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EMAS AMC (Singapore)

Engineering 'Lunch & Learn' Series

"Pipeline Installation by Surface Tow (Rentis) Method – Project Examples"

2 November 2012

WIN – EXECUTE – SAFE DELIVERY

Together We Deliver

AMC Energy Marine Production

PLANNED TALKS FOR FY2012/13

No.	Proposed Topic	Speaker	Date	Status
1	Soil classification, Trenching and Lowering of a Live Gas Pipeline	Dr Thusy (CAPE)	18-Oct	Done
2	Surface Tow Method of Pipeline Installation (aka Rentis method)	Eng Bin	02-Nov-12	Confirmed
3	Pipeline bundle (8 pipelines) installation by Bottom Pull Method - Project example	Eng Bin	3-Dec-12	Confirmed
4	Flexible and umbilical installation methods and challenges - Project Examples	Ye Ziqing	7-Jan-13	Pending
5	Introduction to engineering software used by or available to 'Engineering'	Vu Khac Kien	4-Feb-13	Pending
6	Definition of Lift Loads and Lifting Sling Selection & Heavy Lifting Analysis using MOSES software	Santosh	04-Mar-13	Pending
7	Use of Spoiler to Initiate self-burial - project example	Eng Bin	18-Mar-13	Pending
8	Hydrodynamic loading through the splash zone and water column	Kingsley or designate	1-Apr-13	Pending
9	Well-head platform installation - Project Example (Chevron Project using Lewek Champion)	Anthong Wong	22-Apr-13	Pending
10	Management of change & control of engineering documents	Kingsley	6-May-13	Pending
11	Conventional pipeline installation - Project Example (Chevron Project using Lewek Champion)	Pichet	03-Jun-13	Pending
12	Span correction methodology - project example	Eng Bin	18-Jun-13	Pending
13	Lift rigging design	Kingsley or designate	01-Jul-13	Pending
14	Pipeline installation analysis - Shallow water versus deep water	Donikon	5-Aug-13	Pending
15	Deep water riser configurations	TBA	2-Sep-13	Pending
16	Mooring System Installation - Chevron FPSO	Landon	7-Oct-13	Pending
17	Diverless connection systems	TBA	4-Nov-13	Pending
18	Decommissioning of SPM and Mooring System - Project Example	Moorthi	2-Dec-13	Pending

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Potential Future Topics for L&L

No.	Proposed Topic	Speaker	Date
1	Pipeline repair methodology - shallow water & deep water	Eng Bin	TBA
2	Bottom roughness analysis	Eng Bin	TBA
3	Seabed invention by pre-lay trenching	Eng Bin	TBA
4	Post-trenchng methods by conventional ploughs & jetting	Eng Bin	TBA
5	Drilling & blasting	Eng Bin	TBA
6	Pipeline protection against anchor drop & drag - theory & mitigation	Eng Bin	TBA
7	Pipeline protection - Rock manufacture & rock dumping	Eng Bin	TBA
8	Span correction methodology - project example	Eng Bin	TBA
9	Sacrificial anode manufacturing for subsea pipelines	Eng Bin	TBA
10	Pipe corrosion & weight coating , anode installation & pipe load-out	Eng Bin	TBA
11	Pipeline installation in inter-tidal zone by pulling from shore to offshore - Project example (India)	Eng Bin	TBA
12	Installation of 36" OD 80' x 80' U-bend expansion spool by Surface Tie-in Method - Project Example	Eng Bin	TBA
13	Horizontal Directional Drilling (HDD) - project example	Eng Bin	TBA
14	Strengthening of existing 'live' platform leg with external sleeve welded to existing leg (Mexsub system)	Eng Bin	TBA
15	Mooring chain off-loading from transportation vessel, loading onto installation vessel and storage in chain locker - project example (Vietnam)	Eng Bin	TBA
16	Mooring piles: dimensional checks, shackle fitting, load-out and seafastening - project example (Vietnam)	Eng Bin	TBA

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Other Lunch & Learn Topics in the Planning

Helmy (SCM Dept) will also help add the following topics to our Lunch & Learn Programs:

- Helmy – ‘negotiation’
- Wellstream (GE) – subsea product offering
- Fugro TSM – trenching

Moorthy (Projects & Ops) has volunteered to give the following talks:

- Oil & Gas Geological features
- Exploration of Petroleum & Drilling Technology (Rotary Drilling & Lateral drilling)
- Arctic Engineering
- Shale Gas and Heavy Oil
- Subsurface Field Architecture & Subsea intervention
- Offshore Construction Safety and key lessons

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Rentis (Surface Tow) Installation Methodology for Short Pipelines

- Rentis method is typically used to install offshore pipelines ranging from 6” to 16” in water depths up to 60 m in Brunei by Brunei Shell Pertroleum (BSP).
- This method has been used in Sarawak by Sarawak Shell Berhad (SSB) in the past but the practise has since been abandoned
- Two examples are shown in this presentation:
    1. SSB’s Twin Ventlines – the Rentis method was used to install a twin 10-inch pipeline 2 km long (Installation photos from this project are used for illustration)
    2. BSP’s East/West Replacement Project - the Rentis method was used for the installation of 6-inch, 8-inch and 12-inch nominal OD pipelines not longer than 3 km long (Engineering & Stringing Site from this project are used for illustration)

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Rentis (Surface Tow) Installation Methodology for Short Pipelines (Cont'd)

- In this method, the required pipe string length is fabricated and fitted with buoyancy devices at a given spacing onshore, then it is launched and finally towed to the desired offshore location.
- One end of the pipeline is connected to a pre-installed line on the platform.
- After positioning and aligning of the pipe string, the buoyancy devices are stripped by one of the tugs in a control manner so that the pipeline settles to seabed due to its own weight in a controlled manner.

