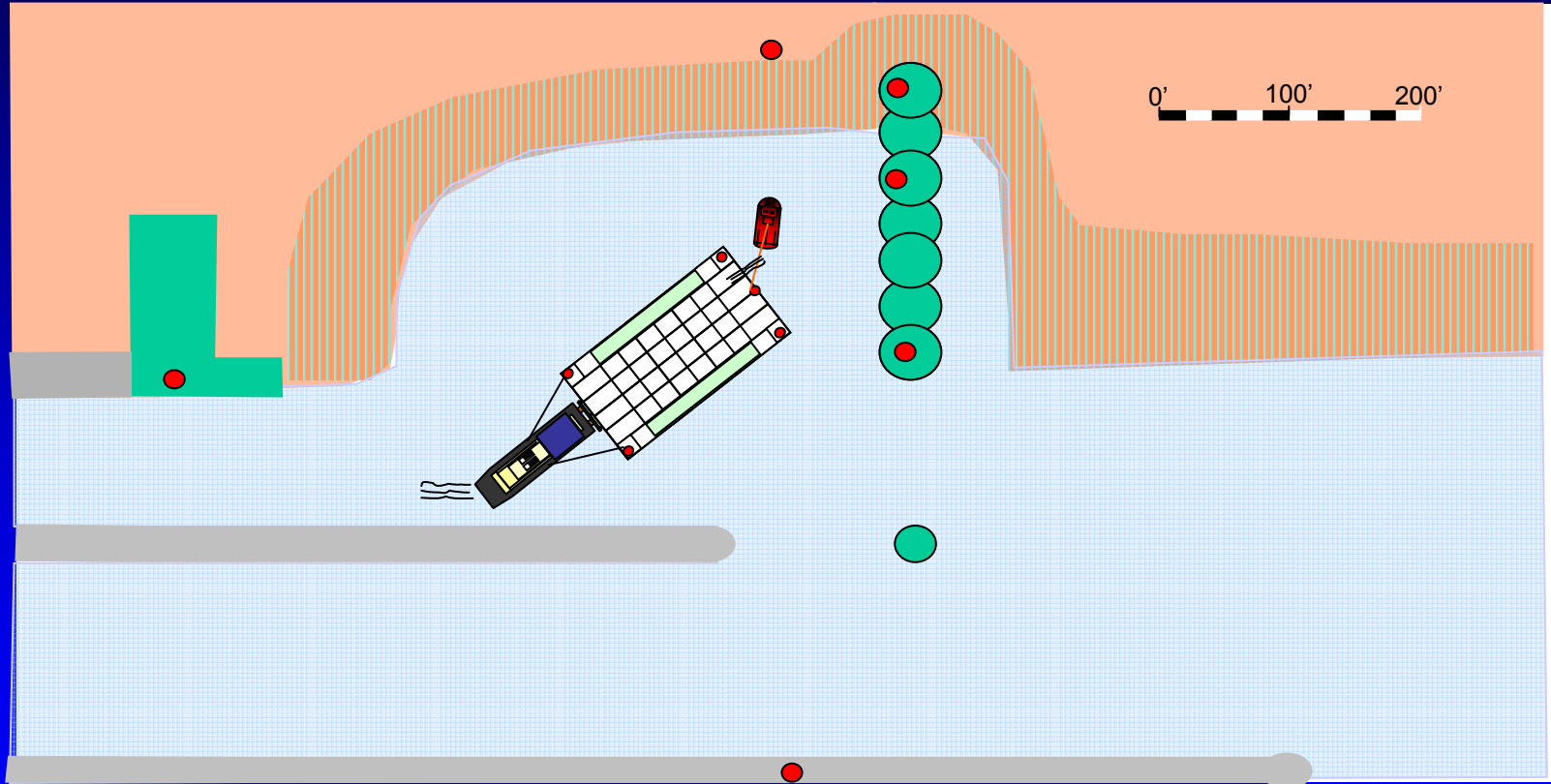


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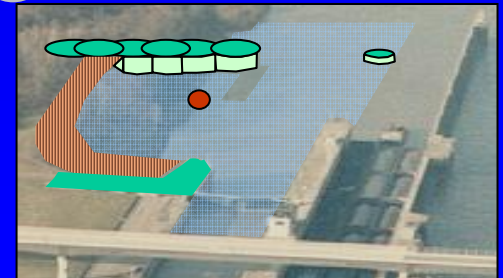
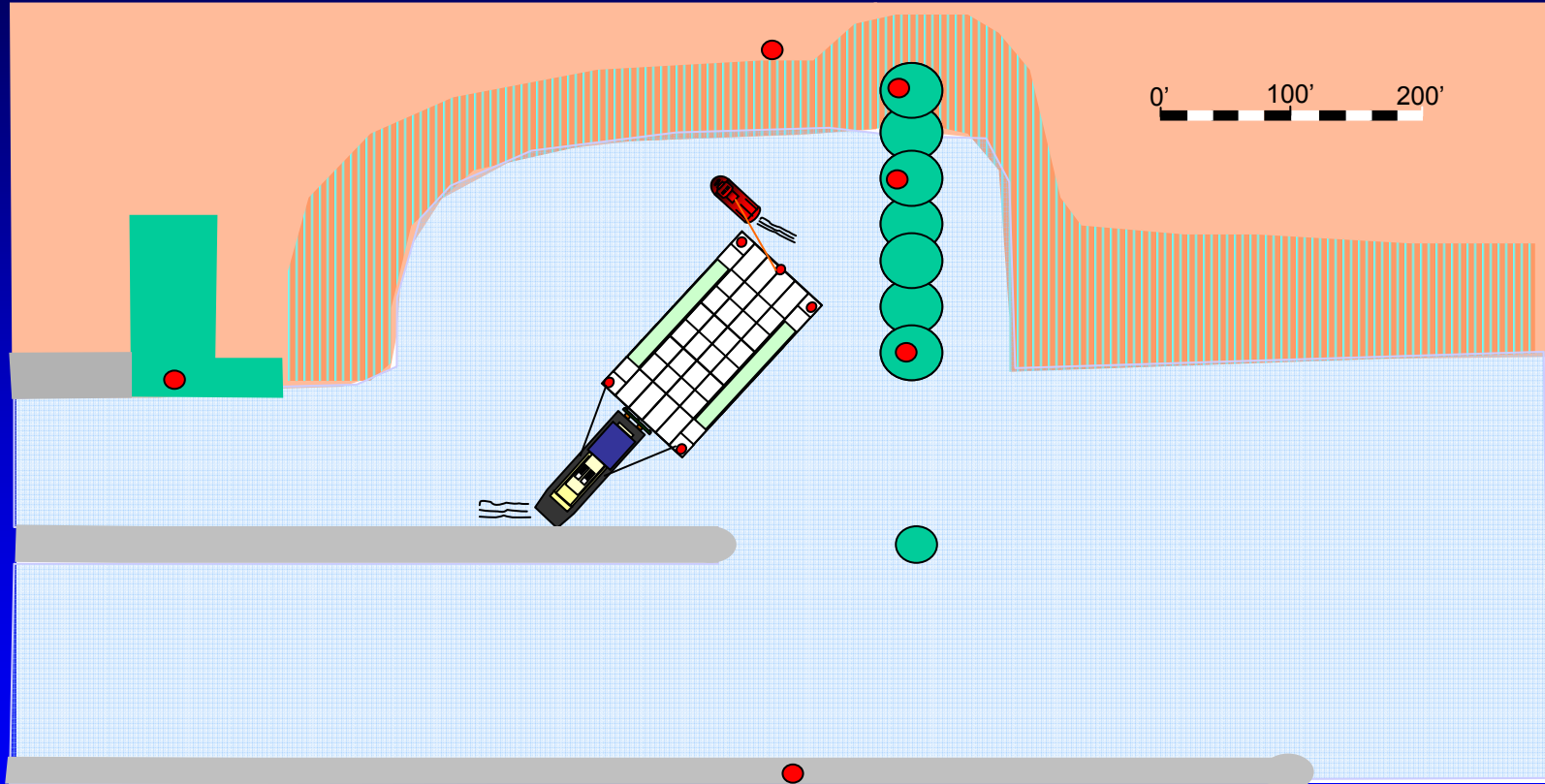


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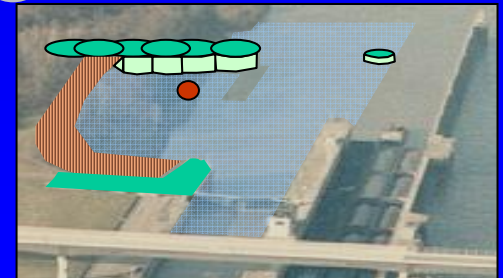
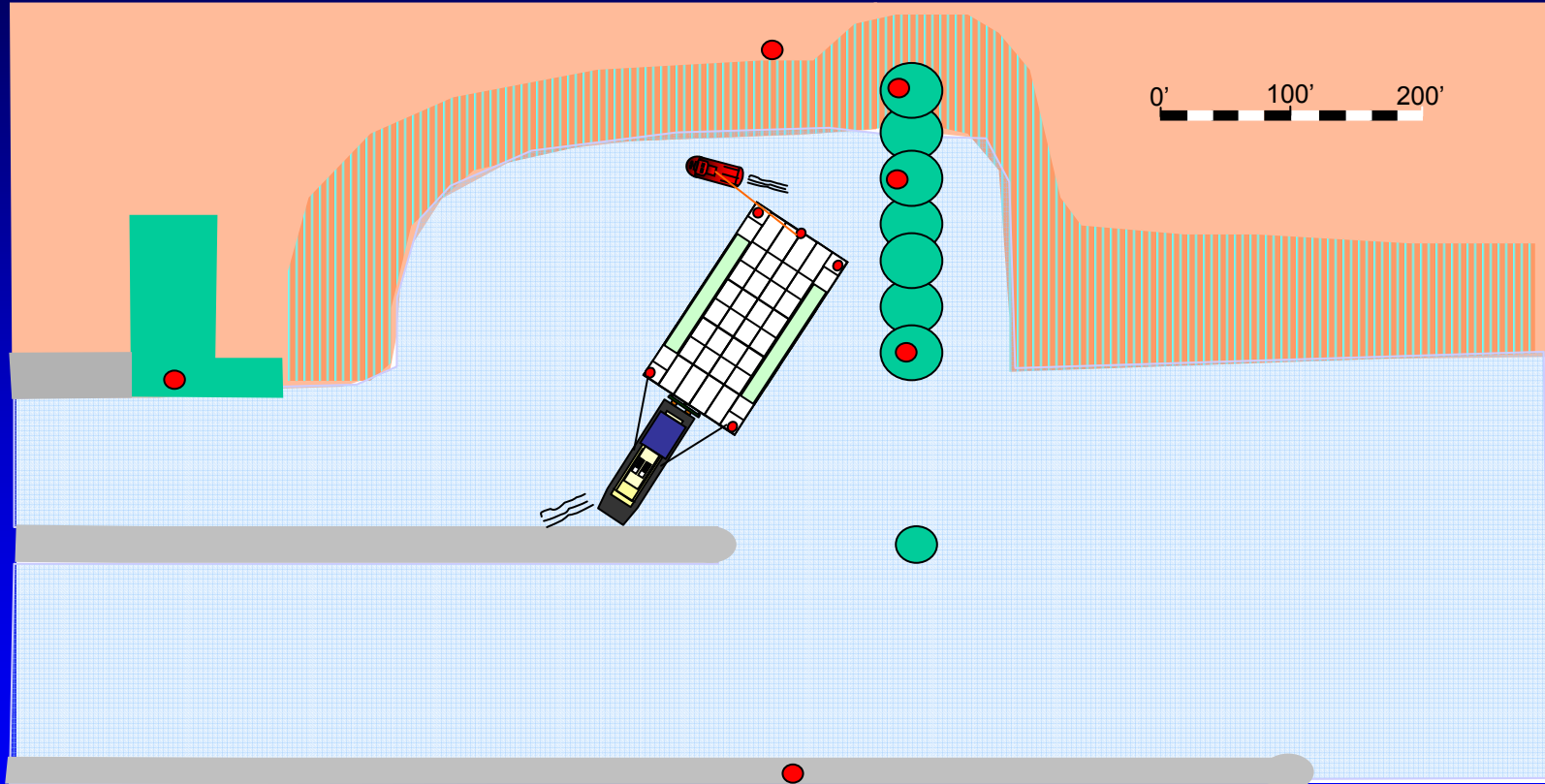


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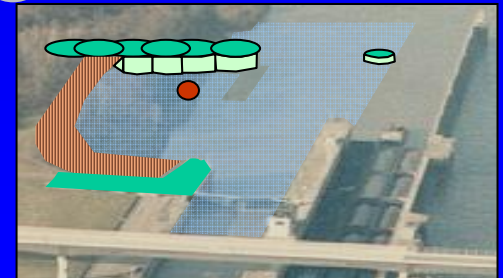
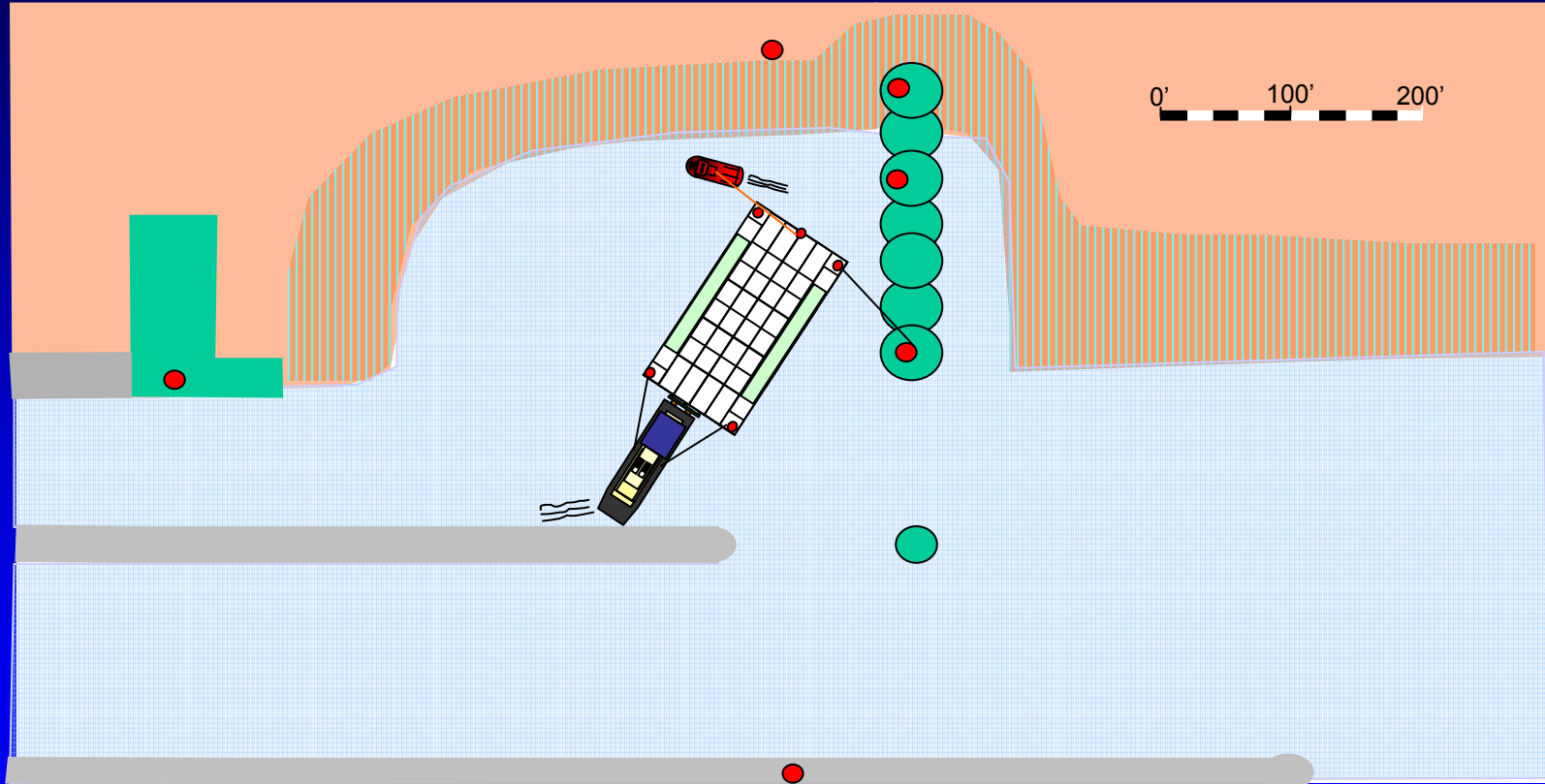


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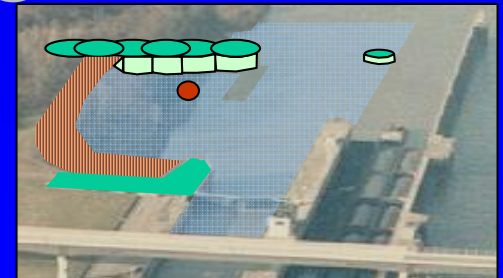
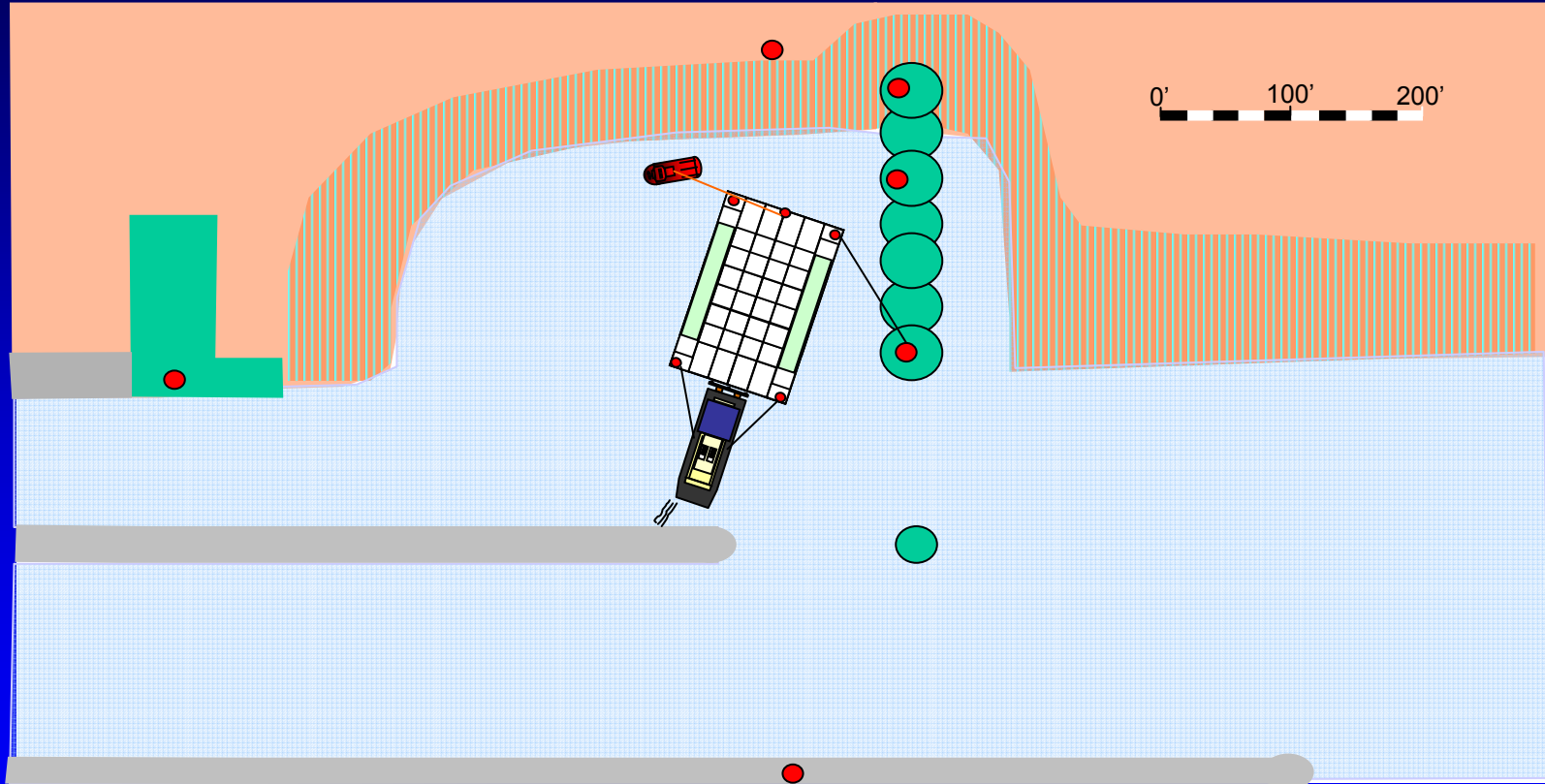


