MEMORANDUM

DATE: June 21, 2012
TO: Ralph Dollhopf, United States Environmental Protection Agency (U.S. EPA)
FROM: Christopher Haux, Enbridge Energy, Limited Partnership (Enbridge)
Re: 2012 Morrow Lake Delta Containment Strategy
Design and Engineering Considerations

1.0 INTRODUCTION

This memorandum addresses the U.S. EPA Directive dated May 30, 2012 regarding the installation of E 4.5 and the alternate solutions proposed by Enbridge. This document summarizes the engineering considerations relating to the design of the alternate containment measures being implemented within the Morrow Lake Delta and neck area. Attached to this memorandum are associated figures and engineering calculations providing additional information regarding the containment measures.

2.0 ENGINEERING DESIGN CONSIDERATIONS

The following considerations were evaluated in order to plan for anticipated high flow events and to ensure sustainability and maintenance.

1. A maximum flow rate of 5,000 cfs was assumed for design calculations to ensure sustainability and maintenance. Further evaluation will occur based upon changing flow conditions and current.

2. Subsurface flows for anchoring of ballast and curtain ballast: Subsurface conditions include flow and velocity, sediment loading, and river bed substrate.

3. Evaluation of forces acting upon components of the system including surface boom, curtain, and anchor points. This includes forces caused by flow, wind loading, and debris movement. This information is detailed in the attached drawing.

4. Sequence of construction: The boom will be installed downstream to upstream, starting installation at the bottom of E 4. The sequence is identified by numbering as shown on the attached 2012 Spring Proposed Boom Locations.

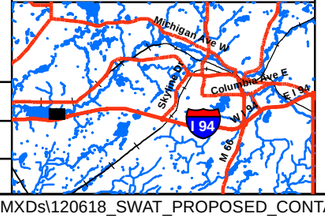
5. Construction: The construction as shown in the attached detailed drawing will consist of in-stream anchors consisting of 2.5-inch schedule 80 PVC pipe with supporting guy wires, containment boom with high tension top cable and shoreline natural anchor, and partial x-tex curtain with adjustable slings to accommodate fluctuating flow rates.

6. Monitoring plan and collection of data: Monitoring of the anchors systems, surface containment boom and subsurface curtain will be completed on a daily basis for the first week following installation to ensure the integrity of the containment system. Further monitoring will be completed during high flow events or other fluctuations in the water levels or velocities. Visual inspection will be completed for the containment system as well as video documentation of the subsurface ballast chain to ensure that the desired position is sustained.

ENBRIDGE

Drawn:	JW	6/18/2012
Approved:	KK	6/18/2012
Project #:	60246209	

Map Location



Legend

- Anchors
- Water Pipeline Morrow Lake
- Proposed Containments
- Quarter Mile Grid Segments