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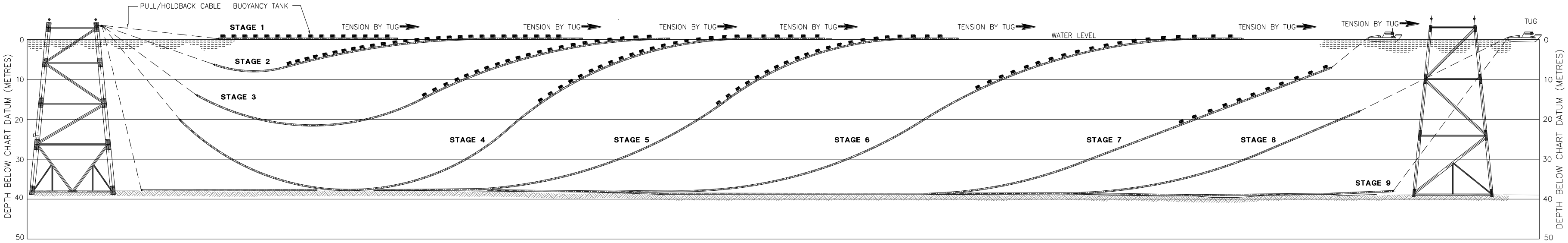
Schematic Showing Stripping of Buoyancy Drums and Laying of Pipeline



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Project Example 1

SARAWAK SHELL BERHAD – RENTIS PROJECT

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INSTALLATION OF TWIN 8” VENTLINES

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Preparatory Works

- Background – Rentis fabrication yard was not used for launching for more than 5 years, and need repairs and retrofit works before it could be used
- Pipeline strings were already fabricated and buoyancy drums attached

Track & trolleys were rusty and needed repairs & oiling, buoyancy attachments needed to be secured, etc

Hydrostatic testing of twin pipelines

Pigging & Gauging of Pipelines – Notice How Exhausted the Pig is After Running Thru 2 Pipelines

Final check on towing padeyes and bridle before commencement of launch

Performing MPI on launching/towing padeyes

Tow/launch bridle arrangement

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Digging out existing trolley collection track & re-instating track for use

Re-instating launchway rollers at beach area so that pipeline bundle can be launched into the sea

Pre-installing tow wire using shallow draft tug (so that designated tow tug can reach & retrieve the tow wire)



Attaching pipelay ‘initiation’ cable to platform prior to surface tow

Commencement of Bundle Pipe Pull to Beach
(Fabrication site was a few kilometres from the shoreline)

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Putting ‘Jumped’ Trolley Back on Track

Pipeline bundle approaching the beach

Two bull-dozers were used as land towing vehicle

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Bundle approaching beach– note diverter used to allow pulling vehicles to turn 90º to avoid entering water

Pull wire diverter at ‘landfall’ is required to allow bull dozers to pull the pipe string bundle into the sea

On reaching the diverter, pull wire needs to be disconnected from tow bridle and attached to the intermediate pull clamp

Lifting and positioning forward end of pipeline bundle over 'beach' rollers before bundle is launched into the sea

Note where trolley drops to

Connecting tow wire from tow tug to bundle pulling bridle, and launching bundle into the sea (via onshore equipment)

Launching of Pipeline Bundle (onshore bull-dozers pulling intermediate clamp to launch pipeline into sea)

Onshore bull-dozers and tow tug jointly launch pipeline bundle into the sea

Note tug at left far end waiting to collect the trailing wire

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Launching of Pipeline Bundle

Launching of Pipeline Bundle (Cont'd)

Intermediate pull clamp removed before reaching divertor

Trailing End of Pipeline Bundle Entering Sea (note 2nd tug waiting to collect the trailing wire)

Towing

- The tug boat (leading tug) will continue to tow the pipeline slowly to sea until it is clear from surf zone and another tug boat (trailing tug) will pick up the tail end wire and maintain tension – this is the most dangerous phase as the pipeline is without tension
- Another vessel will act as an escort for the pipeline and warn all other vessels to keep clear from the pipeline.
- The towing speed should not exceed 2 m/s in good weather condition.

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Most critical moment of operation is when trailing wire is released and before 2nd tug takes over this wire

Towing of Pipeline Bundle to Site

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- Once the pipeline has reached the desired location, the pre-installed hold-back wire on the jacket is connected to the pulling head and the towing wire removed.

Connecting Pulling Head to Pre-installed Wire at Platform Leg

Controlled Pipelaying / Sinking

- Sinking of the pipeline is achieved by stripping of the floatation drums.
- The trailing tug will maintain the required tension while the vessel strips the floatation drums in a control manner.
- Once stripped, the pipeline will sink onto the seabed due to its own weight and the floatation drums will be collected by the vessel and transported back to Telisai.

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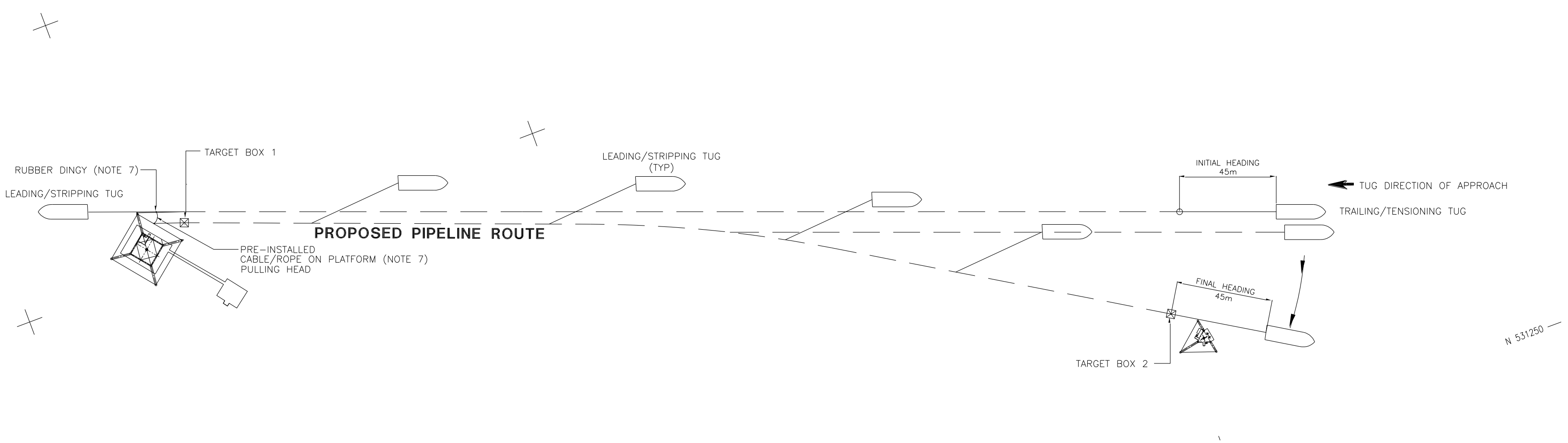
Retrieval of Stripping Wire

Bird's eye view showing stripping of buoyancy drums by tug



Stripping of Buoyancy Drums (view from Tensioning Tug)

Stripping of Buoyancy Drums – various stages

(view from Platform)

Stripping of Buoyancy Drums – various stages (Cont’d)

Final Stage of Buoyancy Removal - Note that Pipeline has Partially Settled to Seabed

Collection of Buoyancy Drums after Pipeline Installation

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Project Example 2: Brunei Shell (BSP) Rentis Facilities & Sample Project

- Description & View of BSP's Telisai Rentis Fabrication Yard
- Sample Project for BSP by Rentis Installation

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BSP’s Rentis Fabrication Yard

- BSP owns a pipeline fabrication yard at Telisai.
- The Telisai yard serves as the fabrication area to prepare the required pipe strings.
- The yard contains a welding station where 5 joints are simultaneously welded up to 60 m.
- Then, the completed 60 m pipe strings are welded together to form longer pipe strings of 300 m.