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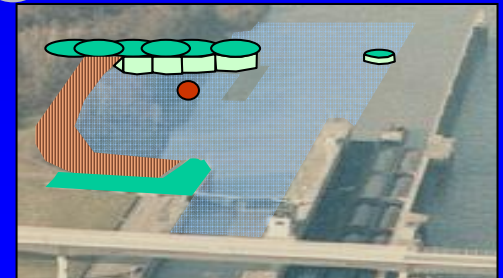
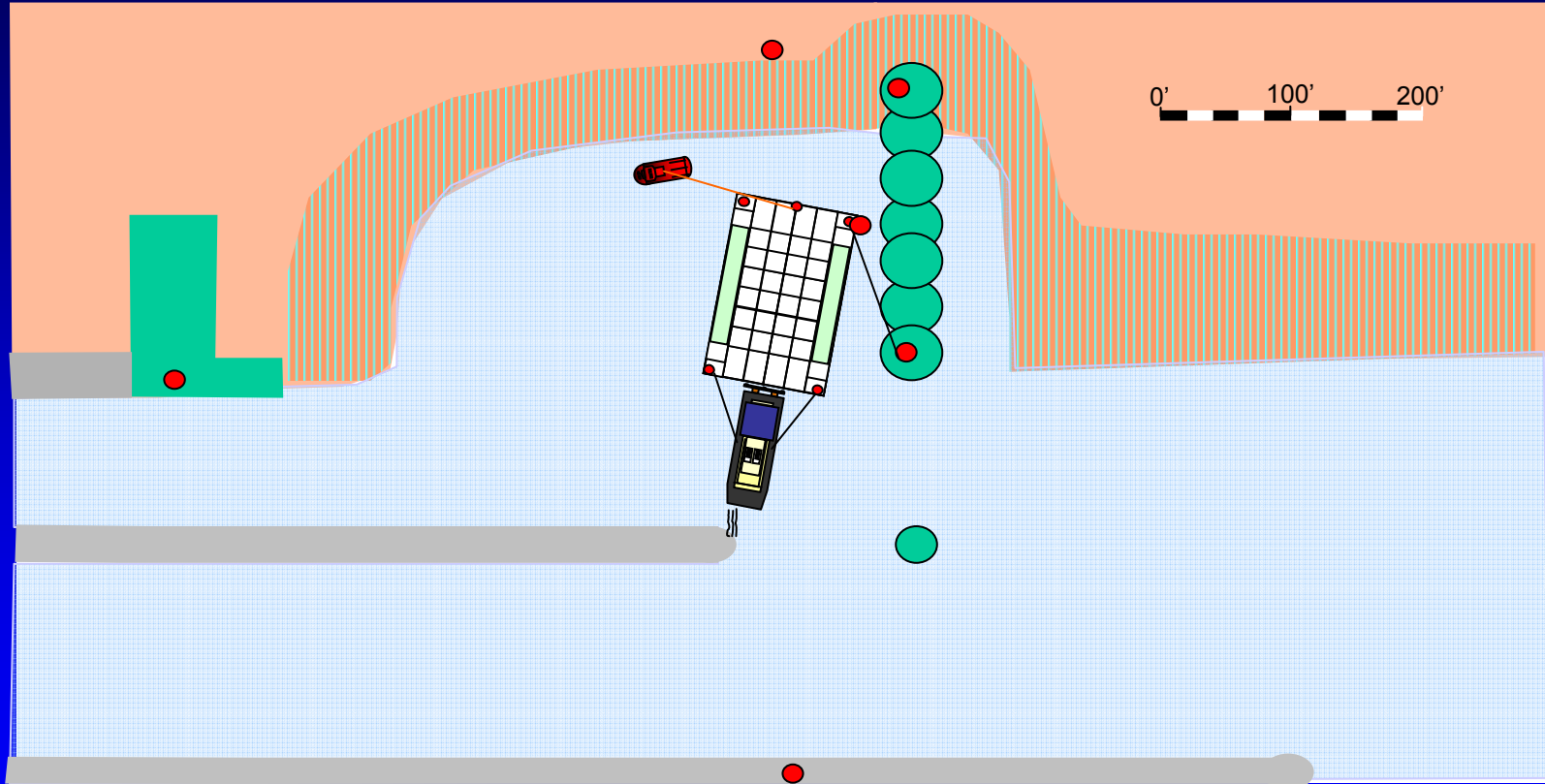


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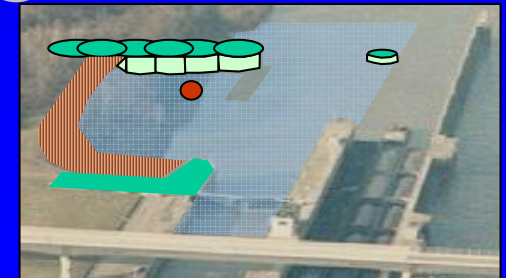
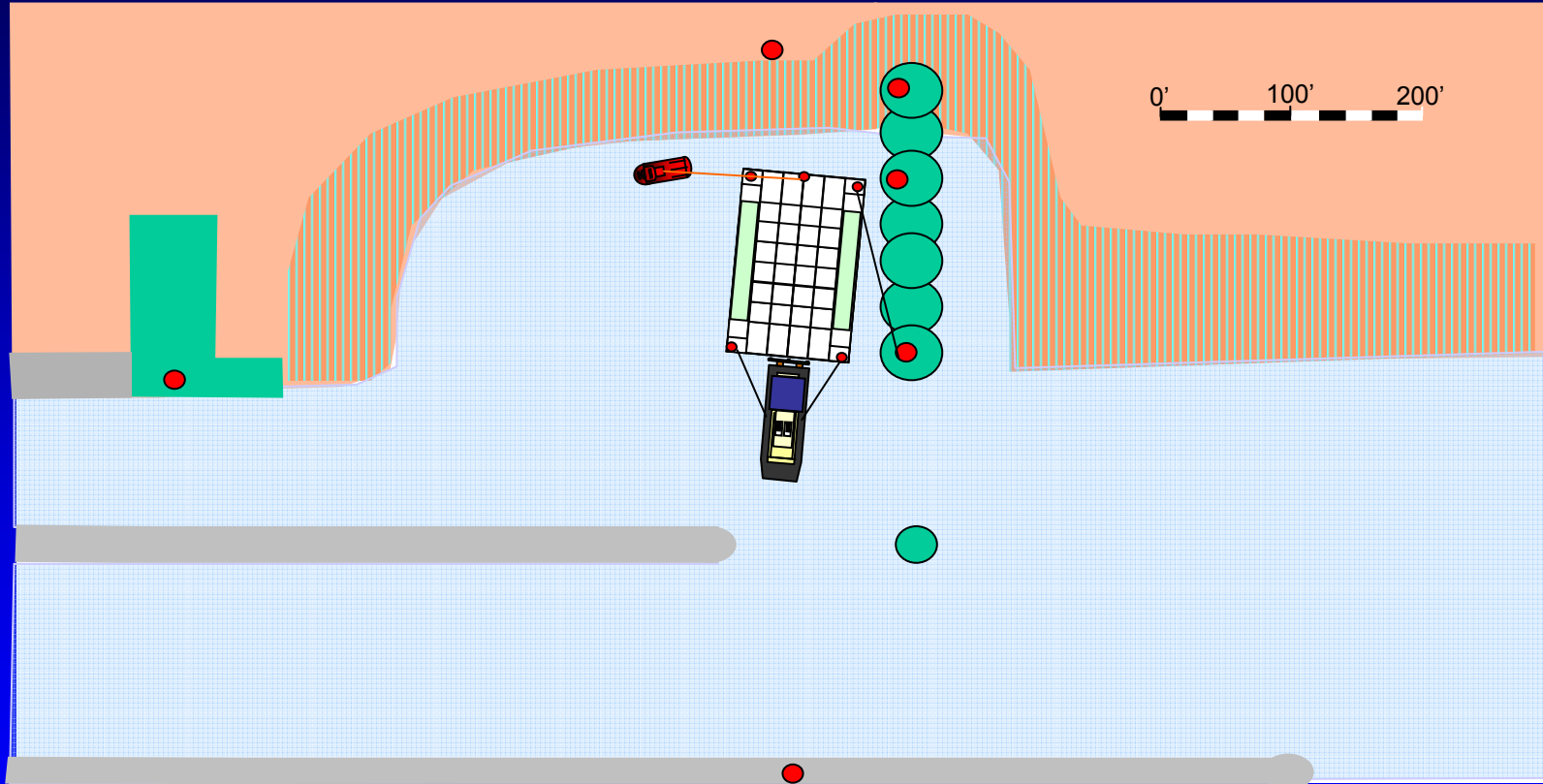


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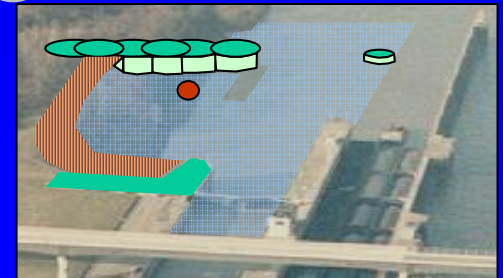
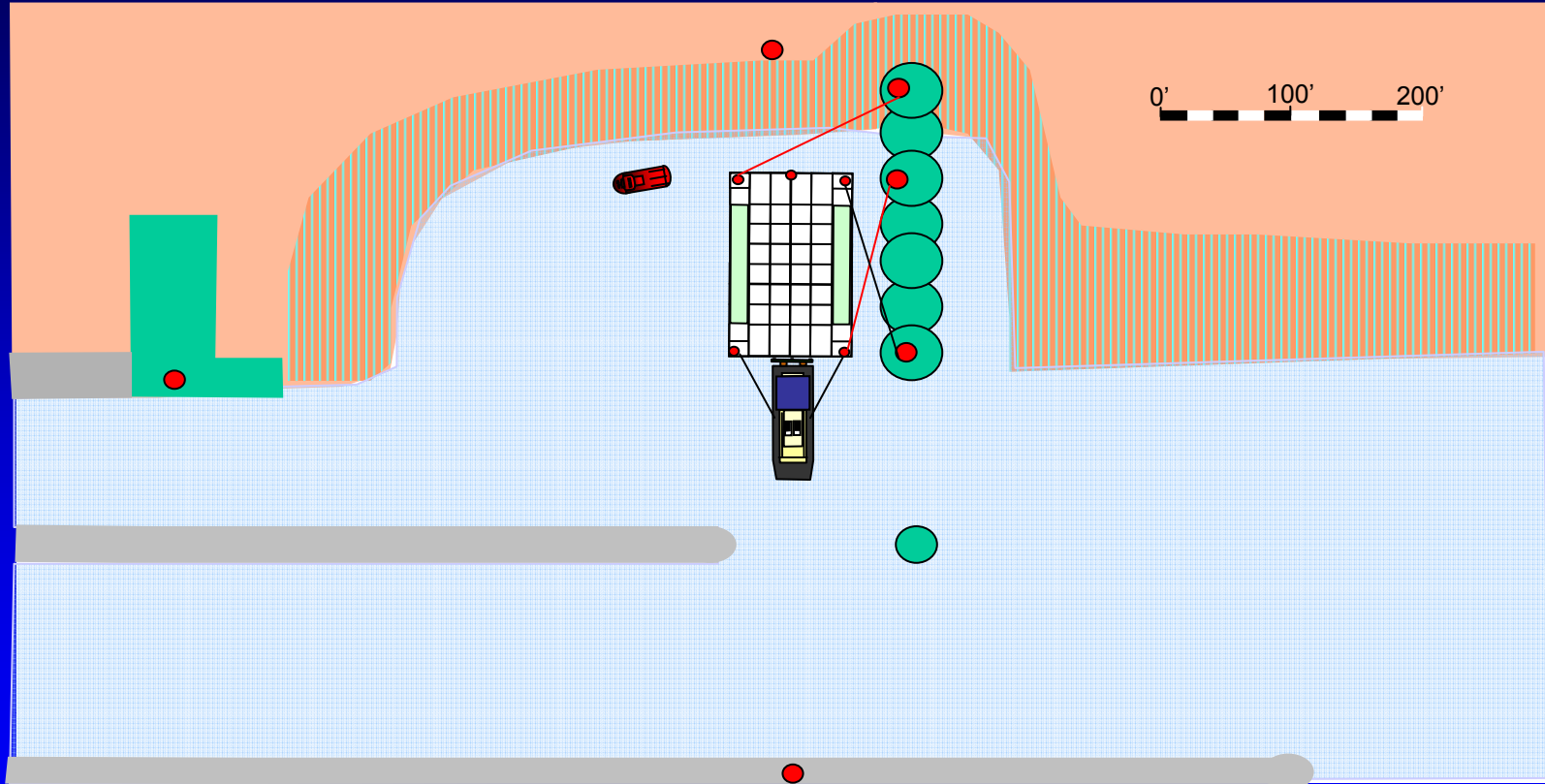


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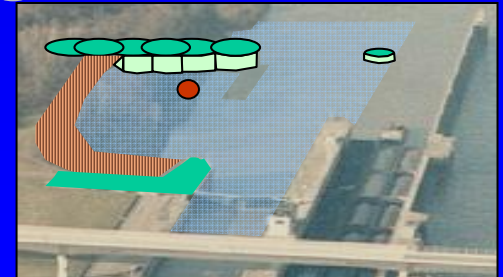
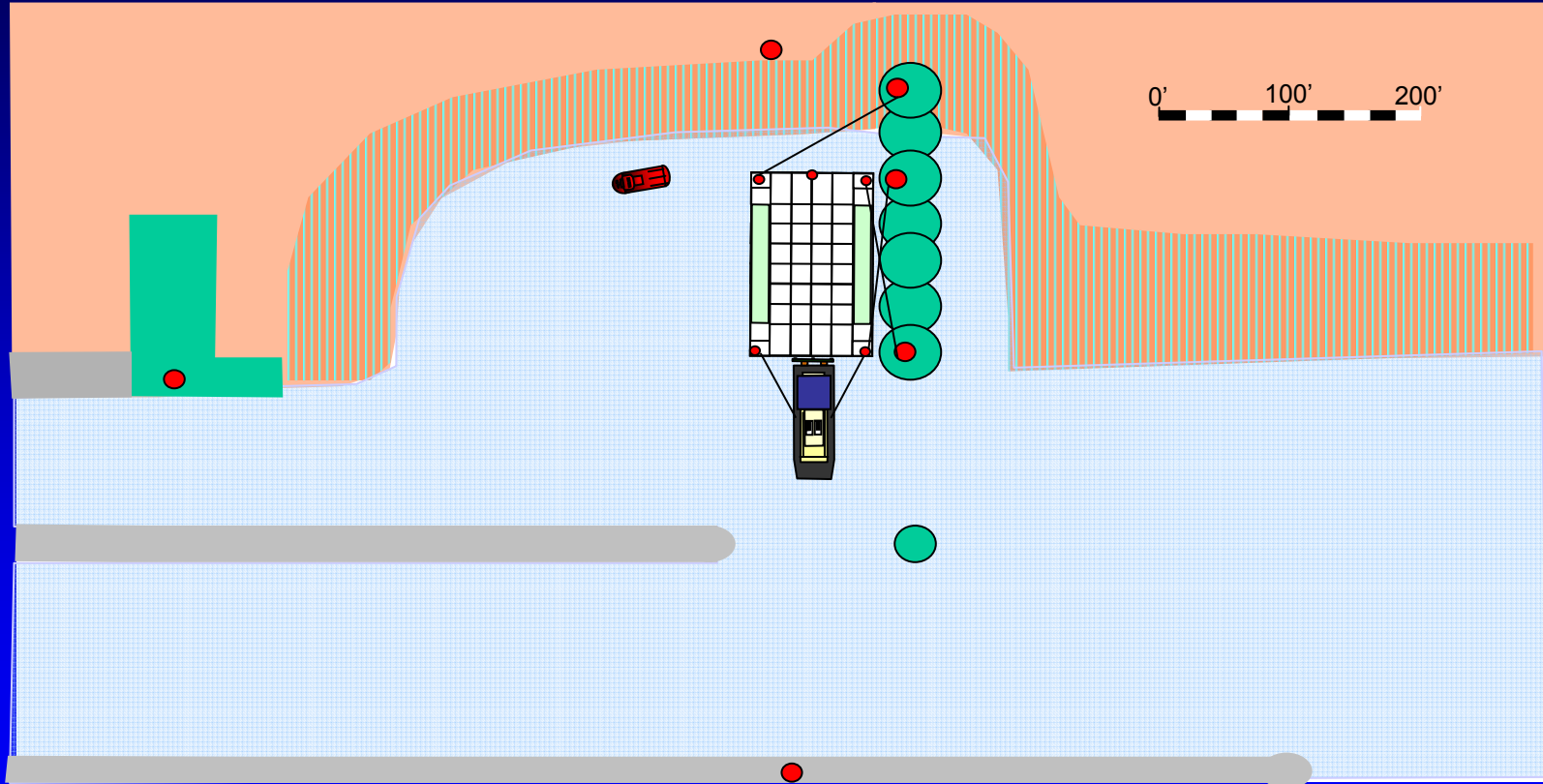