N

0 125 250 500

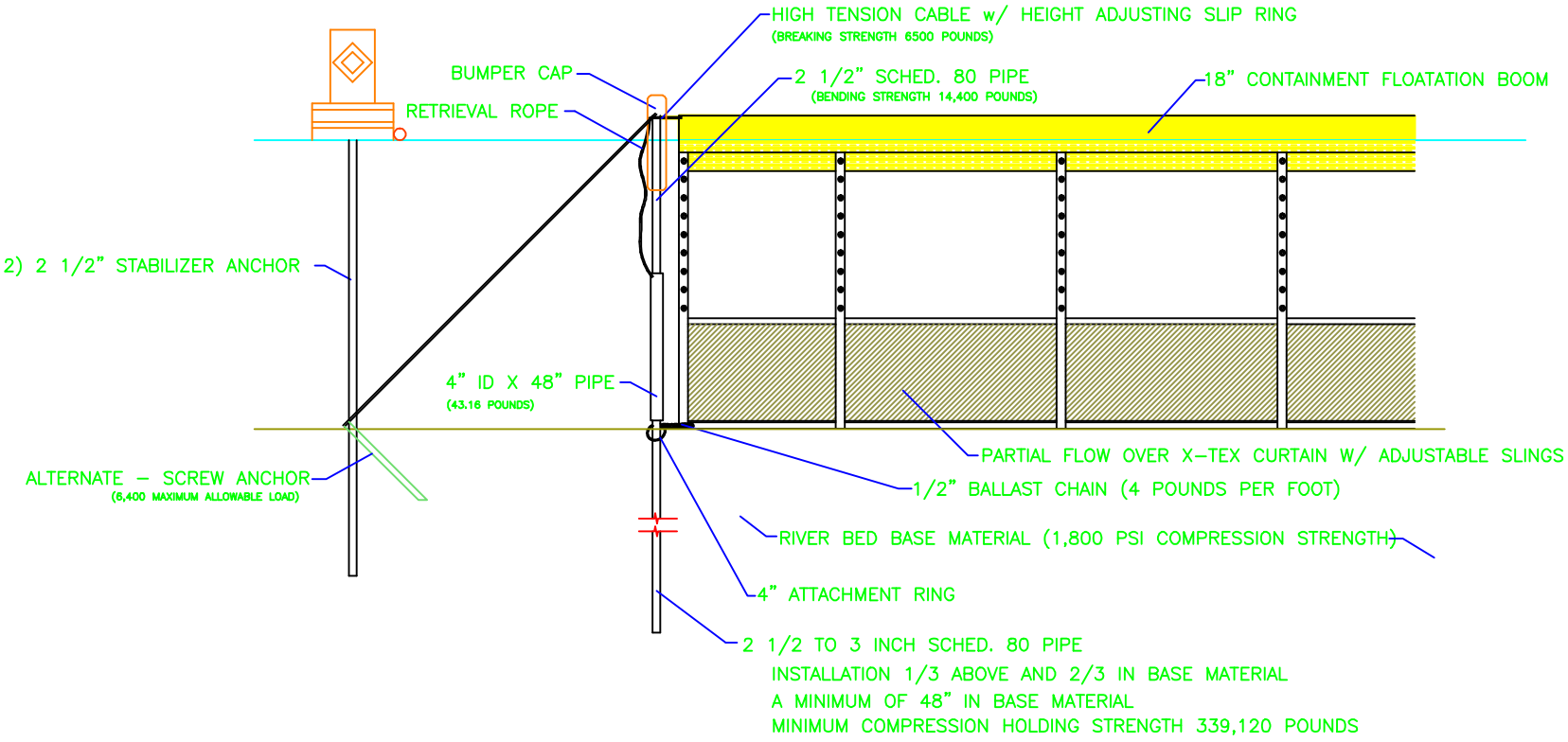
Scale in Feet

2012 SPRING REASSESSMENT
PROPOSED CONTAINMENT LOCATIONS
FIGURE 1

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

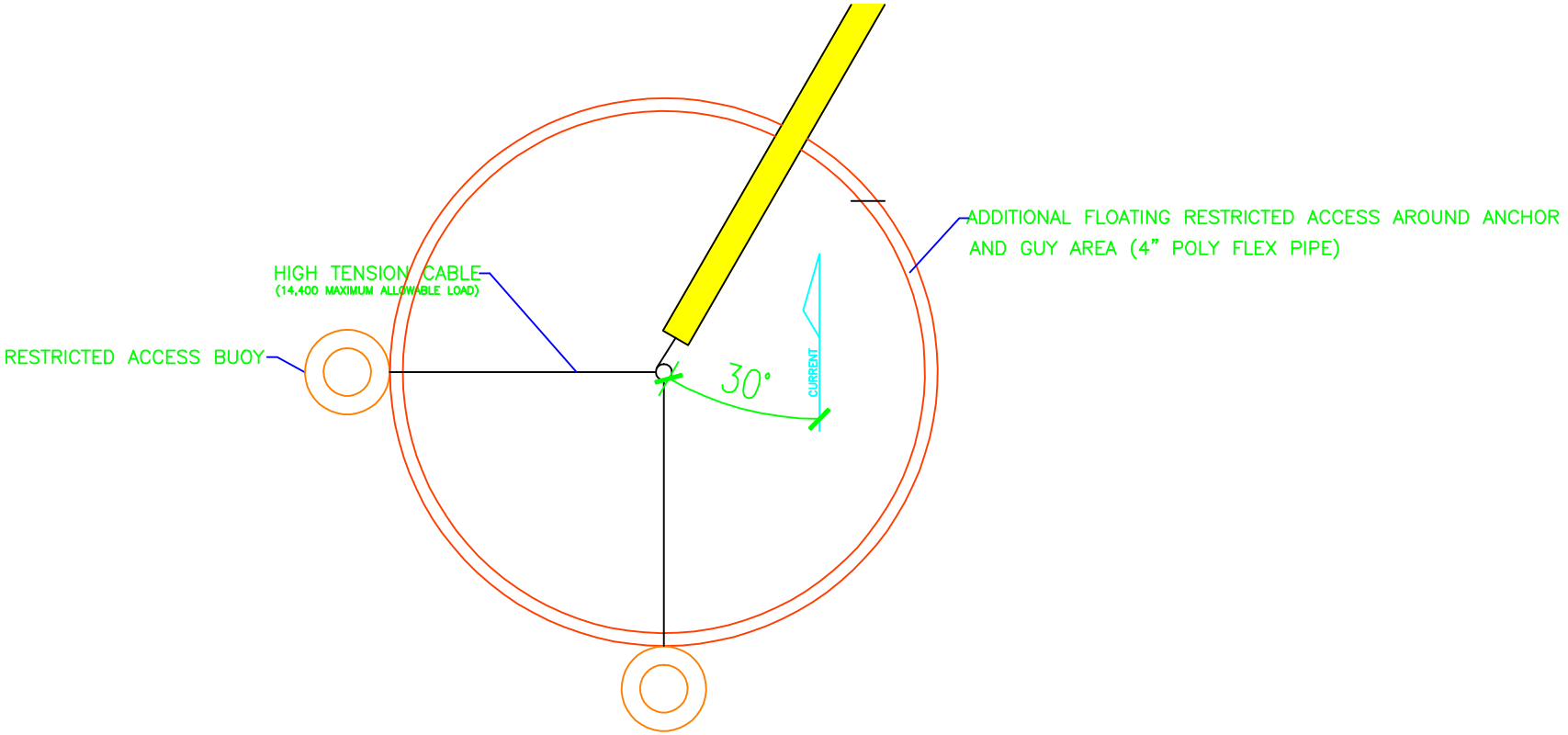
Z:\Work\GIS\2012_SO_Reassessment\MXDs\120618_SWAT_PROPOSED_CONTAINMENT_LOCATIONS_FIGURE1.mxd