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Pipe Strings at BSP's Telisai Yard

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Fabrication Yard (cont'd)

- After stringing, the 300 m long pipe strings will be x-rayed, flushed, scraped, gauged and hydrotested.
- Upon the completion of hydrotest, the 300 m long strings will be field joint coated, capped at both ends and stored in the storage area.
- The pipe strings are rolled over on to the trolleys on the launching track once the pipe strings are sufficient.
- Finally, the floatation drums and a stripping wire are strapped onto the pipeline.

Pre-rigged Oil Drums Ready for Deployment on Pipe Strings

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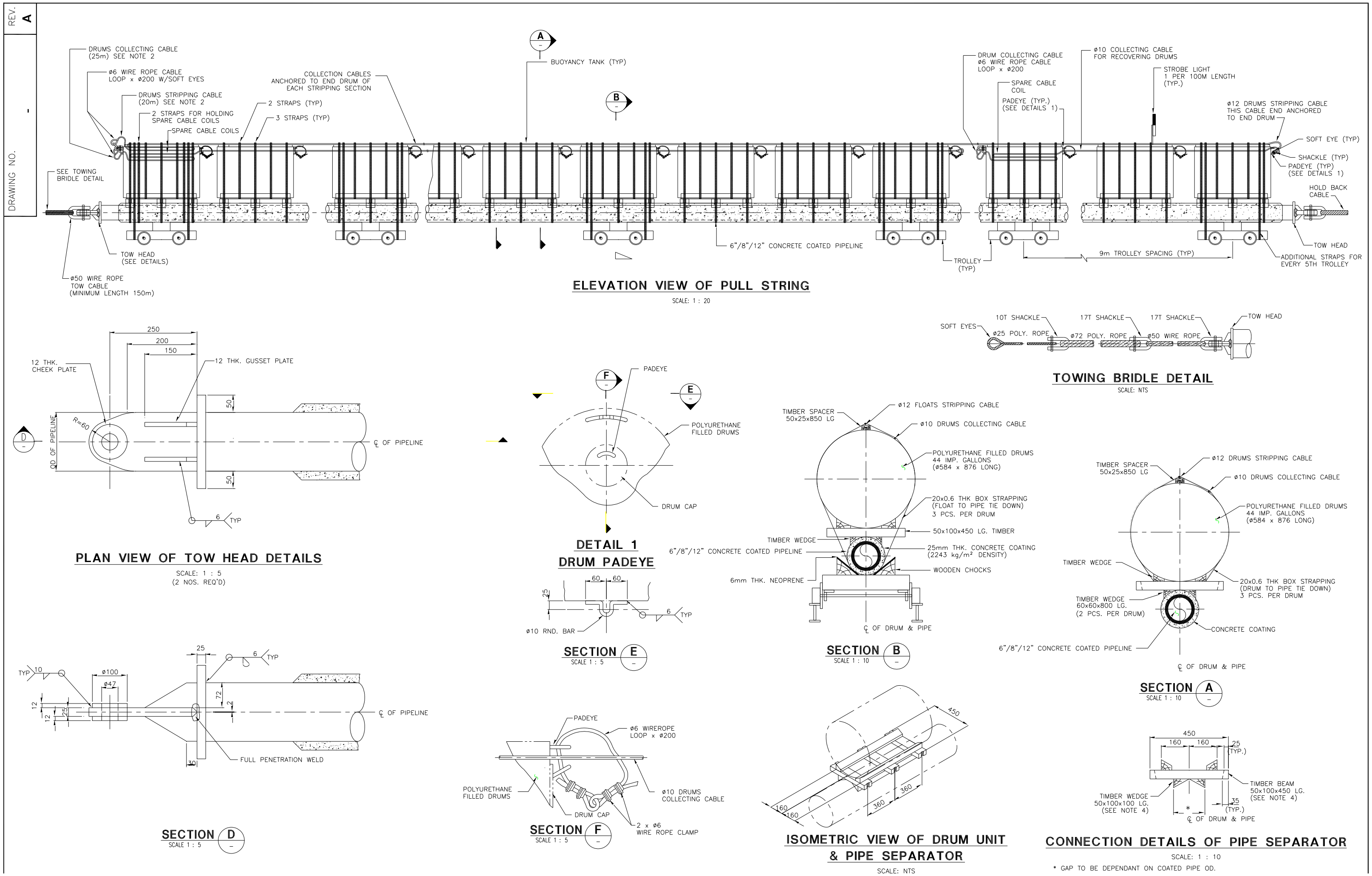
Attaching Oil Drums and Stripping Wire to Pipe String

Typical strapping details for Rentis Installation



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BSP's Rentis Fabrication Yard at Telisai

Pipeline Completed and Ready for Launch at Telisai Yard

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Launchway Arrangement at BSP Telisai Yard