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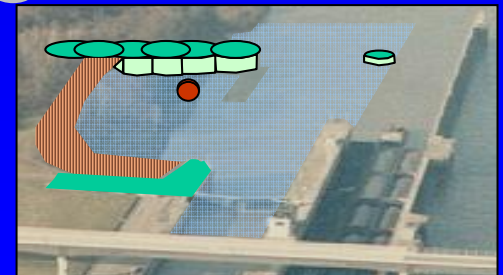
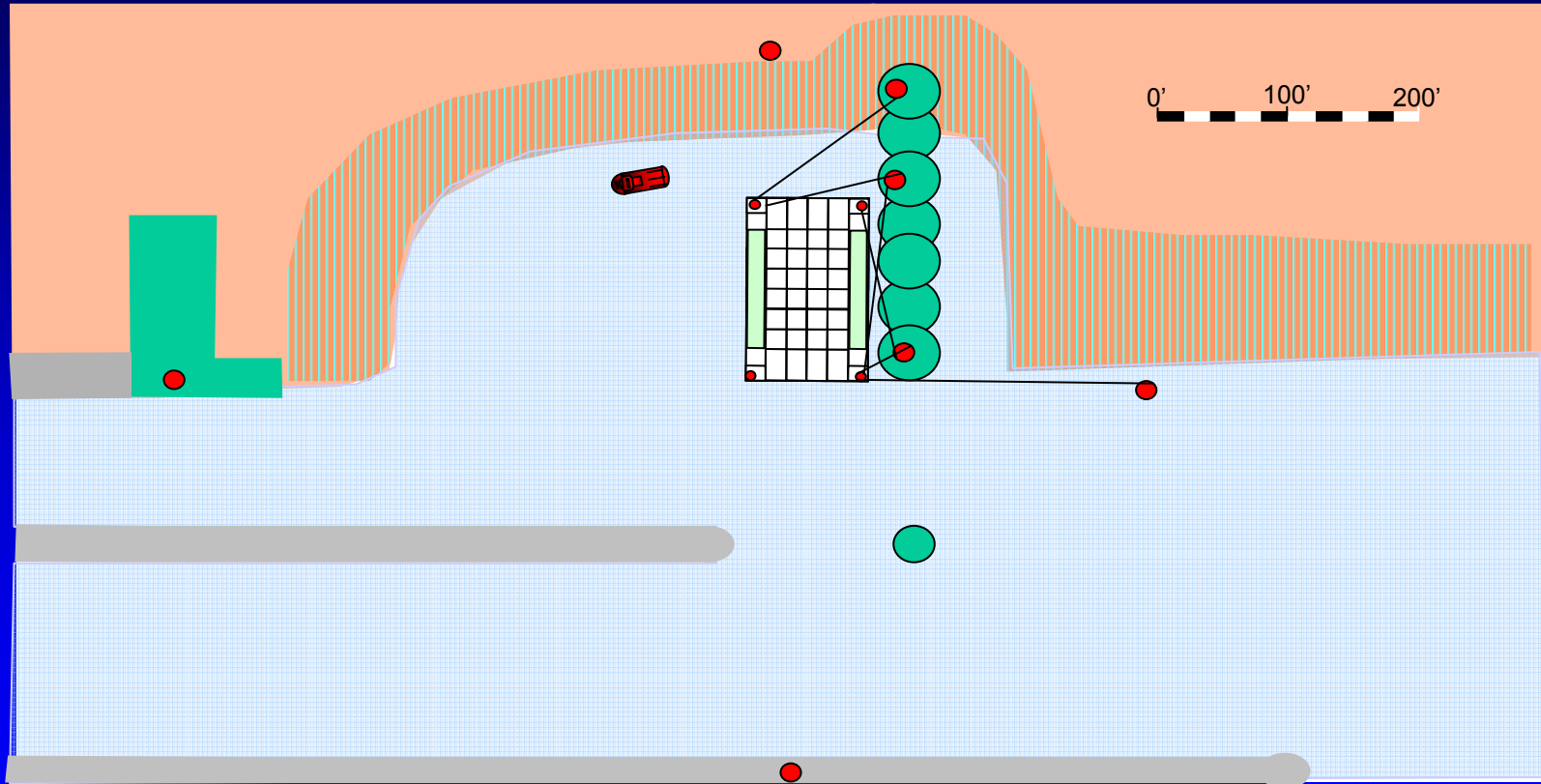


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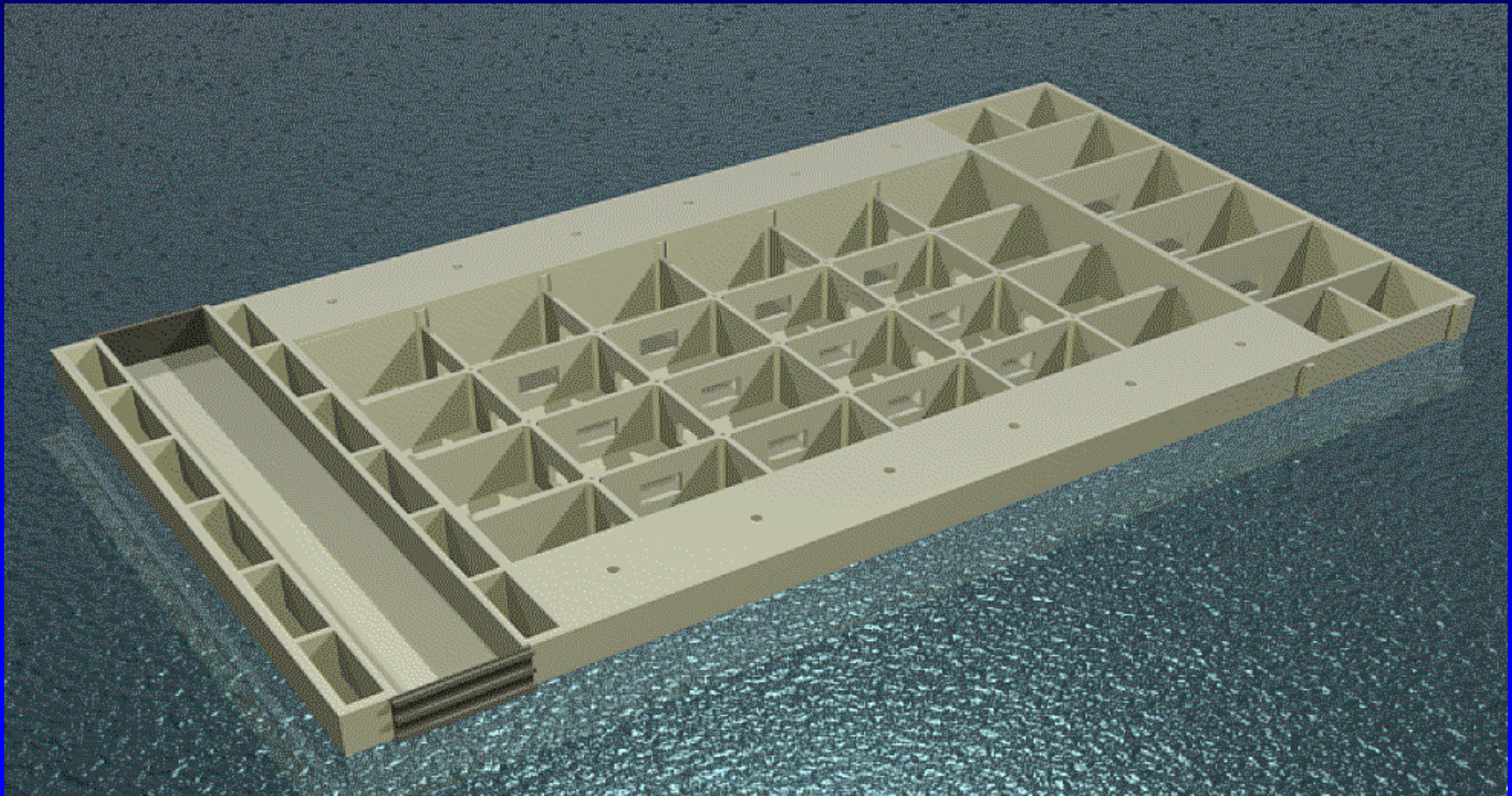


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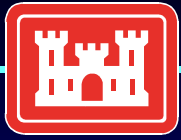
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Phase 3: Arrival at floating construction site

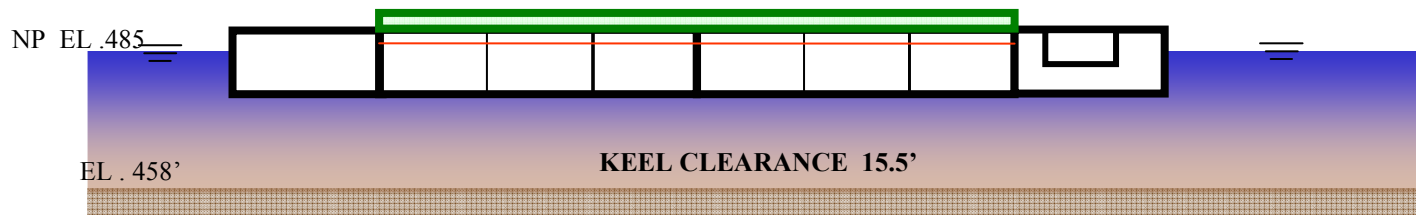
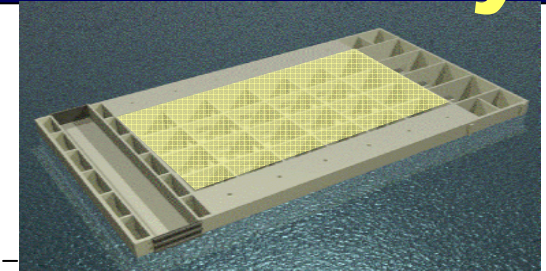
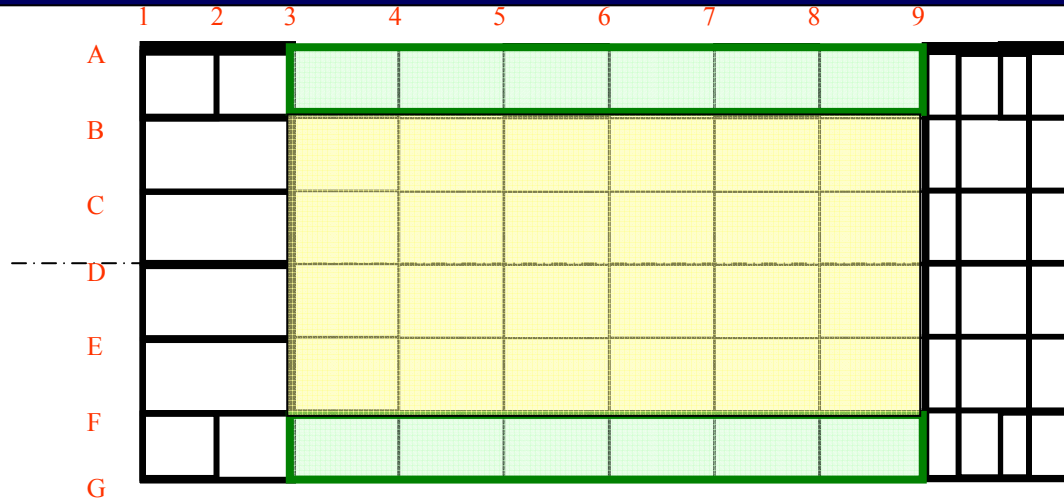


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Phase 3A:
CONSTRUCTION deck BF_39

DRAFT	11.5 ft
FREEBOARD	5.5 ft
KEEL CLEARANCE	15.5ft

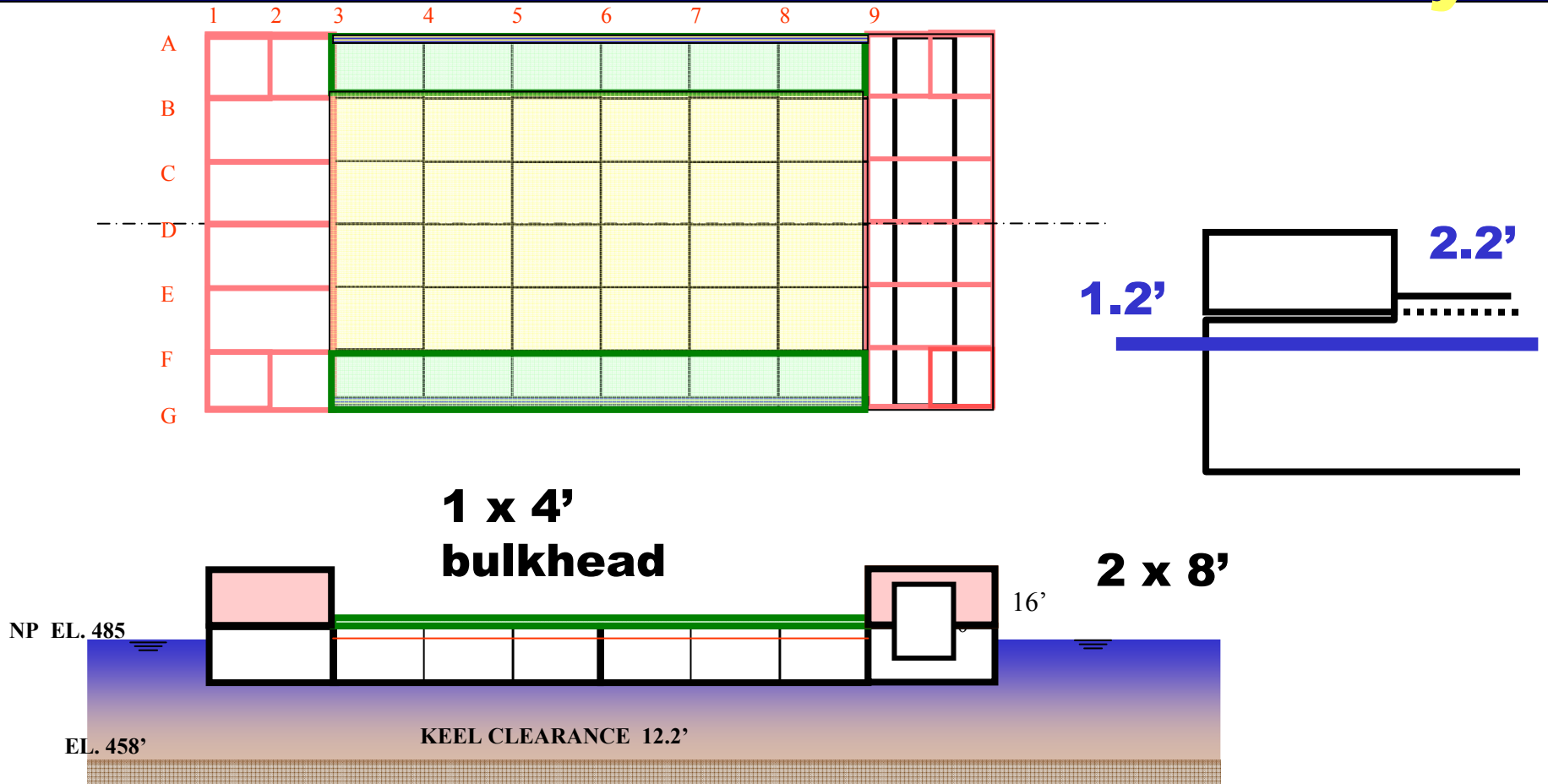


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Phase 3B: SHAFTS, height 0-16 ft

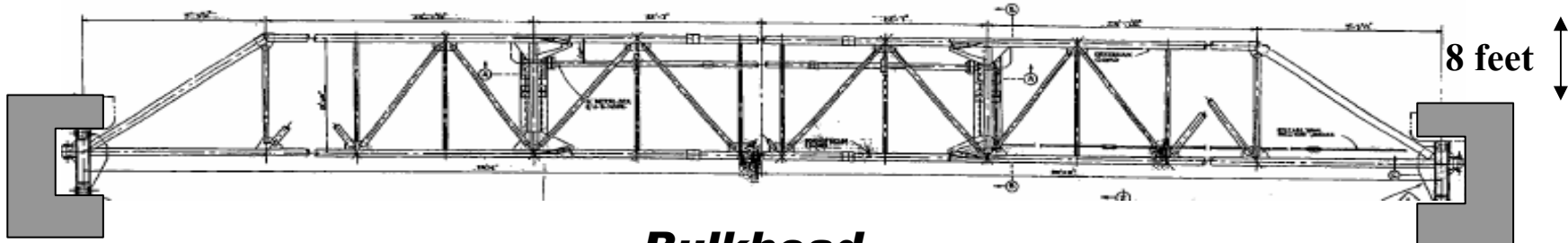
DRAFT	14.8 ft
FREEBOARD	2.2 ft
KEEL CLEARANCE	12.2ft



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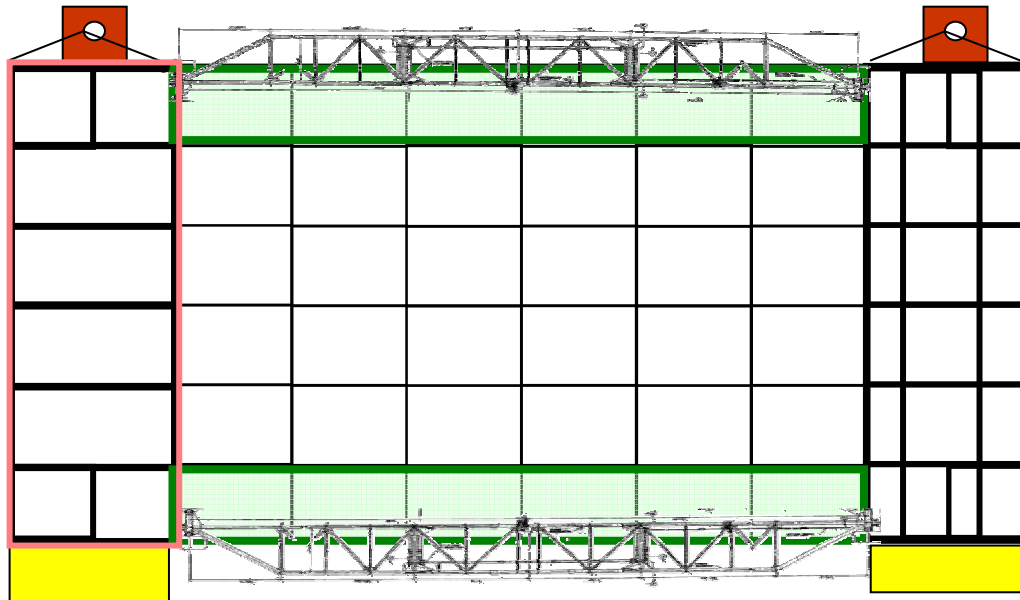
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Bulkhead