Aerial Photography Date: November 2011



SECTION VIEW OF BOOM ANCHOR & CURTAIN CONFIGURATION

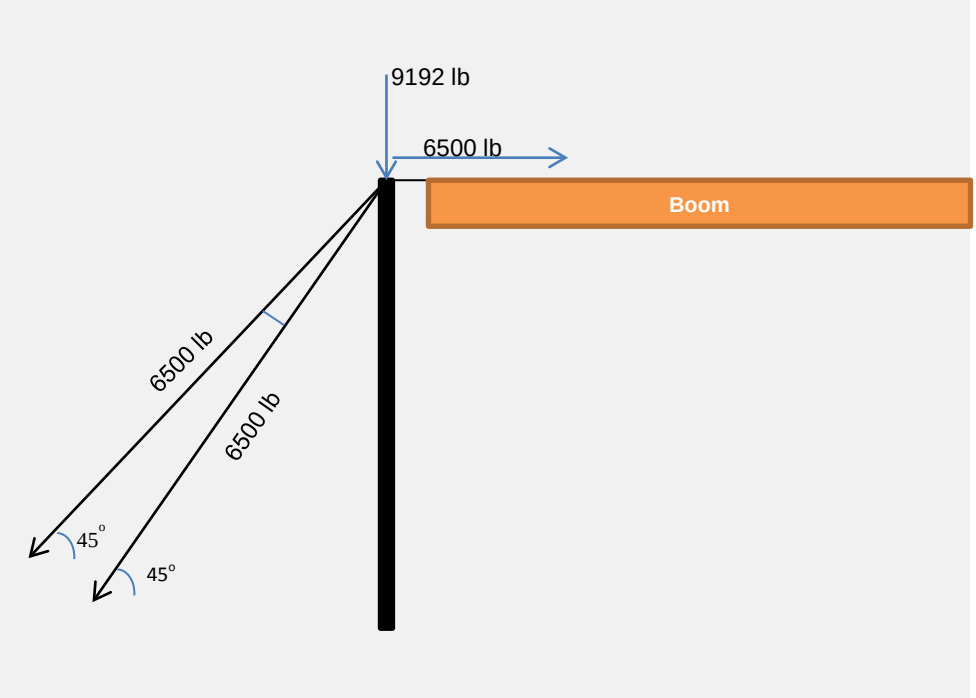
SCALE: – – NO SCALE



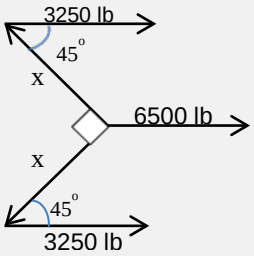
PLAN VIEW OF BOOM ANCHOR CONFIGURATION

SCALE: – – NO SCALE

Tie Back Anchor Forces

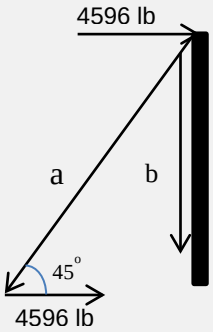


Plan View



$$x = \frac{3250\ lb}{\cos(45)} = 4596\ lb$$

Elevation View



$$a = \frac{4596}{\cos(45)} = 6500\ lb$$

$$b = 4596\ lb \tan(45) = 4596\ lb$$

Anchor (assumed 90°)
- Shear Force = 4596 lb
- Pullout force = 4596 lb

Cables
- Tensile force = 6500 lb

Pipe
- Compressive force = 2*(4596 lb)= 9192 lb

Maximum Unsupported Pipe Length Calculations

Assumption:

K value was assumed to be 1.25, as it is a semi rigid support braced with the anchors and boom.