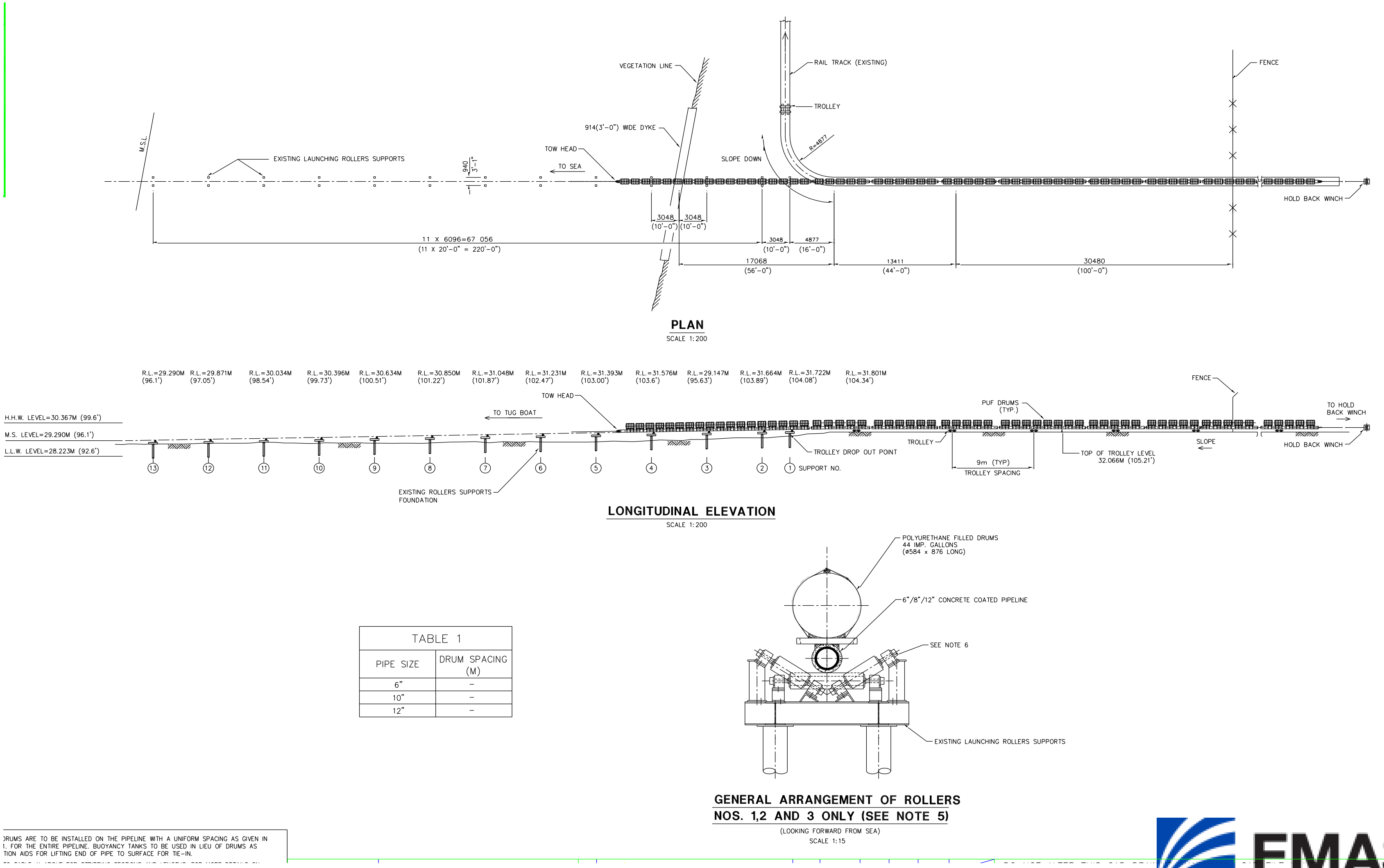

TABLE 1

PIPE SIZE	DRUM SPACING (M)
6"	–
10"	–
12"	–

Actual View of Launchway Arrangement at Telisai Yard

Typical Launching Procedure for Telisai

- The tow wire is connected from the tow/leading tug boat to the tow head of the pipeline for launching of the pipeline.

- The leading tug will align itself with the track and will commence to pull the pipeline at speed of approximately 1 m/s.

- A hold back winch line is connected to the tail end of the pipeline to maintain tension in the pipeline. The hold back line will act as a brake if the launching operation needs to be stopped.

- The tug will maintain tension on the pipeline to prevent buckling.

- The hold back winch will reverse if the pipeline needs to be hauled back up the track.

- The hold back line will be disconnected from the pipeline when the tail end is close to the water.

Rentis Installation Analysis

Allowable Stress (% SMYS)

- Laystress criteria can follow any code specified by Client
- To be conservative, the following criteria is used:
  - Overbend : 72%
  - Sagbend: 72%

Buoyancy Devices

- The buoyancy device used for floatation of the Rentis pipelines are made from empty 44-gallon oil drums and have the following upthrust and depth limitations:

Type	Net Buoyancy (N)	Estimated Submerged Depth before collapse(m)	Weight in Air (N)
Air-filled	1824	12	294
PUF-filled	1758	24	360

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Software and Analysis Methodolgy

- OFFPIPE was not used for the Rentis installation analysis as it is not geared for such kind of analysis, i.e. is difficult to simulate the buoyancy drums' behaviour
- Instead, another software, NEWPIPE, is proposed.
- NEWPIPE is a non linear materials, large deflections and non linear boundary conditions finite difference program. It is ideally suited for simulating the pipelaying phase of the Rentis installation, and can accurate determine the pipe stresses and pipe profile during stripping of the buoyancy devices.

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Software and Analysis Methodolgy (cont'd)

NEWPIPE can be used to determine the following Information required for the Rentis method of Installation:

- Investigate pipeline profile and stresses during various stage of buoyancy drum removal (controlled sinking) during pipelaying
- Determine the appropriate tension to be applied by the tensioning tug during pipelaying by Rentis method. The tension to be applied is affected by the following considerations:
  - **Overbend and sagbend stresses in the pipeline**. If the stresses exceed design allowable, then the tension has to be increased till the stresses fall within the allowable limits.
  - **The resultant elevation of the buoyancy drums during stripping**. During the stripping operation, the buoyancy drums near the stripping end will rest on the 'S' curve of the pipeline. If inadequate tension is applied, some of these buoyancy drums will find themselves in a depth greater than its design 'collapse depth'. This is 12m for non-foam filled drums and 24m for foam filled drums.

Software and Analysis Methodolgy (cont'd)

Based on the results of the analysis, the following pertinent information required for the Rentis installation will be obtained:

i. Buoyancy drum requirements for each of the pipeline, namely, type of drums (foam filled or not), number and spacing of drums.

ii. Tension capacity required of the tensioning tug, and the recommended pulling tension(s) during stripping (controlled sinking) operation.

iii. Configuration of the pipeline and resultant stresses during various stages of stripping (controlled sinking) operation.

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Examples

- Sample Rentis installation analysis for one 12” and one 6” pipeline are illustrated below.
  - The pipelines are assumed to be 1000km long each.
  - The buoyancy drums are spaced evenly throughout the entire length of pipeline.
  - The buoyancy drums are made from empty oil drums and have the upthrust and depth limitations stated above.
  - Tension is applied by the tensioning tug while the buoyancy drums are being stripped.
  - After all the drums are removed, the tensioning tug moves forward while maintaining tension and lengthening the cable, then the tug stops moving and releases more cable till the pipe pulling head settles on seabed.

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Examples (cont'd)

Seven stages of buoyancy drums removal are considered in each case study, namely, during removal of 50m, 100m, 200m, 500m, 900m, 1000m of floatation drums, respectively, followed by an additional 25m (150 ft) of cable released by the tensioning tug (see Figure 1).