Protective Barge



**Spacer
pontoons**

**Pontoons
40'x 8'x 8'**

Cofferdam

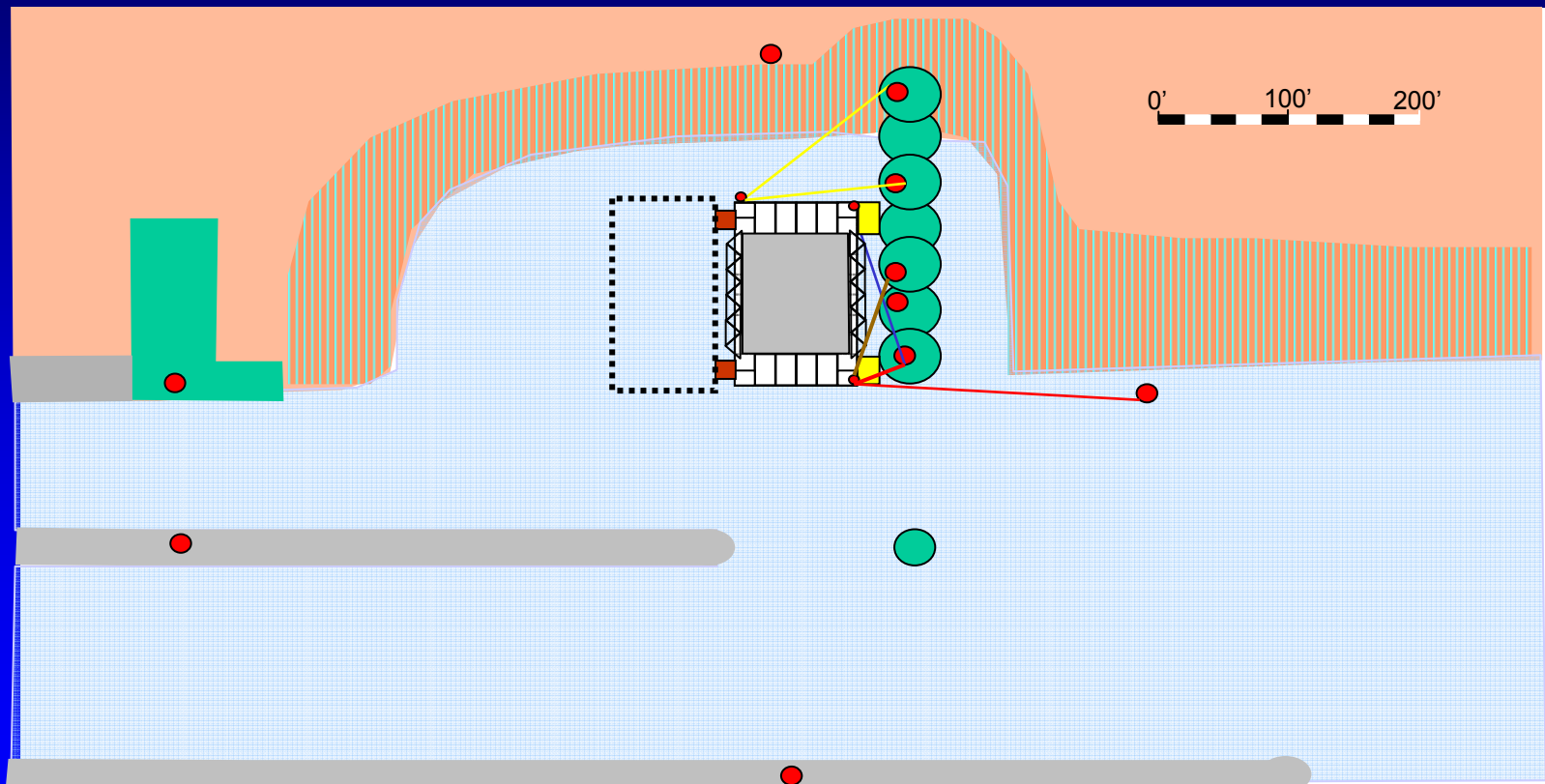


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Mooring Configuration During Floating Construction

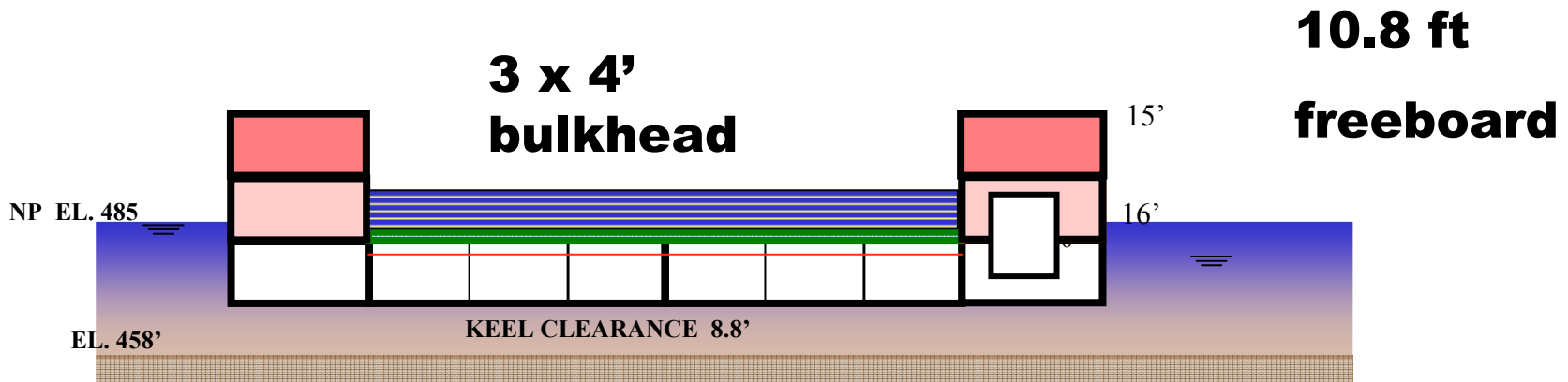
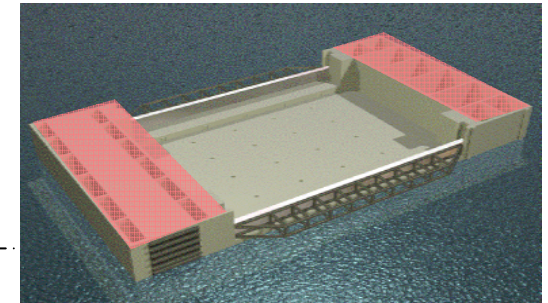
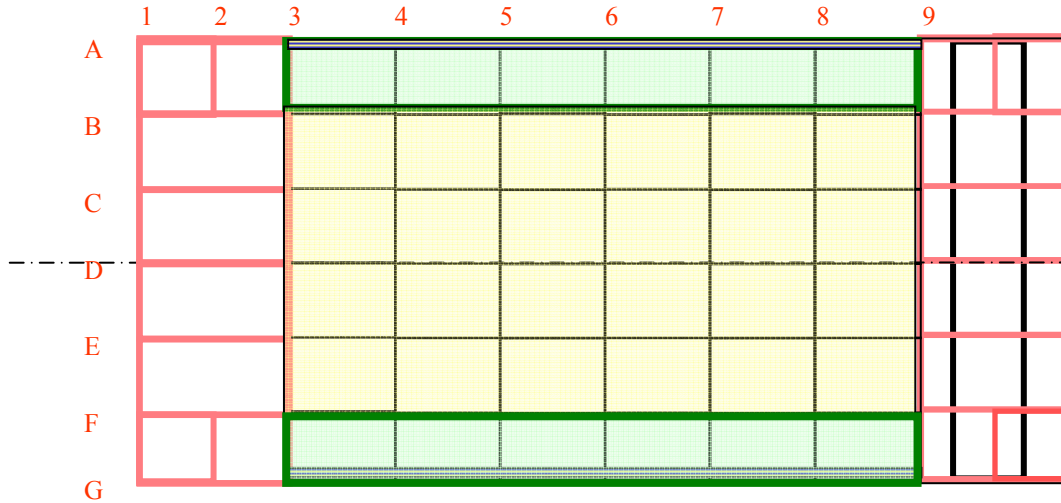


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Phase 3C: SHAFTS, height 16-31 ft

DRAFT	18.2 ft
FREEBOARD	8.8 ft
KEEL CLEARANCE	8.8 ft

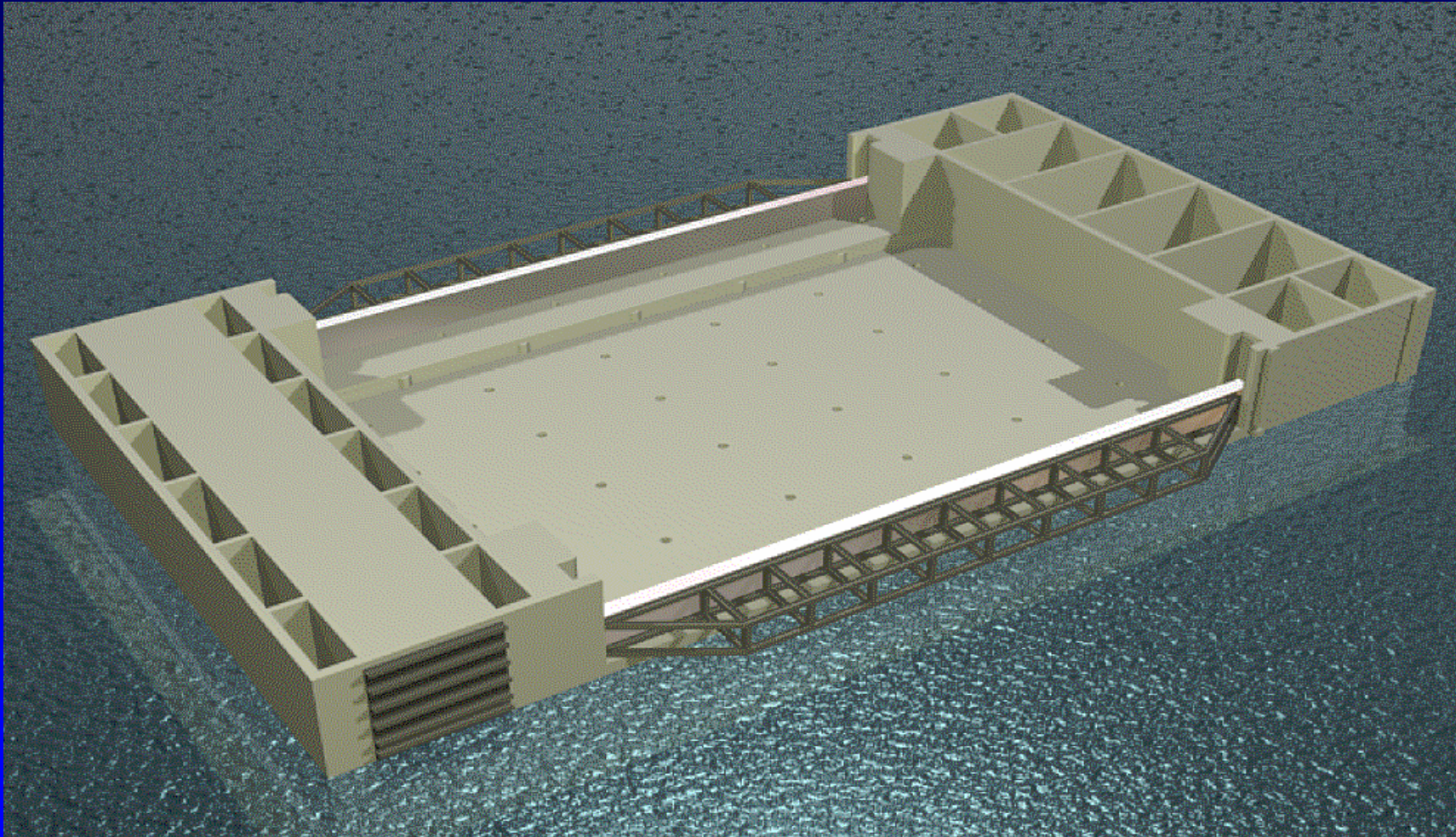


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Phase 3C: SHAFTS, height 16-31 ft, incl. bulkheads

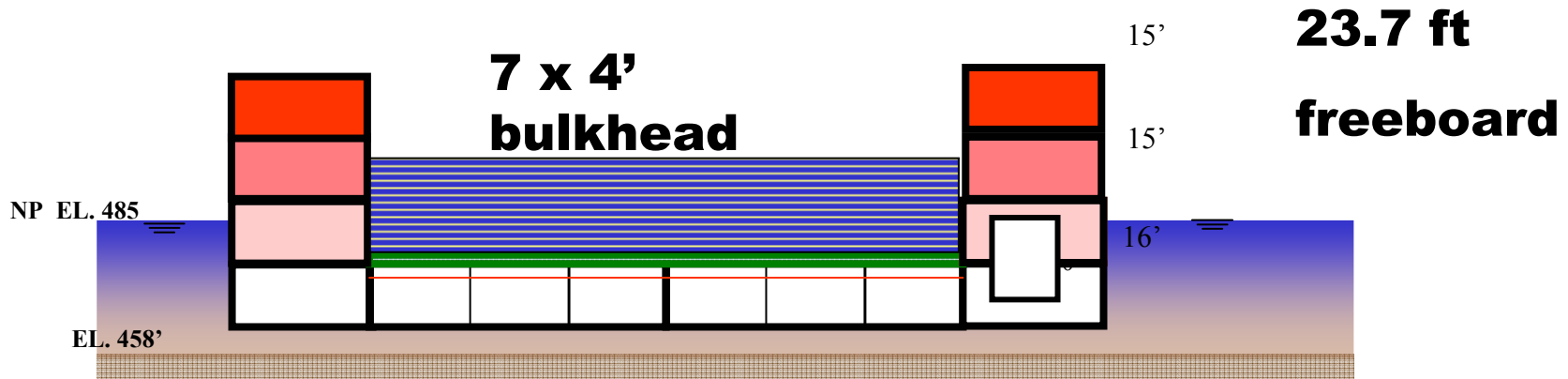
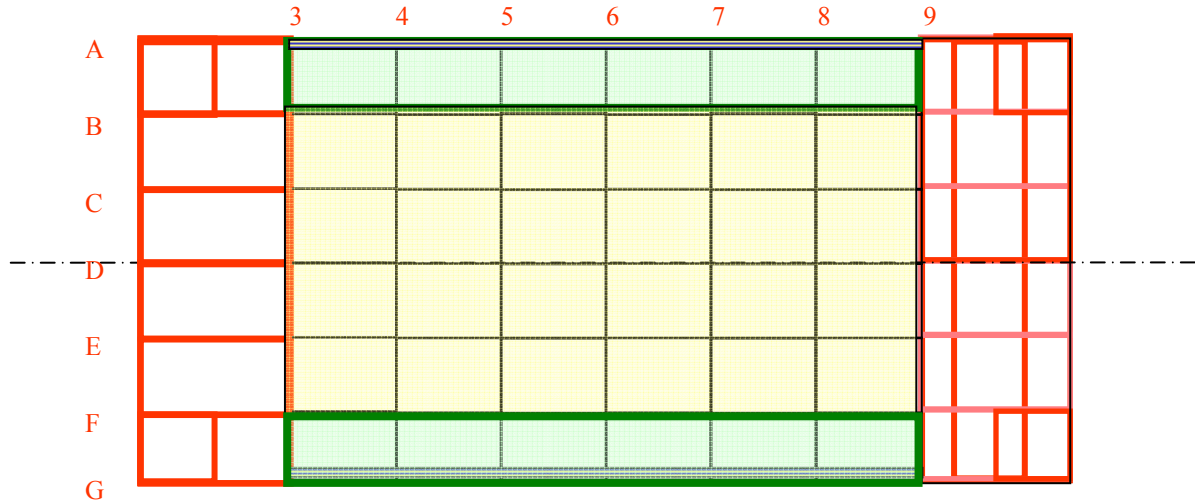


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Phase 3D: SHAFTS, height 31-46 ft

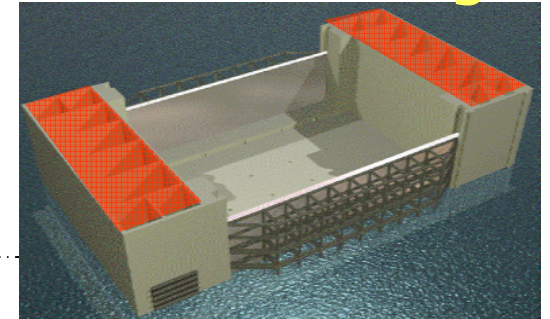
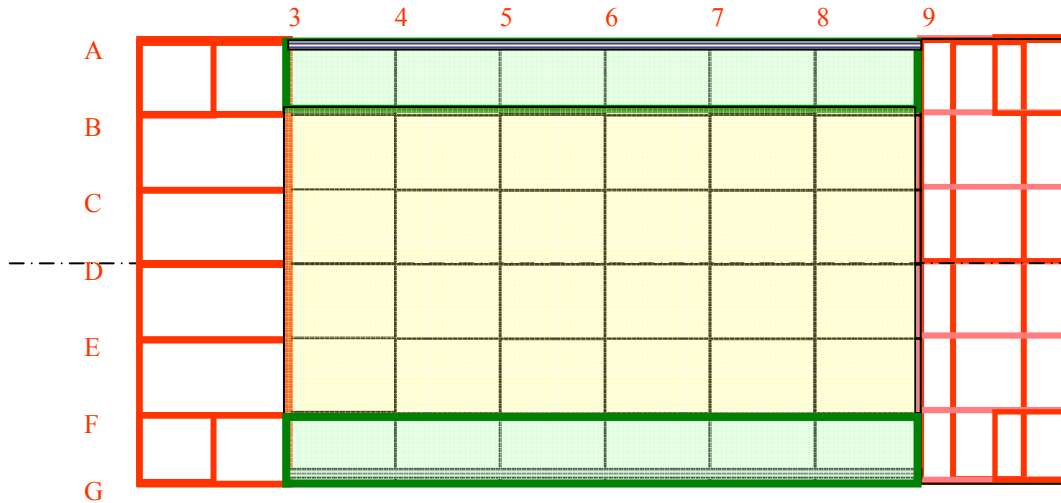
DRAFT	21.3 ft
FREEBOARD	5.7 ft
KEEL CLEARANCE	5.7 ft