Through The Slenderness Ratio

$$\frac{KL}{r} \leq 200$$

Where:

L= unsupported Length

K = effective length factor (assumed K = 1.25)

r = Radius of Gyration

For 2 ½" r = 0.924 L = 12.32'

For 3" r = 1.136 L = 15.15'

Through Euler's Equation

$$L = \frac{1}{K}\sqrt{\frac{\pi * E * I}{F}}$$

Where:

L= unsupported Length
F = max force (assumed F=9192 lb)
E = Modulus of Elasticity (assumed $E=30*10^6$ psi)
I = Moment of Inertia
K= effective length factor (assumed K = 1.25)

For 2 1/2" I= 1.924 L = **9.36'** Maximum Unsupported Length
For 3" I = 3.895 L = **13.3'** Maximum Unsupported Length

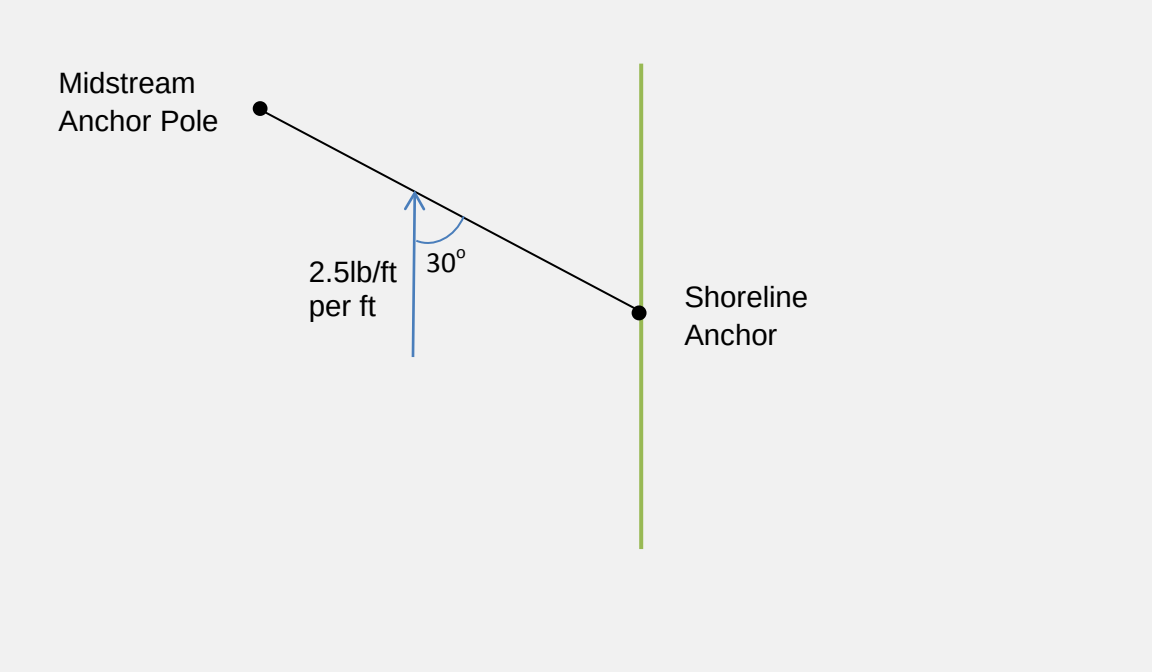
Therefore:

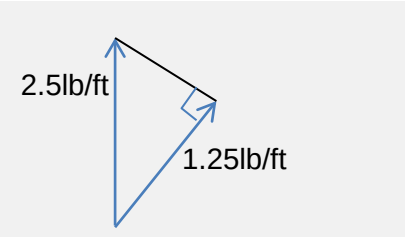
2 ½" will be sufficient for depths up to 7ft.
3" will be sufficient for depths up to 11ft.

Maximum Boom Forces

Assumption:

Water differential at boom imparts less than 2.5 lb/ft force to boom per foot.
Cable is pretension to approximately 5000lb.





Therefore:

3/8” cable with 6500 lb tensile capacity should be sufficient.