- Stage 1: Stripping 1st section floatation drums (50m)
- Stage 2: Stripping 2nd section floatation drums (total 100m long)
- Stage 3: Stripping 3rd section floatation drums (total 200m long)
- Stage 4: Stripping 4th section floatation drums (total 500m long)
- Stage 5: Stripping 5th section floatation drums (total 900m long)
- Stage 6: Stripping 6th section floatation drums (total 1000m long – entire pipeline)
- Stage 7: An additional 45m (150 ft) cable released by tensioning tug

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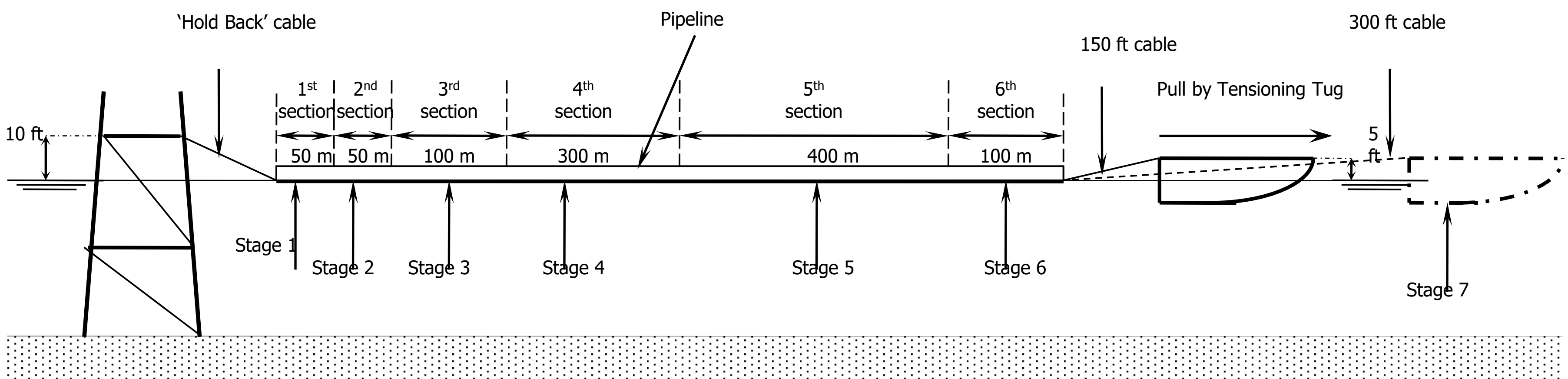

Figure 1: Segmenting of Pipeline for Stripping Operation (assuming a 1000m long pipeline).

Results of Analyses

Case 1: 12” Pipeline

- Results of the analyses are in tabulated in Table 1 for easy reference.
- The results show that the 12-inch pipelines can be installed safely by the Rentis Floatation Method.
- The buoyancy drums requirement is 12 nos. per joint.
- Bending moment diagrams and the pipeline profiles at each stage are shown below.

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Case 1: 12" Pipeline (cont'd)

TABLE 1 – SUMMARY OF RENTIS ANALYSIS (DN 300)				
No. of Floatation Drums Used	**Stage**	**Tension Applied (tonnes)**	**Max. Depth of Floatation Drums[2] (m)**	**Max. Pipe Stress (%SMYS)**
12 drums per pipe joint [1]	1 (total of 50 m floatation drums removed)	10 (98 kN)	-2.2	42
	2 (total of 100 m floatation drums removed)	10 (98 kN)	-9.0	63
	3 (total of 200 m floatation drums removed)	15 (147 kN)	-22.7	48
	4 (total of 500 m floatation drums removed)	15 (147 kN)	-22.4	46
	5 (total of 900 m floatation drums removed)	30 (294 kN)	-21.9	28
	6 (total of 1000 m floatation drums removed)	30 (294 kN)	-	28
	7 (total of 1000 m floatation drums removed with additional 150 ft cable released by tensioning tug)	10 (98 kN)	-	60

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Case 1: 12” Pipeline (cont’d)

- Notes:

1. One pipe joint is taken as 12.2 m (40 ft). The required buoyancy shown for the Rentis Floatation Method of installation is the minimum required in order (i) not to experience uncontrolled sinking and (ii) to ensure that the buoyancy drums do not sink below their rated theoretical collapse depth.