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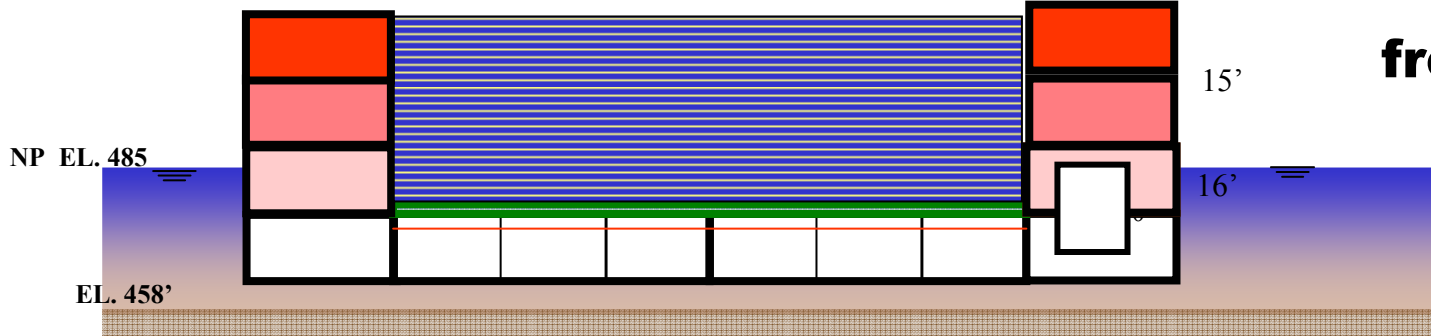


8 x 4' bulkhead

15'

39.5 ft

freeboard



Phase 3E: Preparation for immersion

DRAFT	21.5 ft
FREEBOARD	40.5 ft
KEEL CLEARANCE	5.5 ft

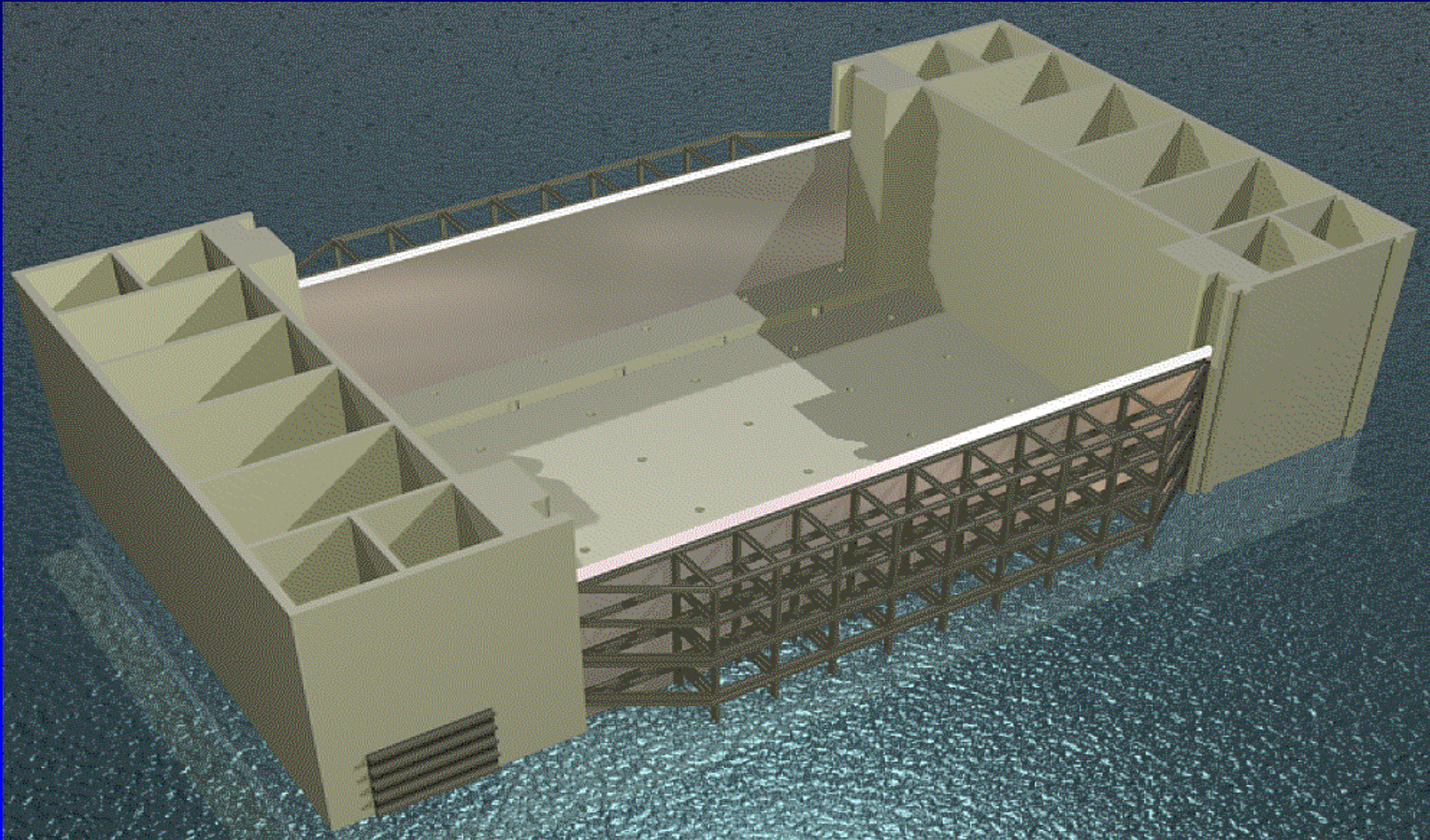


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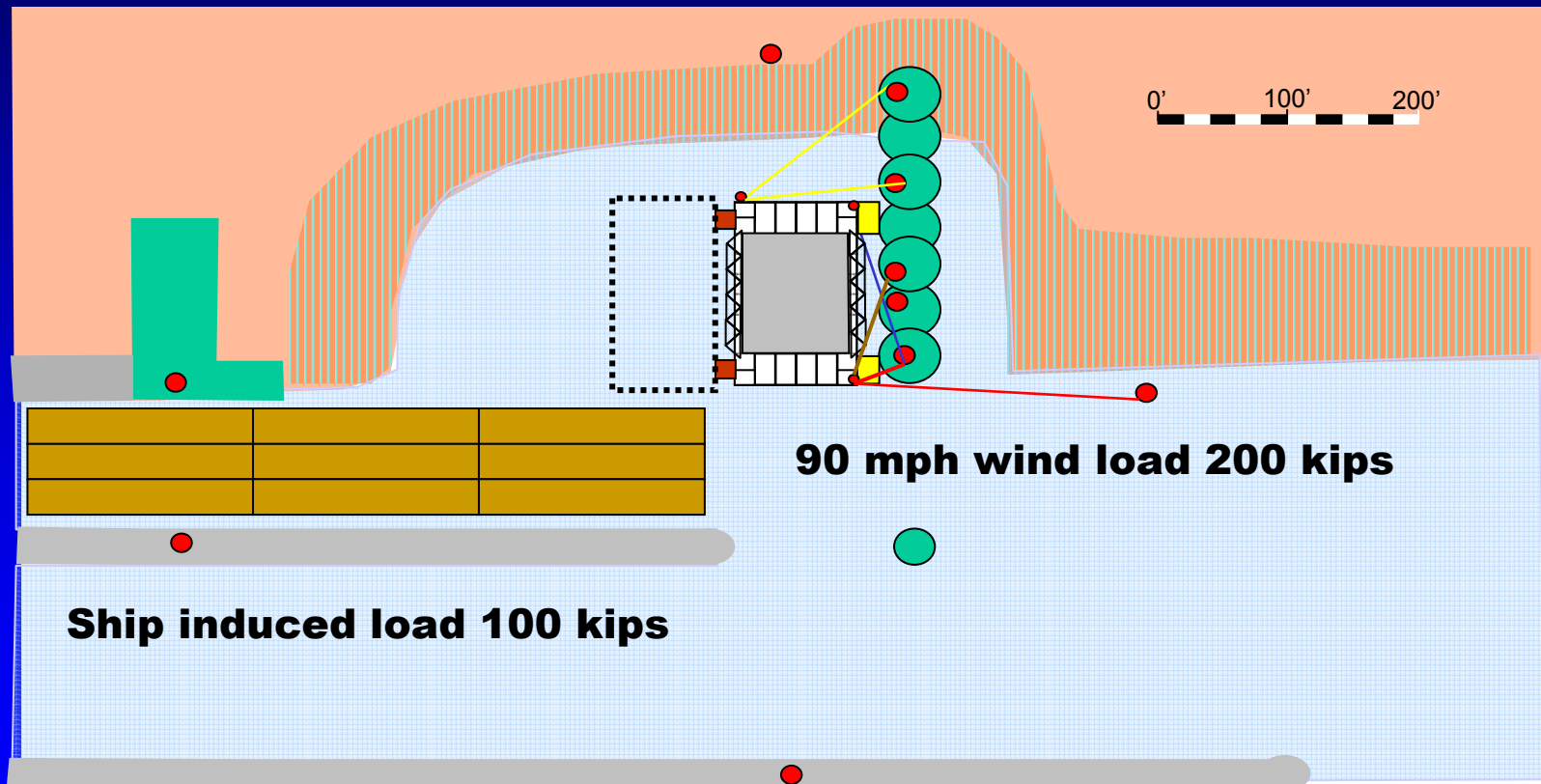
Phase 3E: Ready for Immersion



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Mooring Configuration During Floating Construction

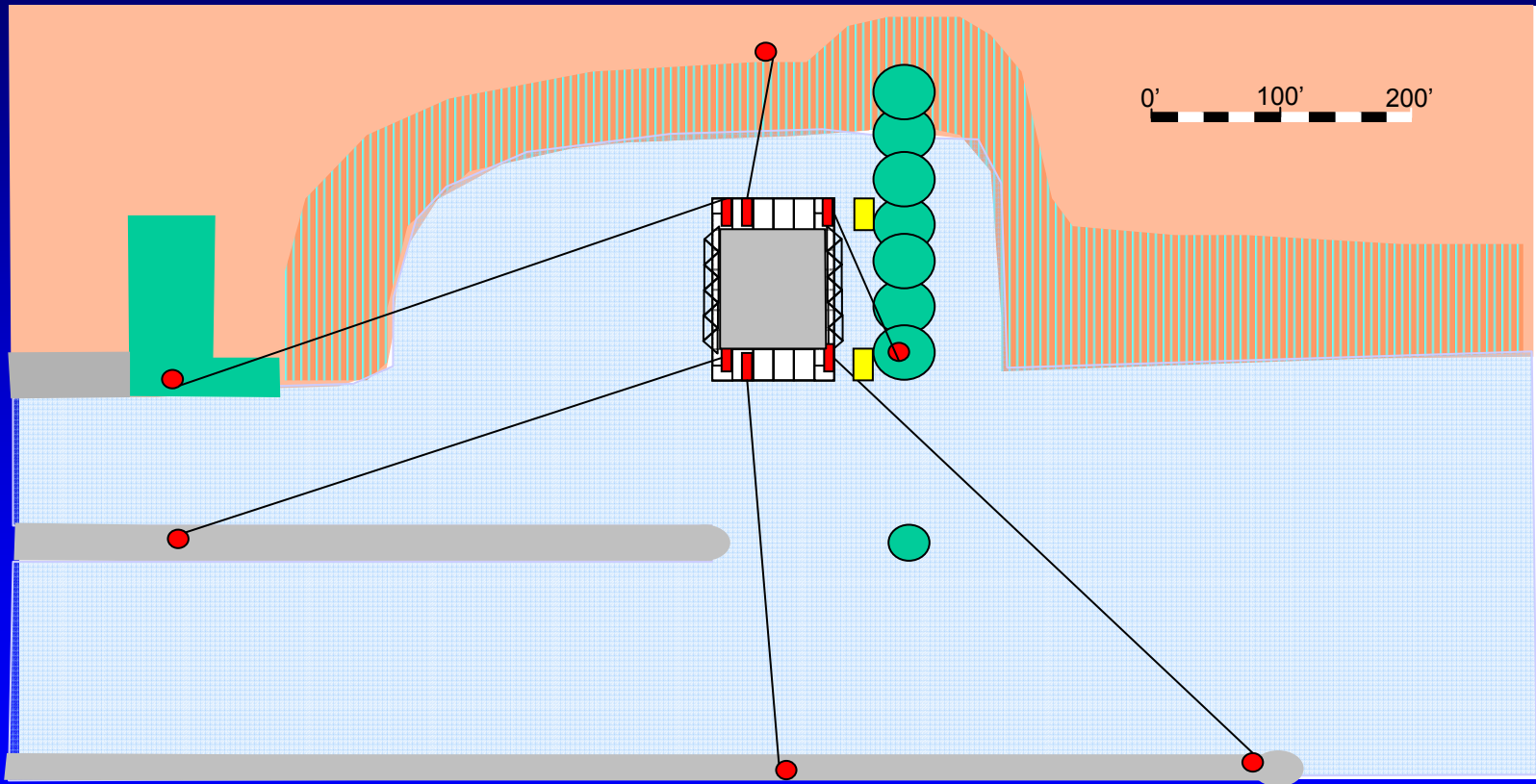


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Start Ballasting at Deep Draft Location

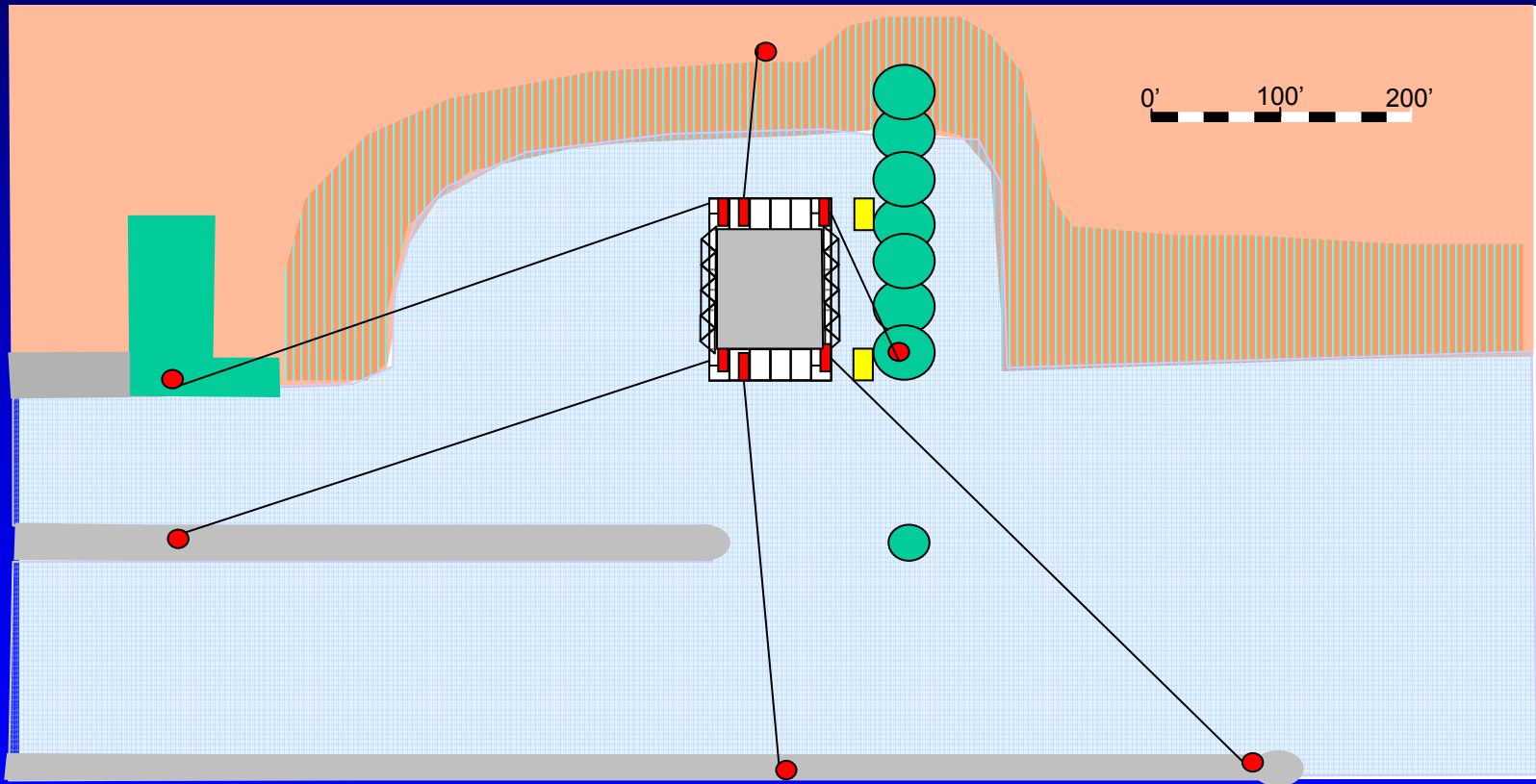


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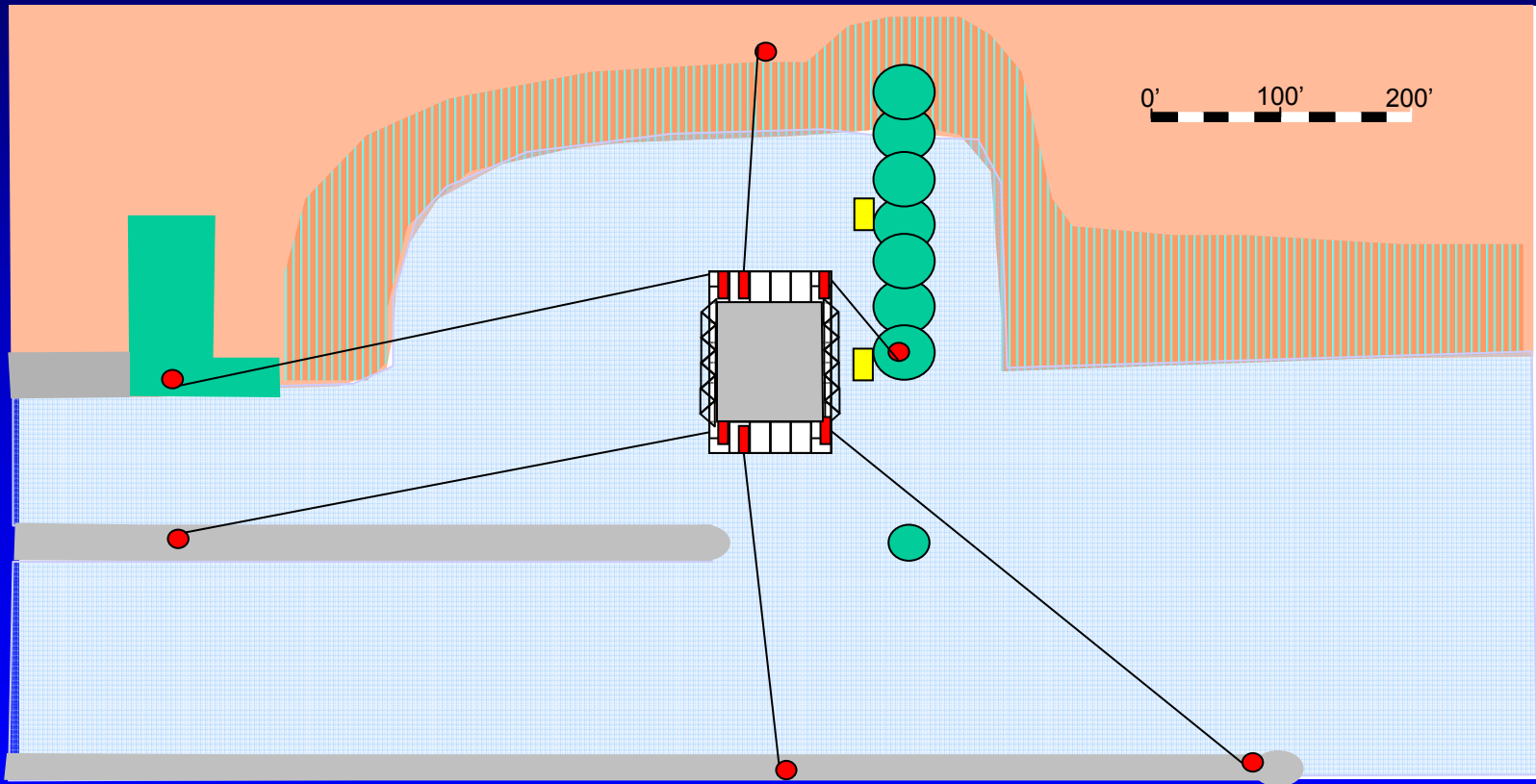


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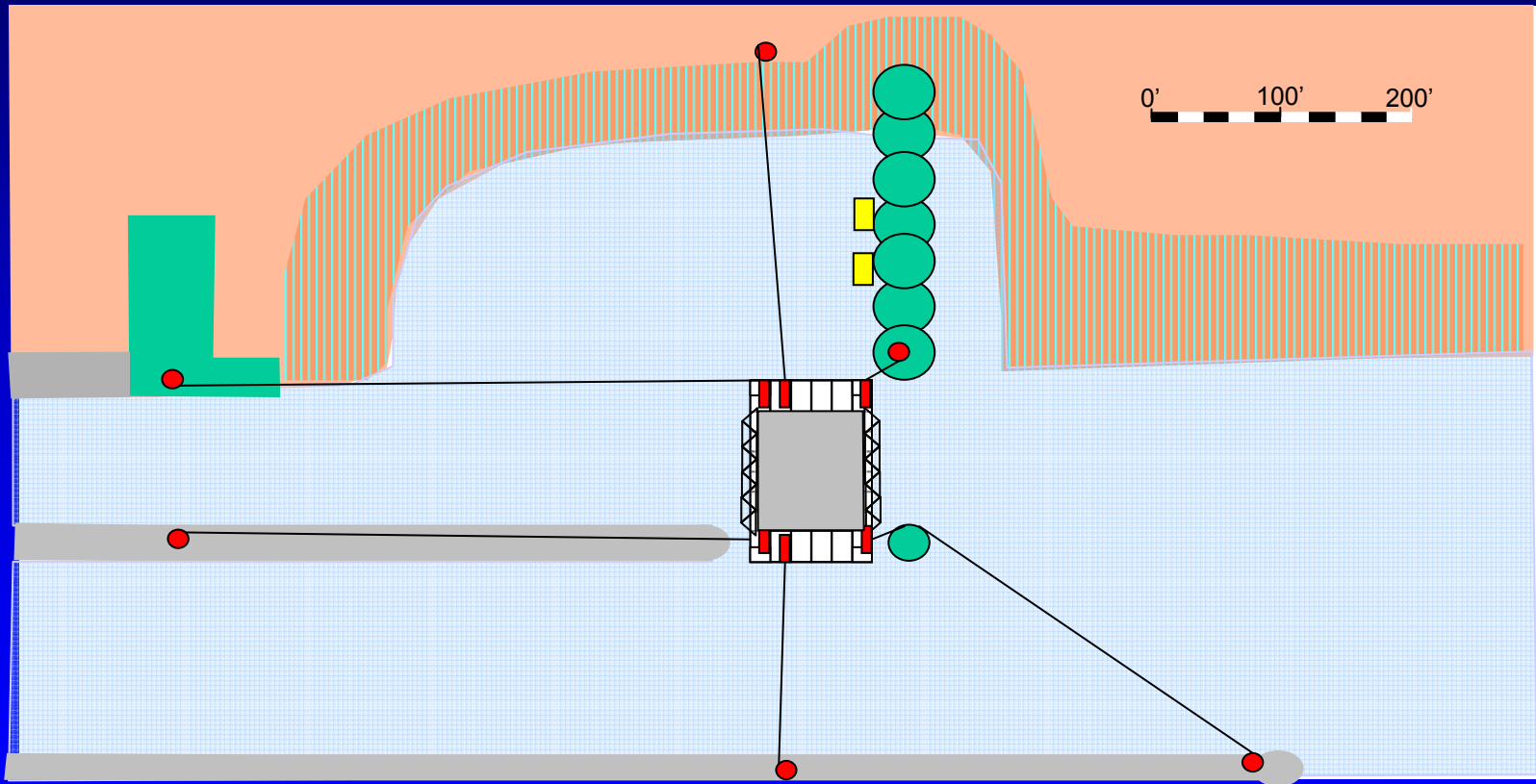


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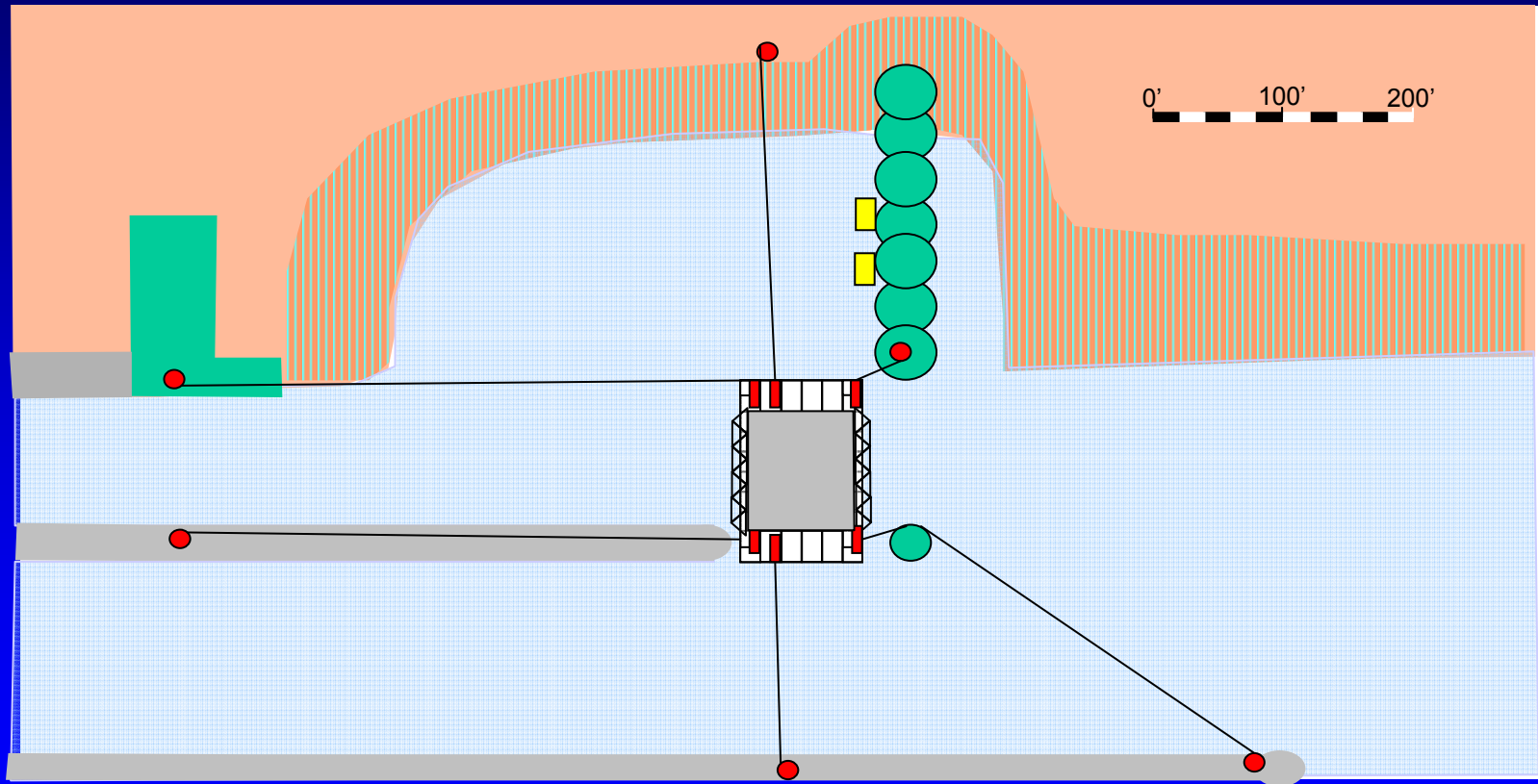


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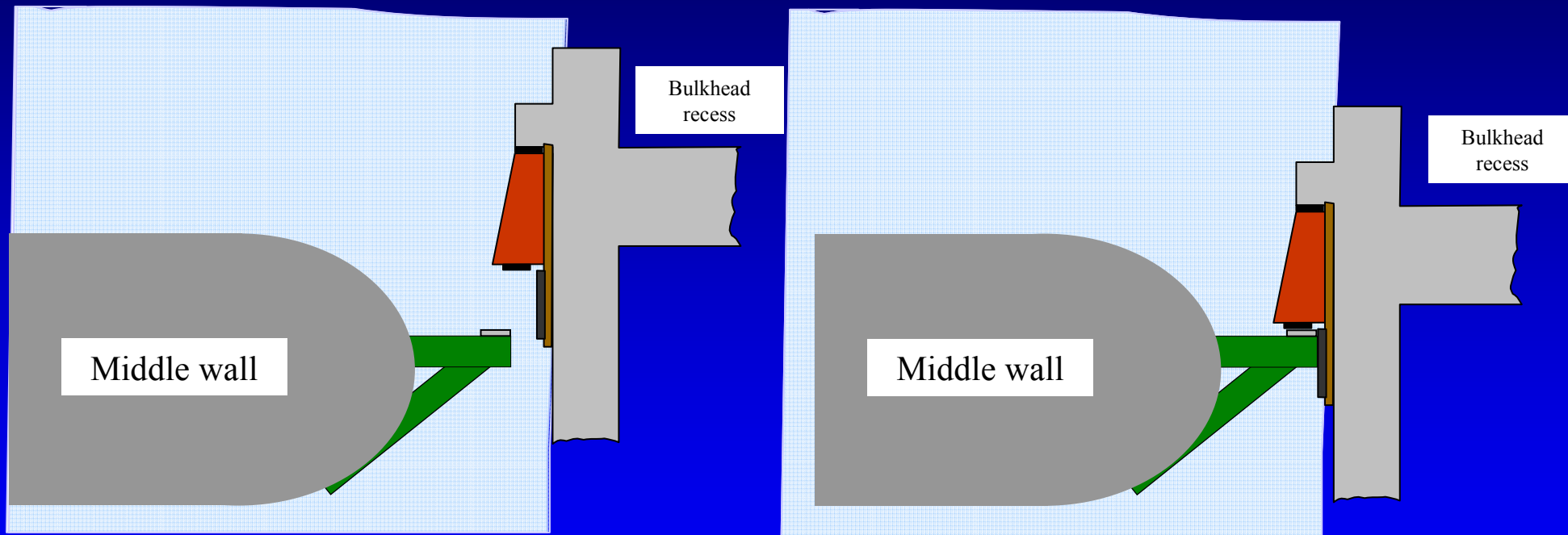
Pitching Set-Down Guide