2. It is with respect to water surface. Negative implies below water level.

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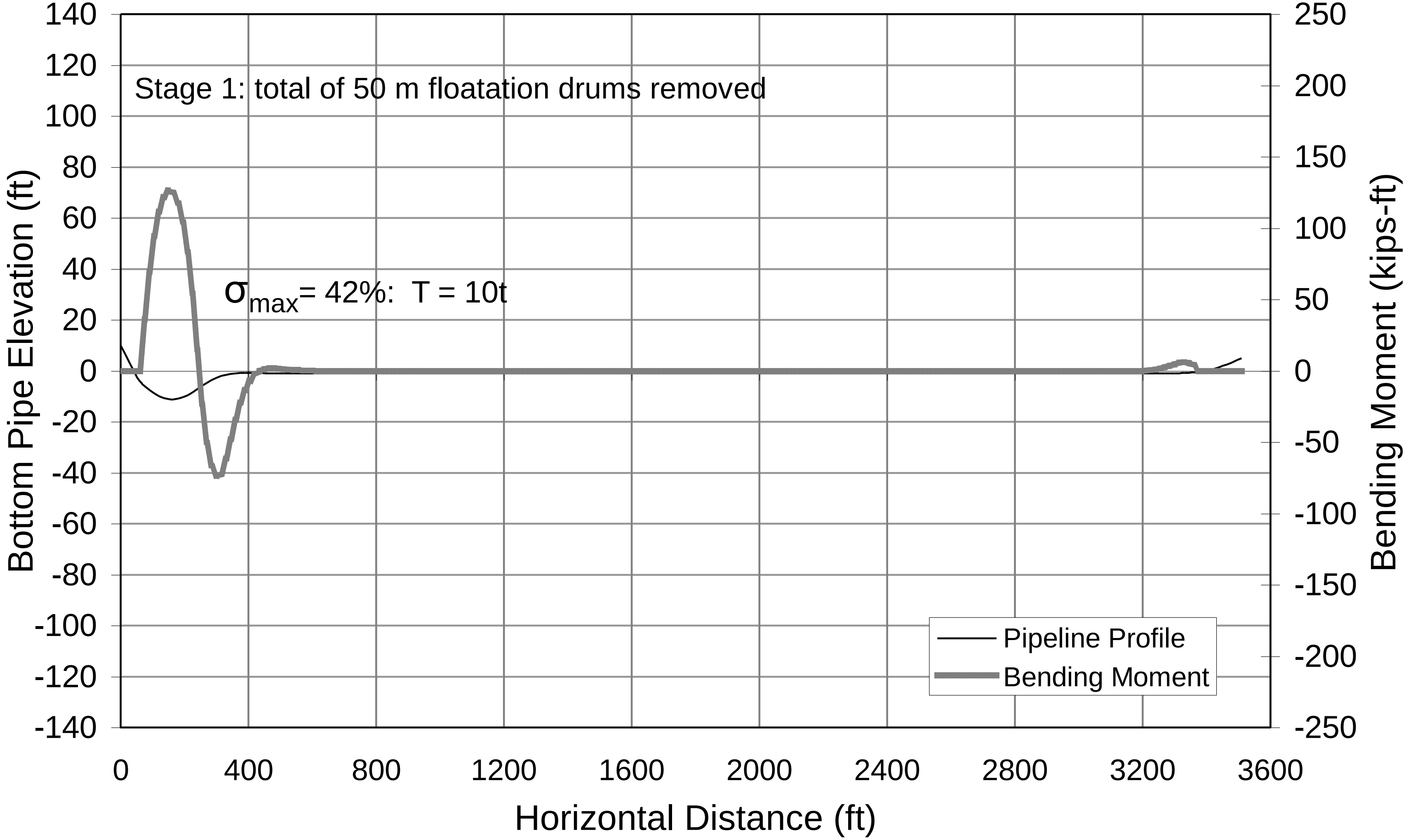
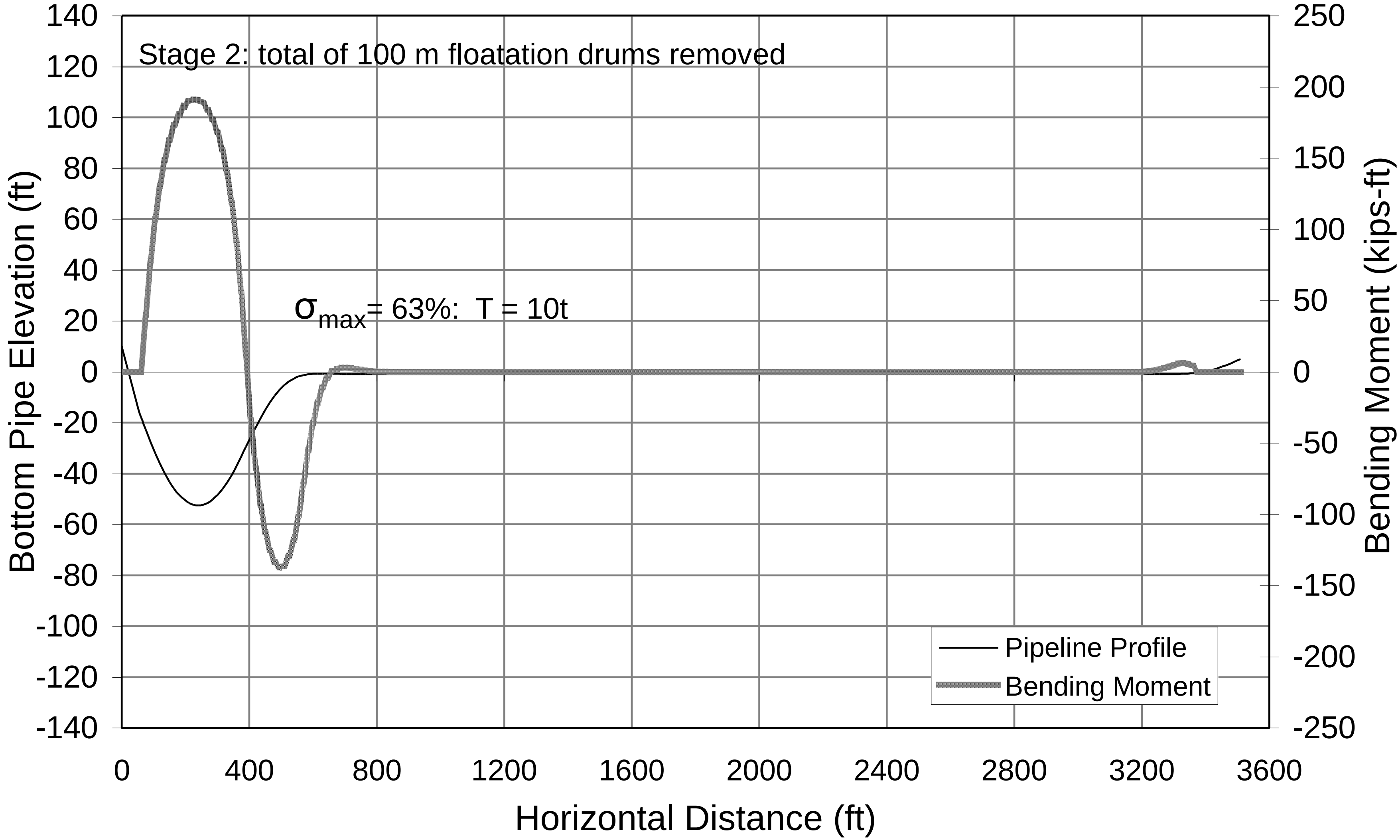
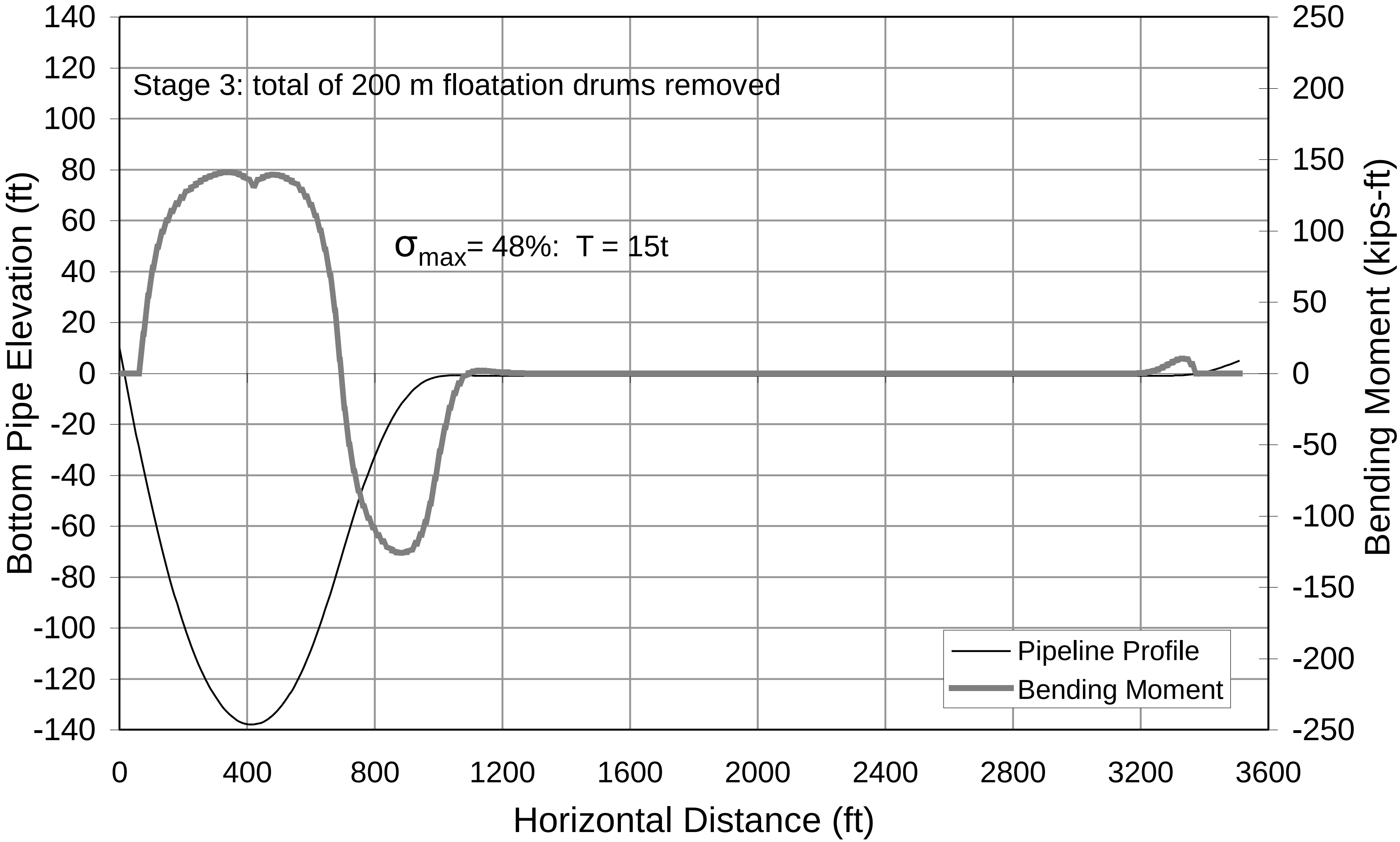


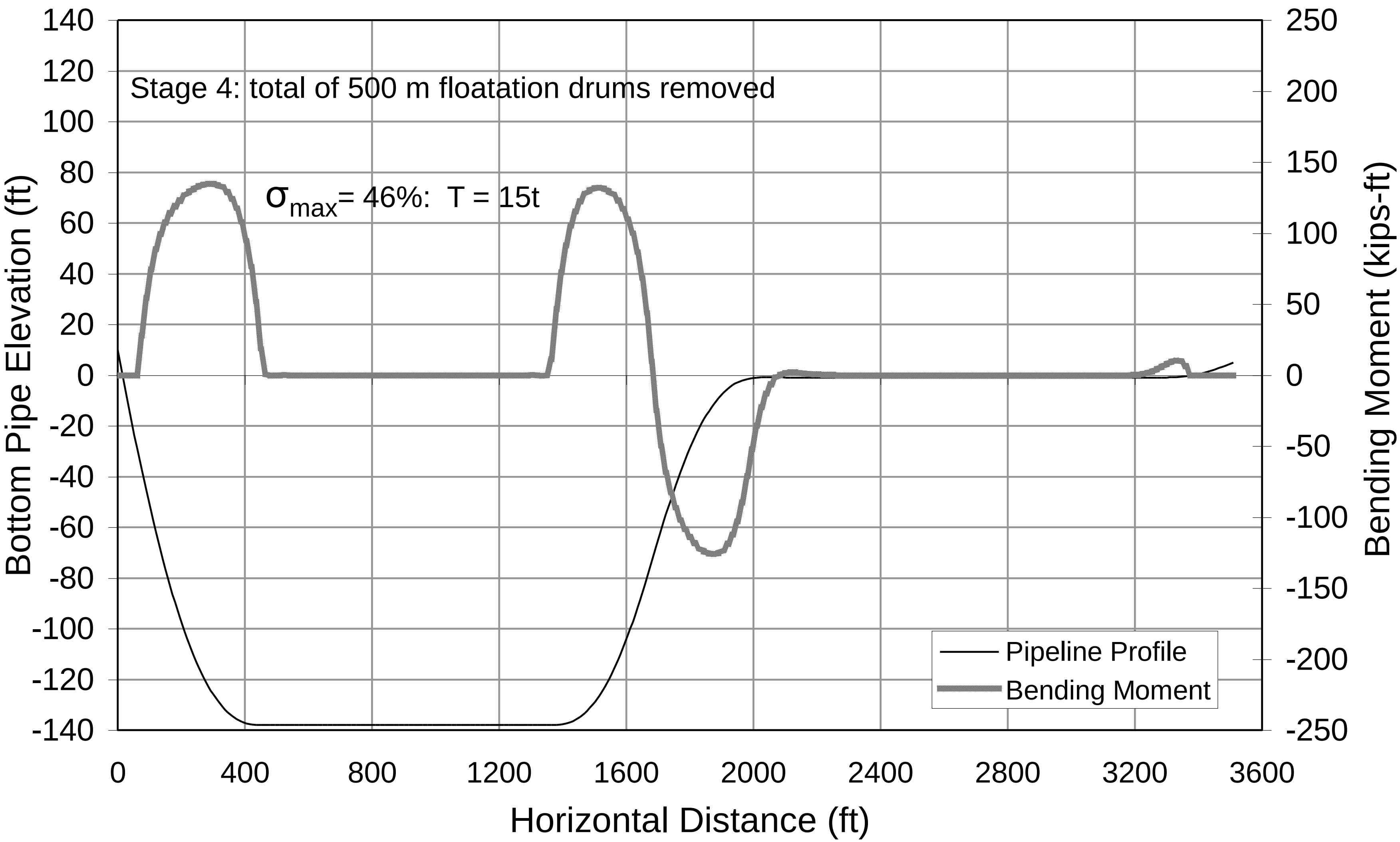
Stage 1: total of 50 m floatation drums removed
σmax= 42%: T = 10t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
Pipeline Profile
Bending Moment
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600