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**Downstream
Middle Wall**

Final Position

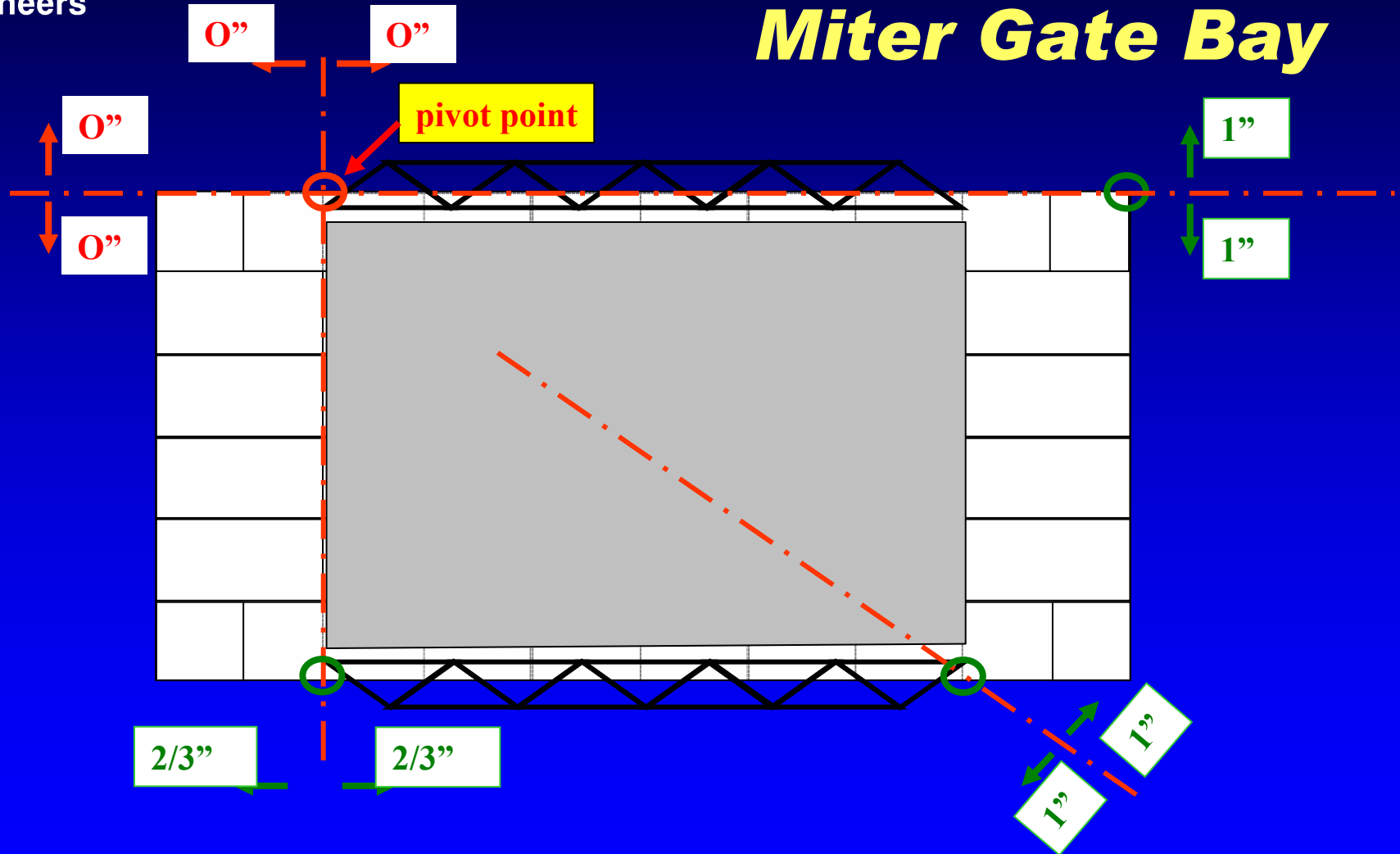
Set-Down Guide



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Installation Tolerances

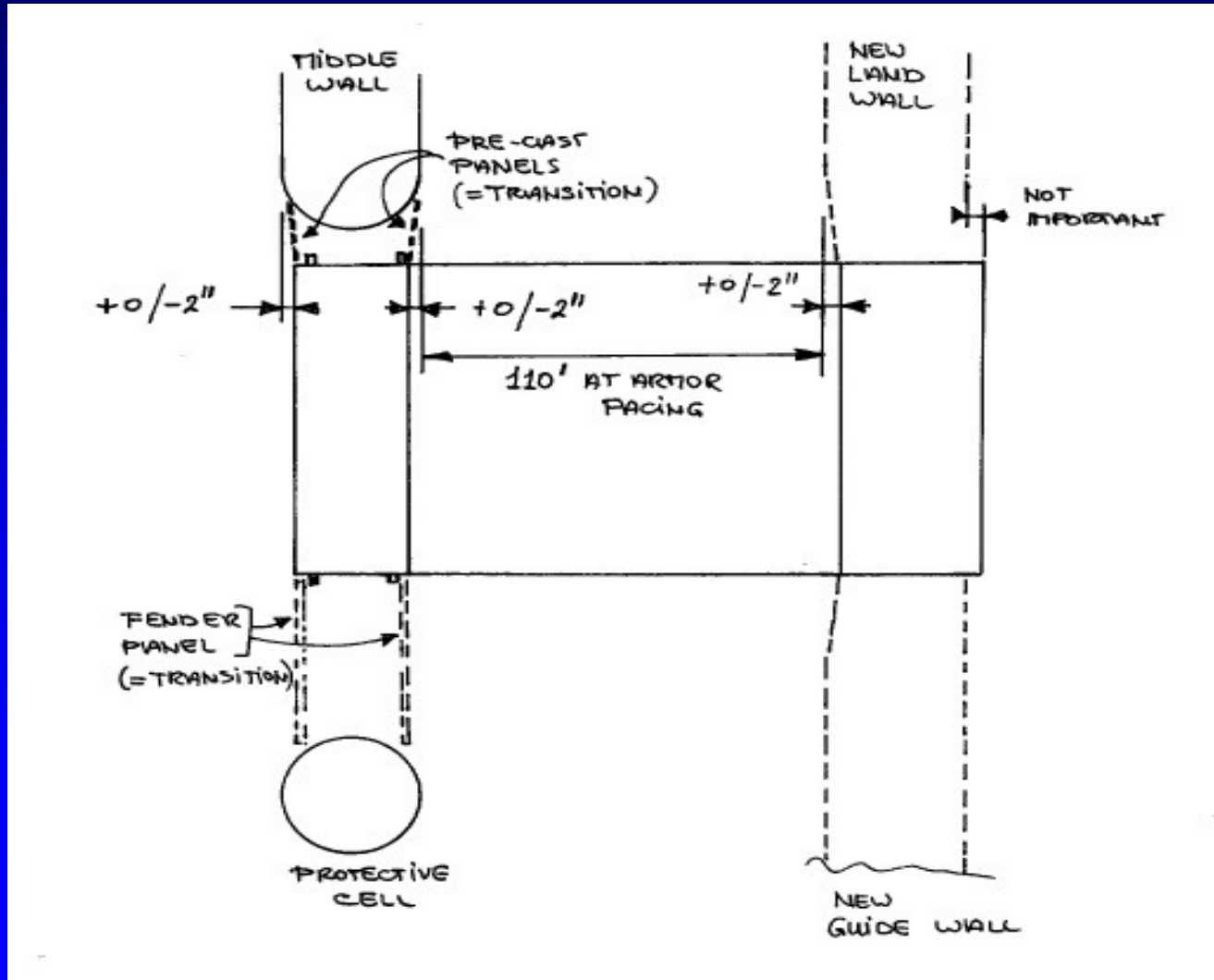


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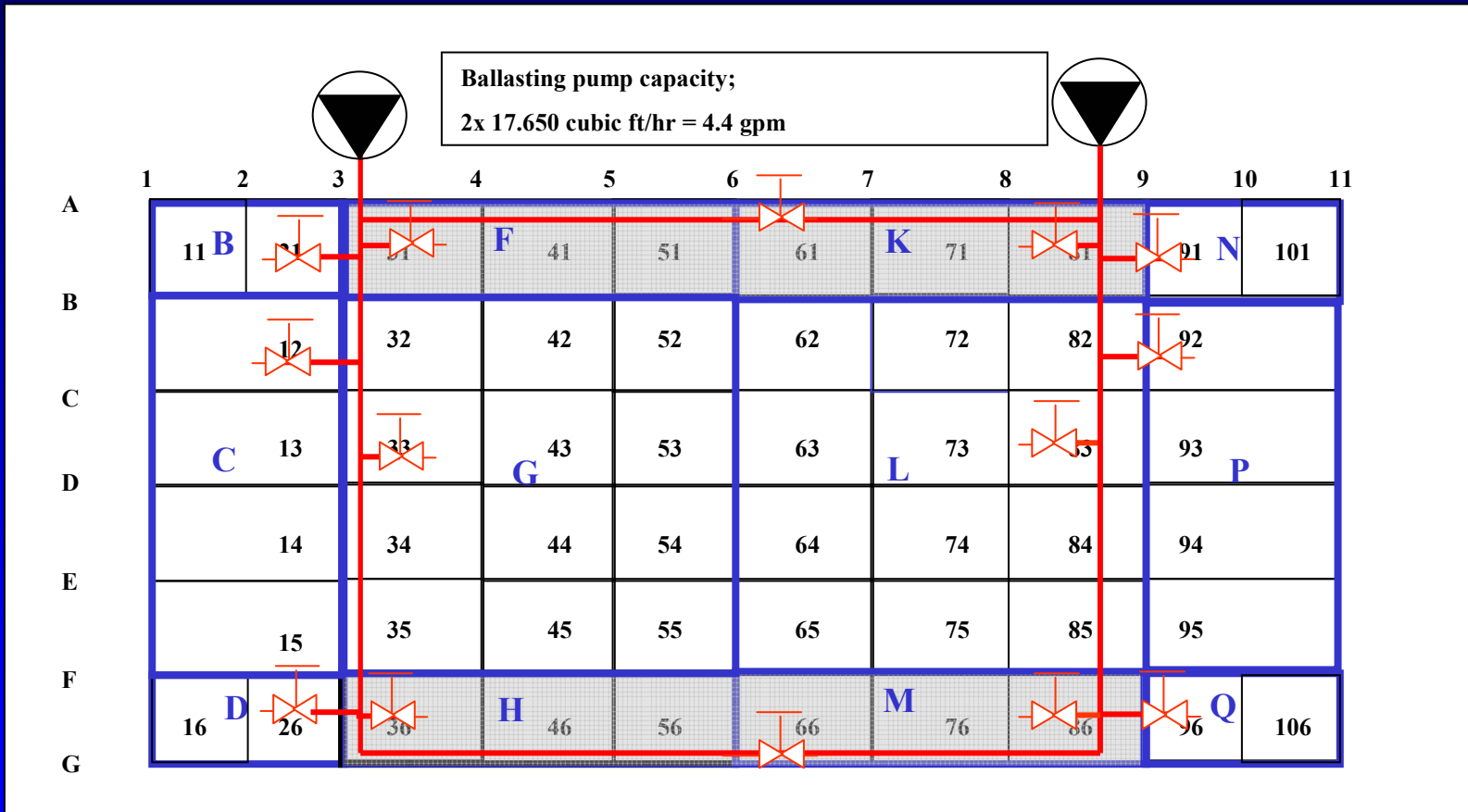
Water Ballast System



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Ballast System



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Piping Water Ballast System

Great Belt Bridge Denmark - Installation Pylon Caisson



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Immersion and Set Down

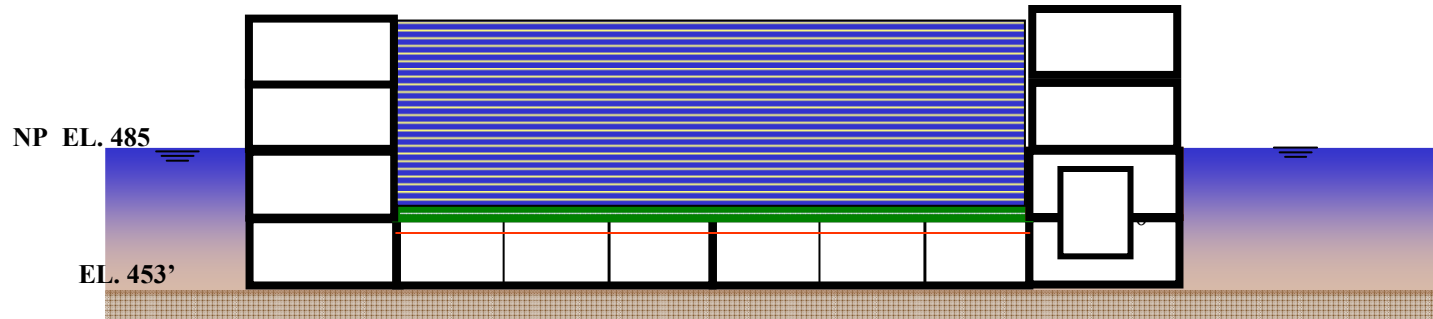
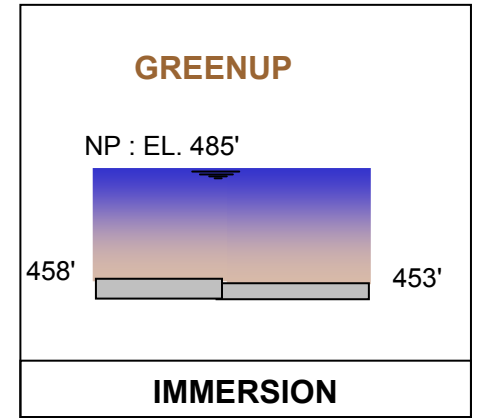
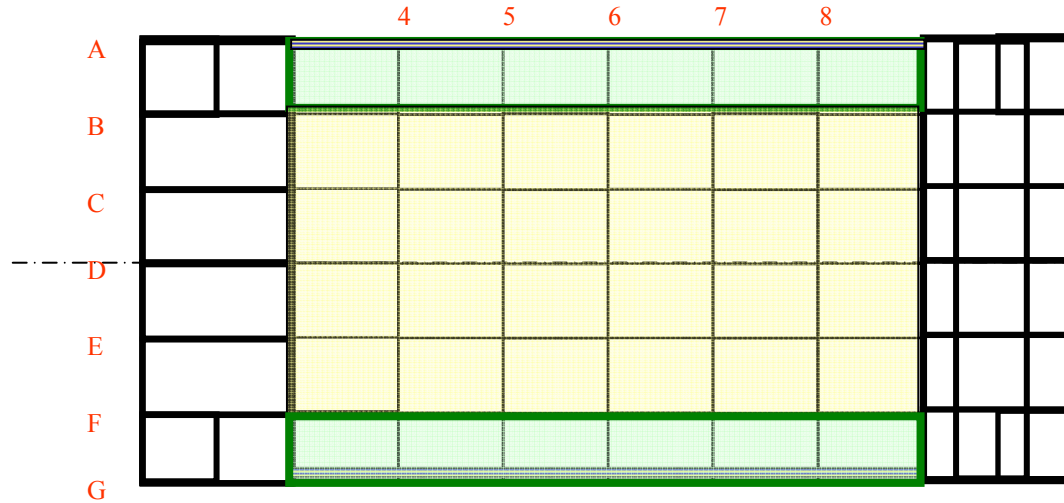


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Phase 4A: Touch down at NP EL 485'

Waterballast (case 2)	7,200 T
Max. immersion speed	3 ft/hr

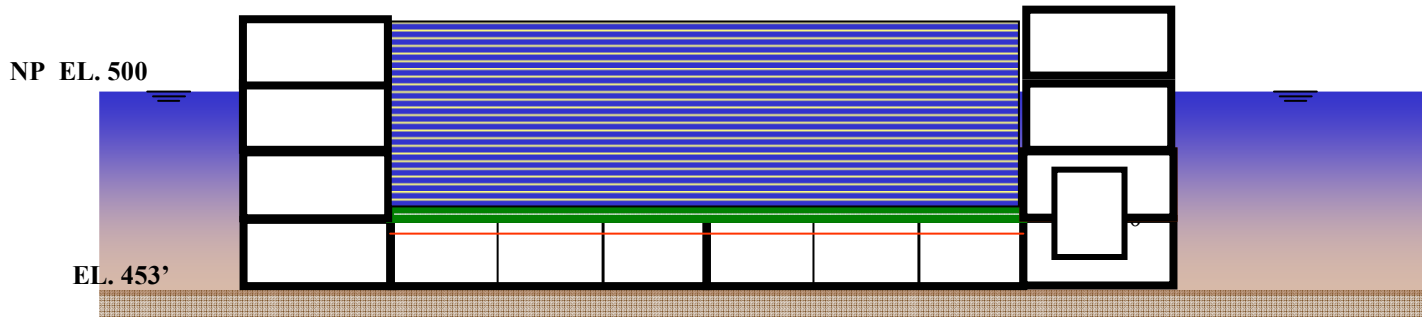
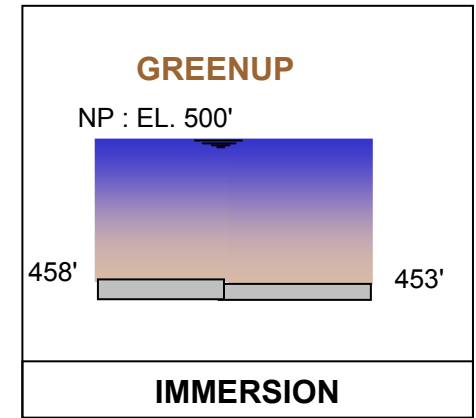
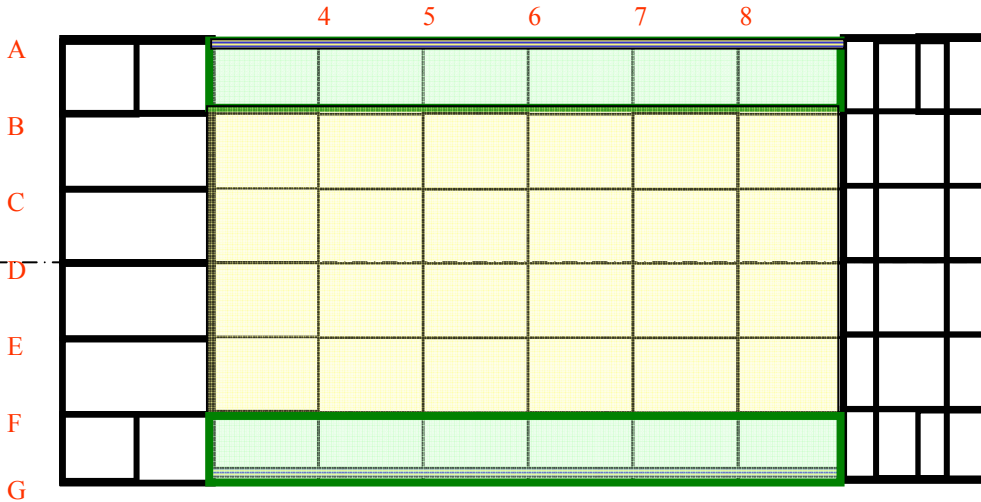


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Phase 4B: Touch down at NP EL 500'

Waterballast (case 2)	16.275 T
Max. immersion speed	3 ft/hr

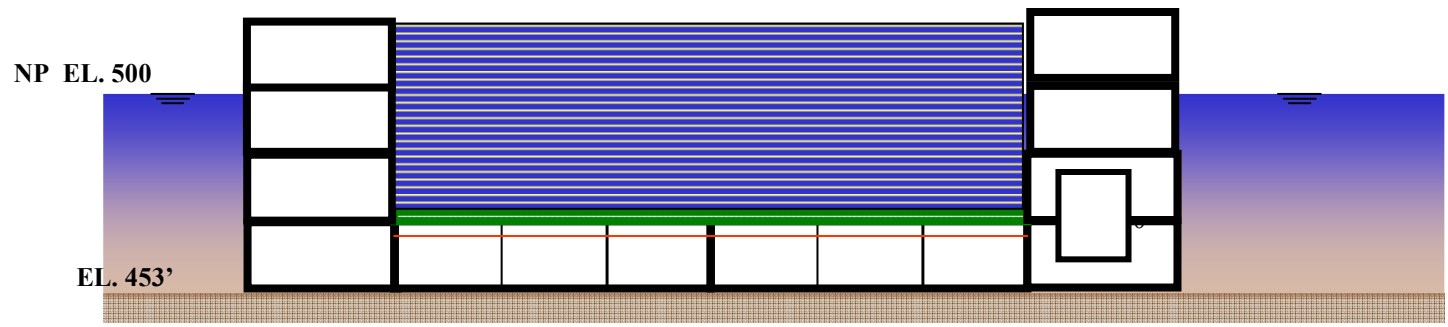
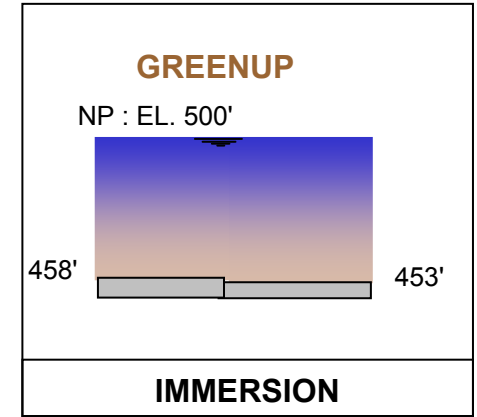
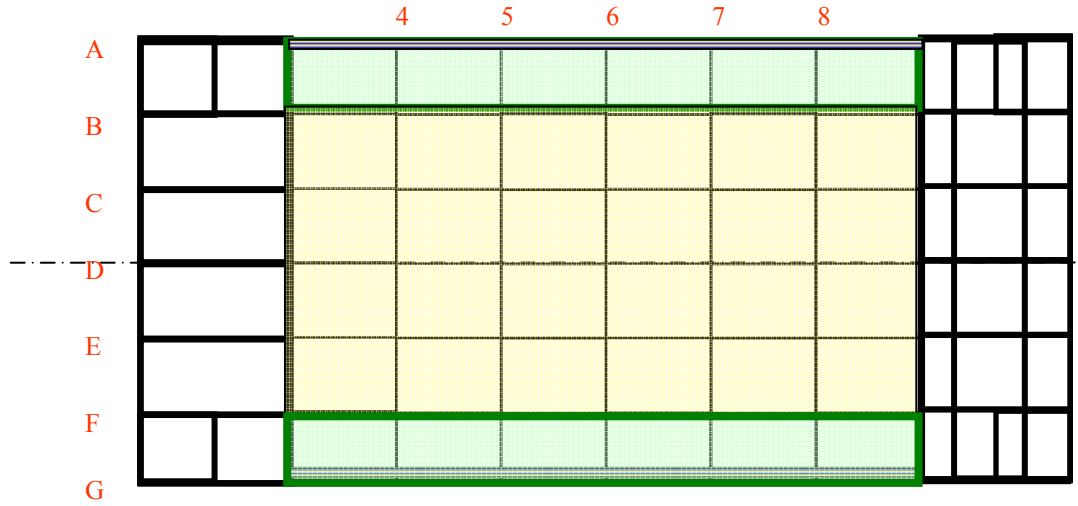


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Phase 4C:
Pre-load 9,000 kip at EL 500'

Waterballast (case 2) 20,800 T
Max. ballasting speed 1,900 T/hr

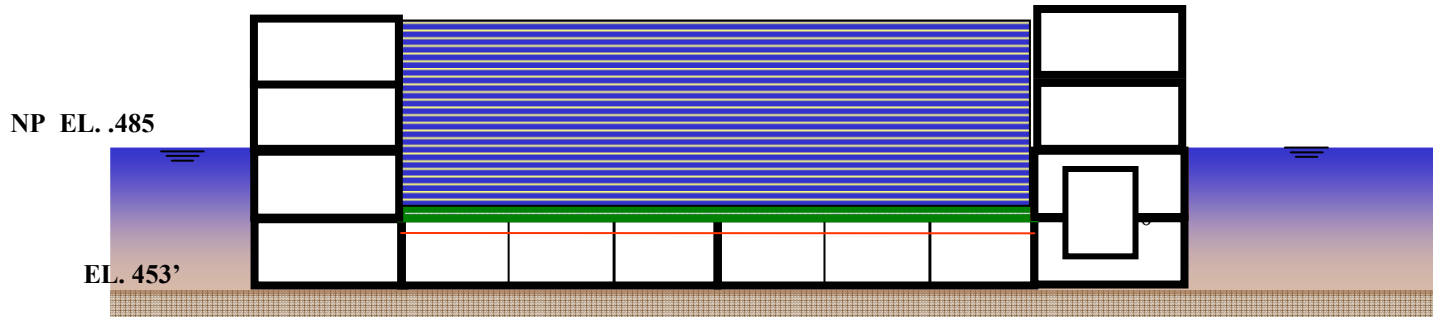
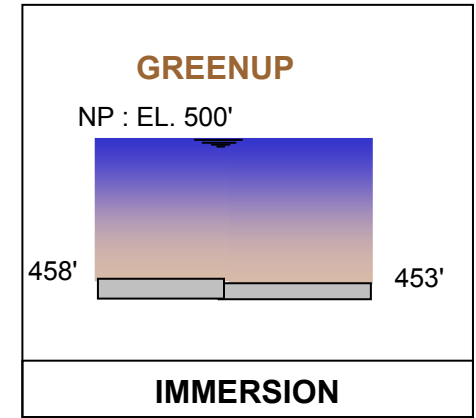
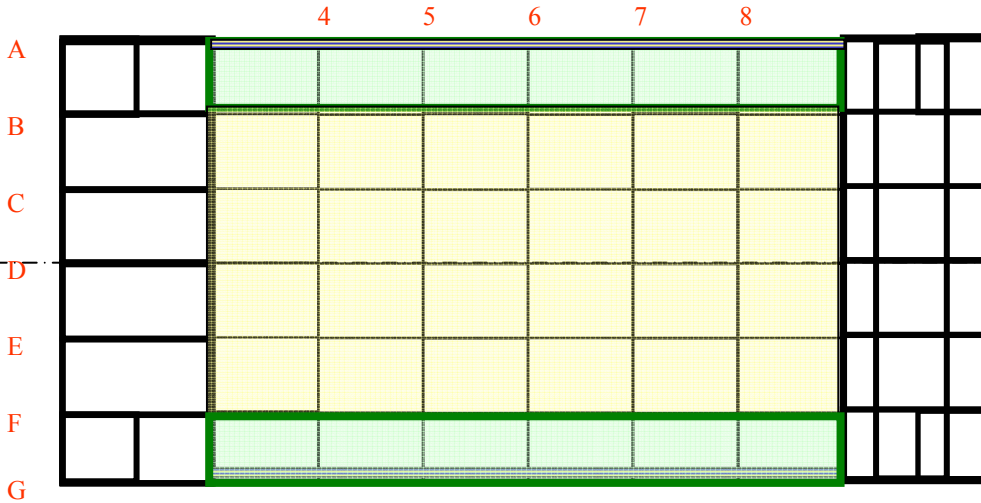


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Phase 4D:
Pre-load 9,000 kip at EL 485'

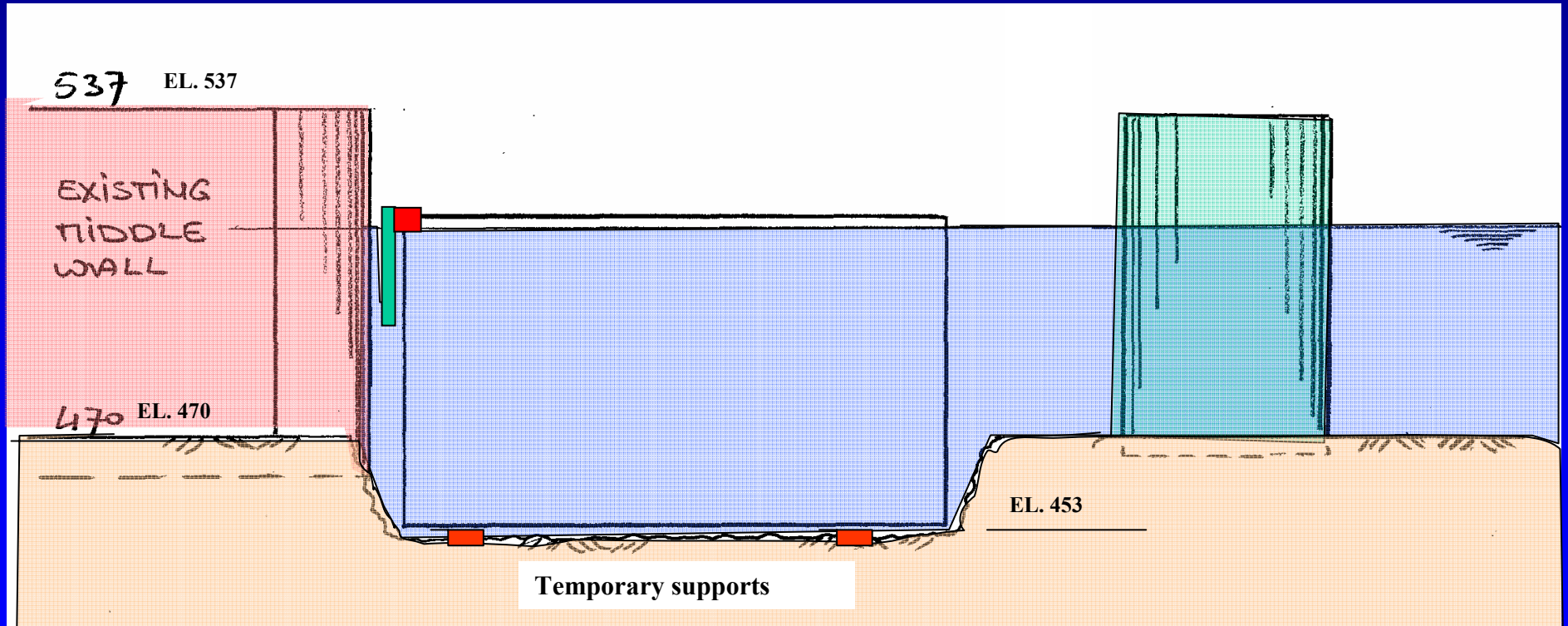
Waterballast (case 2) 11,700 T
Max. ballasting speed 1,900 T/hr



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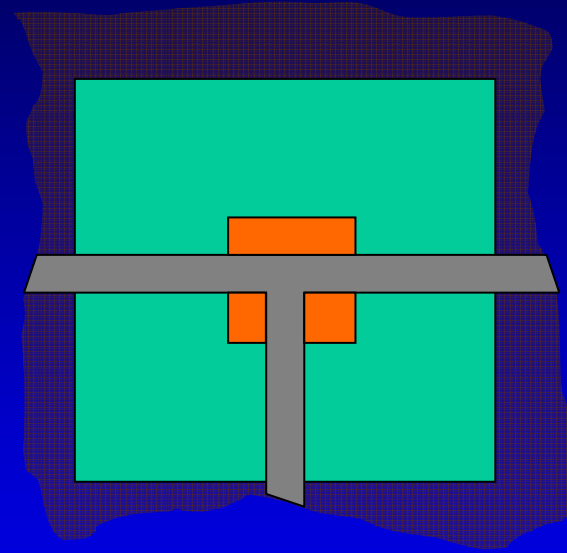
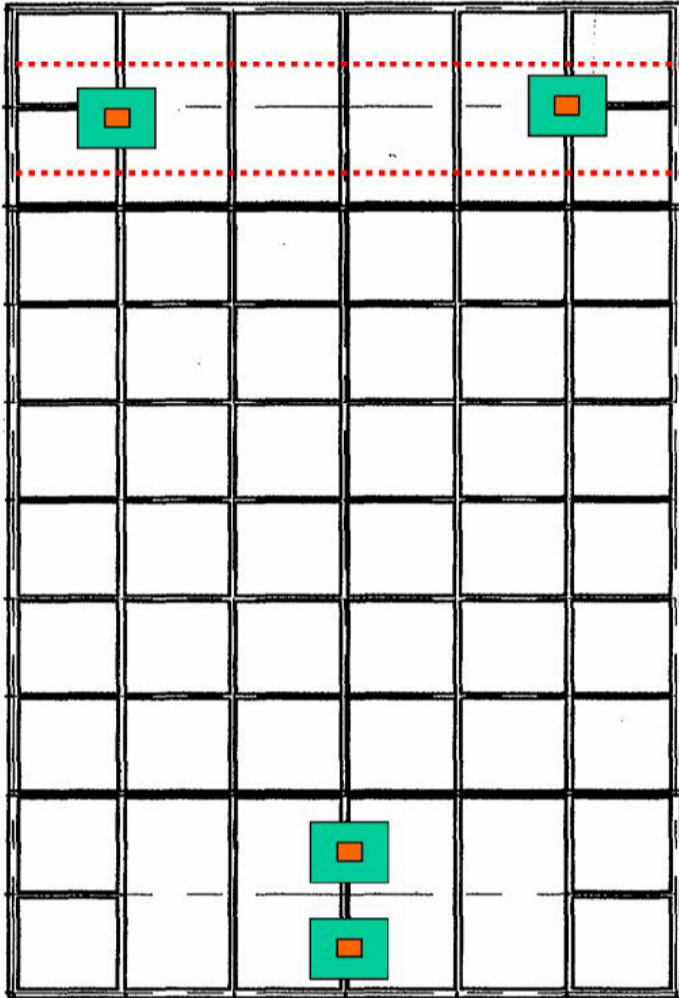


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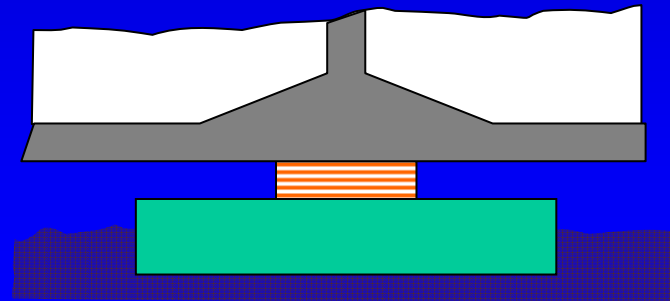
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Slab 10ft x 10ft

Bearing 3ft x 3ft



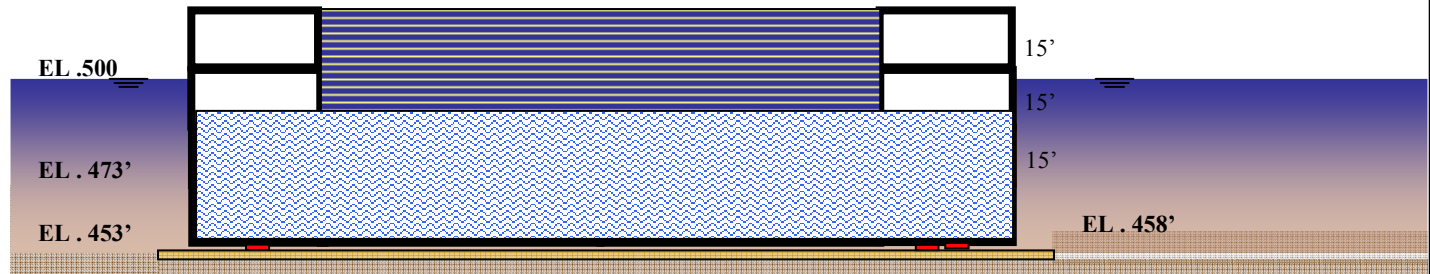
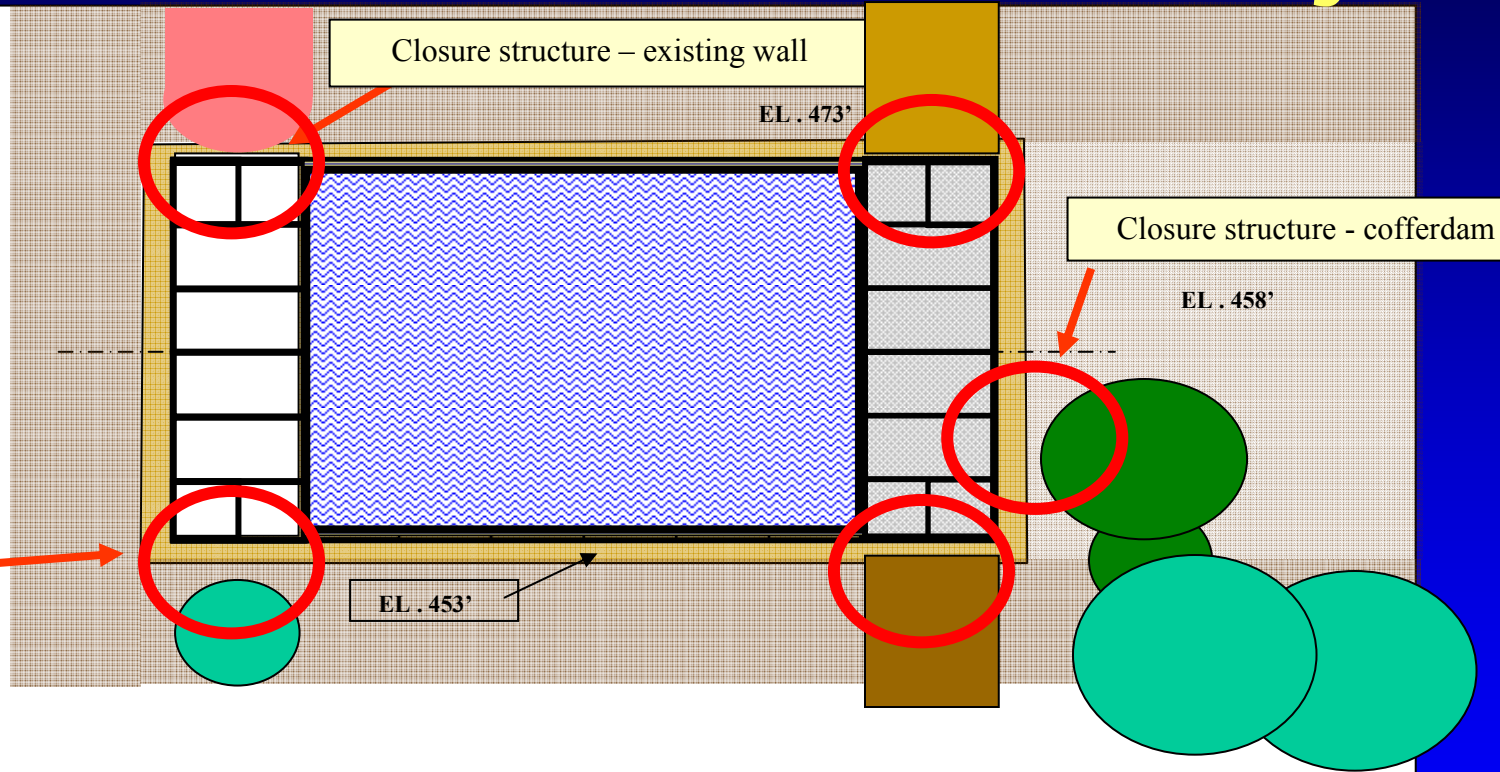
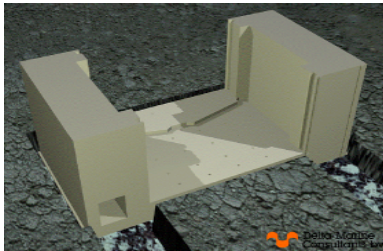
1000 MT Elastomeric bearing



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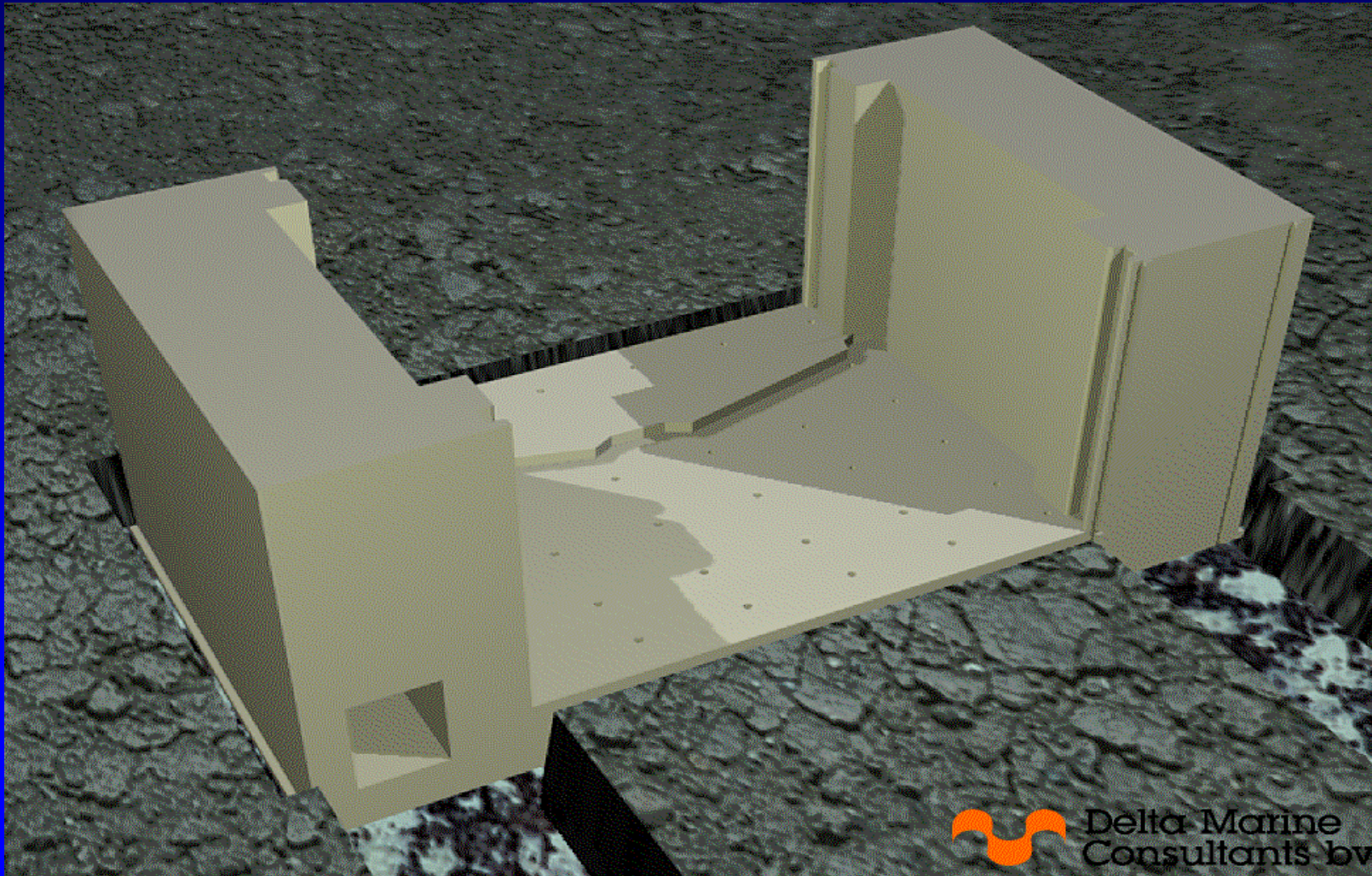


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Delta Marine
Consultants bv



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Project Milestones (with 07 CG Start)

- ◆ **Mooring Cells Construction – 2007 to 2009**
- ◆ **Miter Gate Fabrication – 2007 to 2009**
- ◆ **Lock Extension Construction – 2010 to 2012**
- ◆ **Rehab Main Chamber – 2012 to 2014**
- ◆ **Total Project Completion 2014**



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