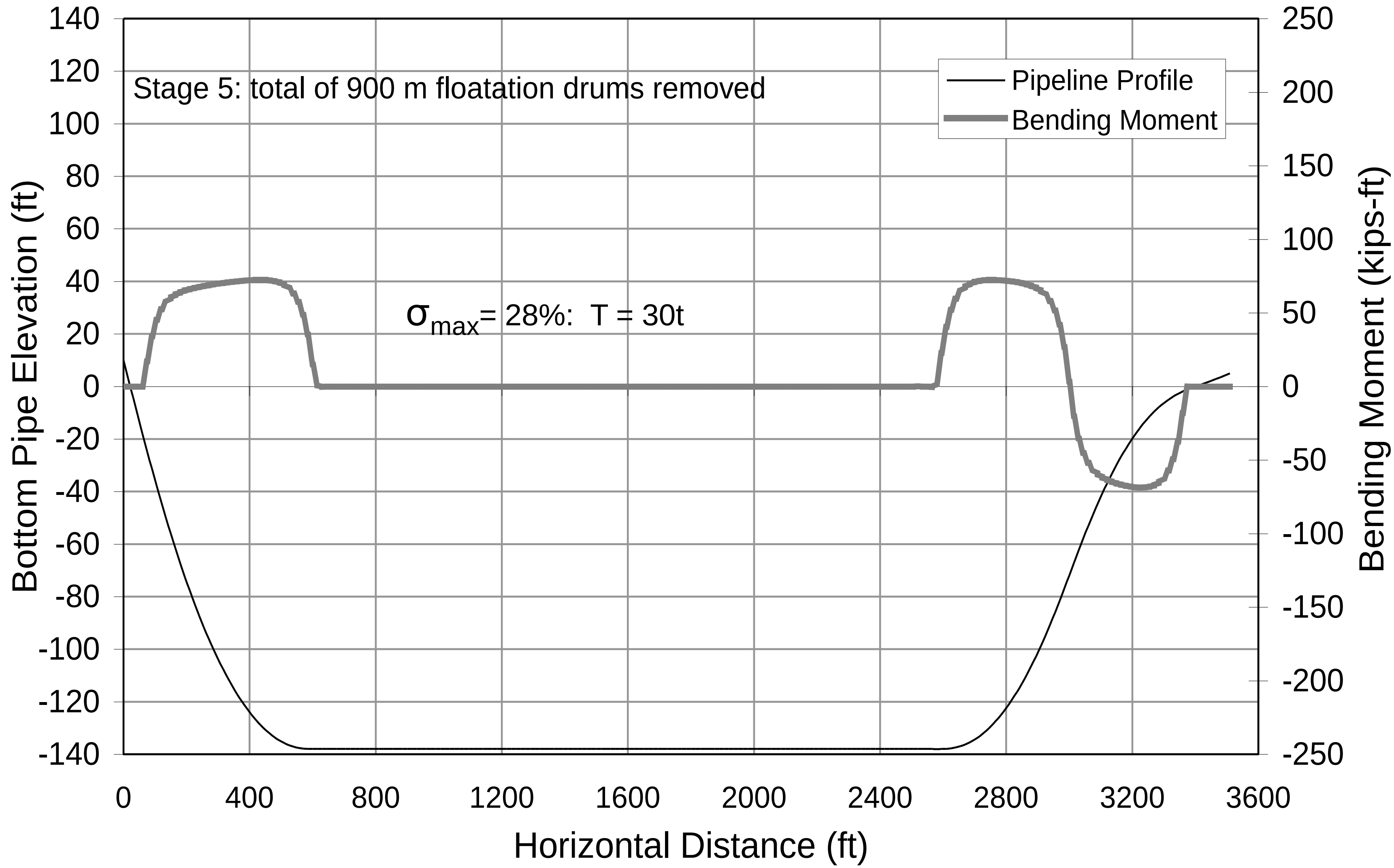
Stage 2: total of 100 m floatation drums removed
σ_{max}= 63%: T = 10t
Pipeline Profile
Bending Moment
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600

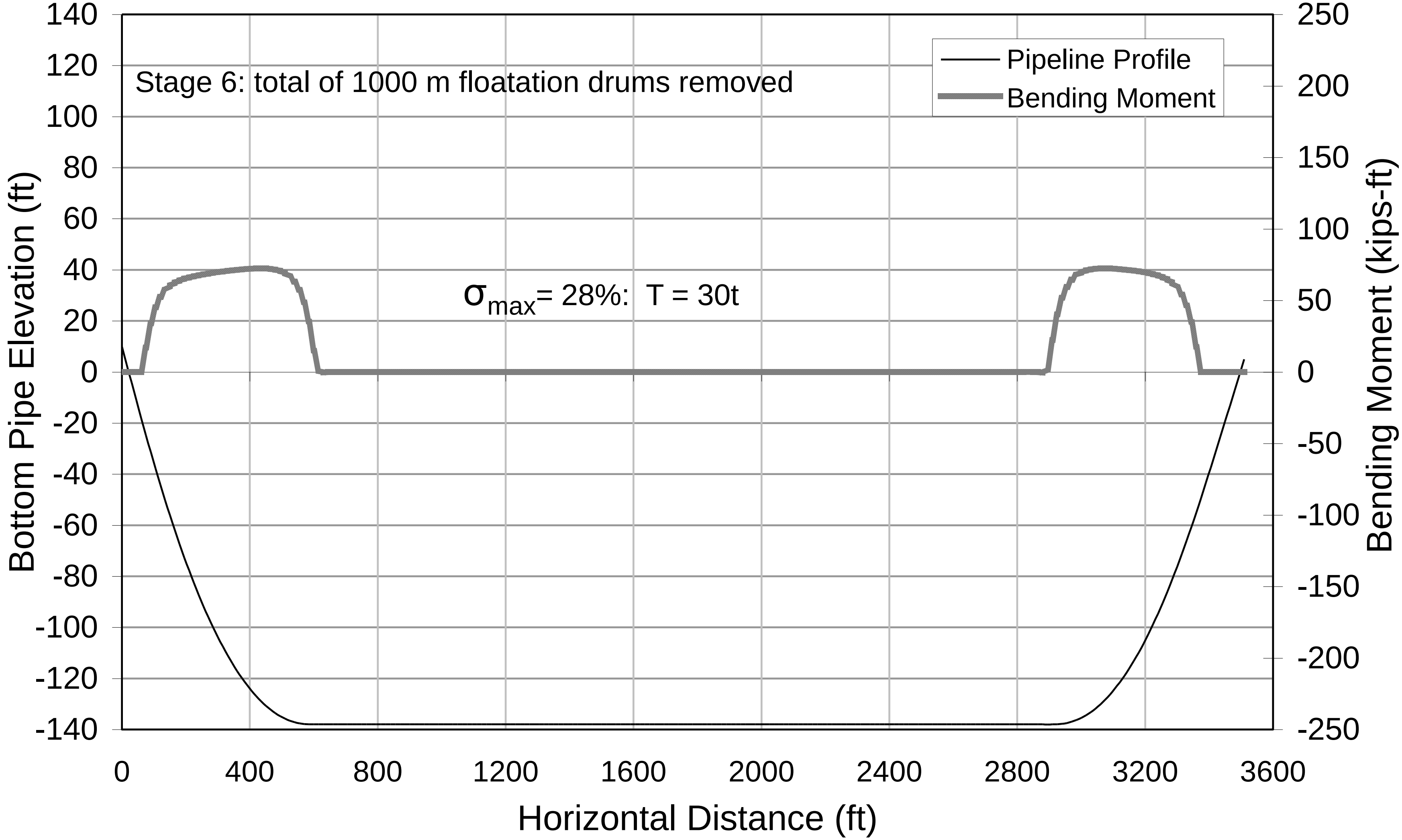


Stage 3: total of 200 m floatation drums removed
σ_{max}= 48%: T = 15t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
Pipeline Profile
Bending Moment
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600

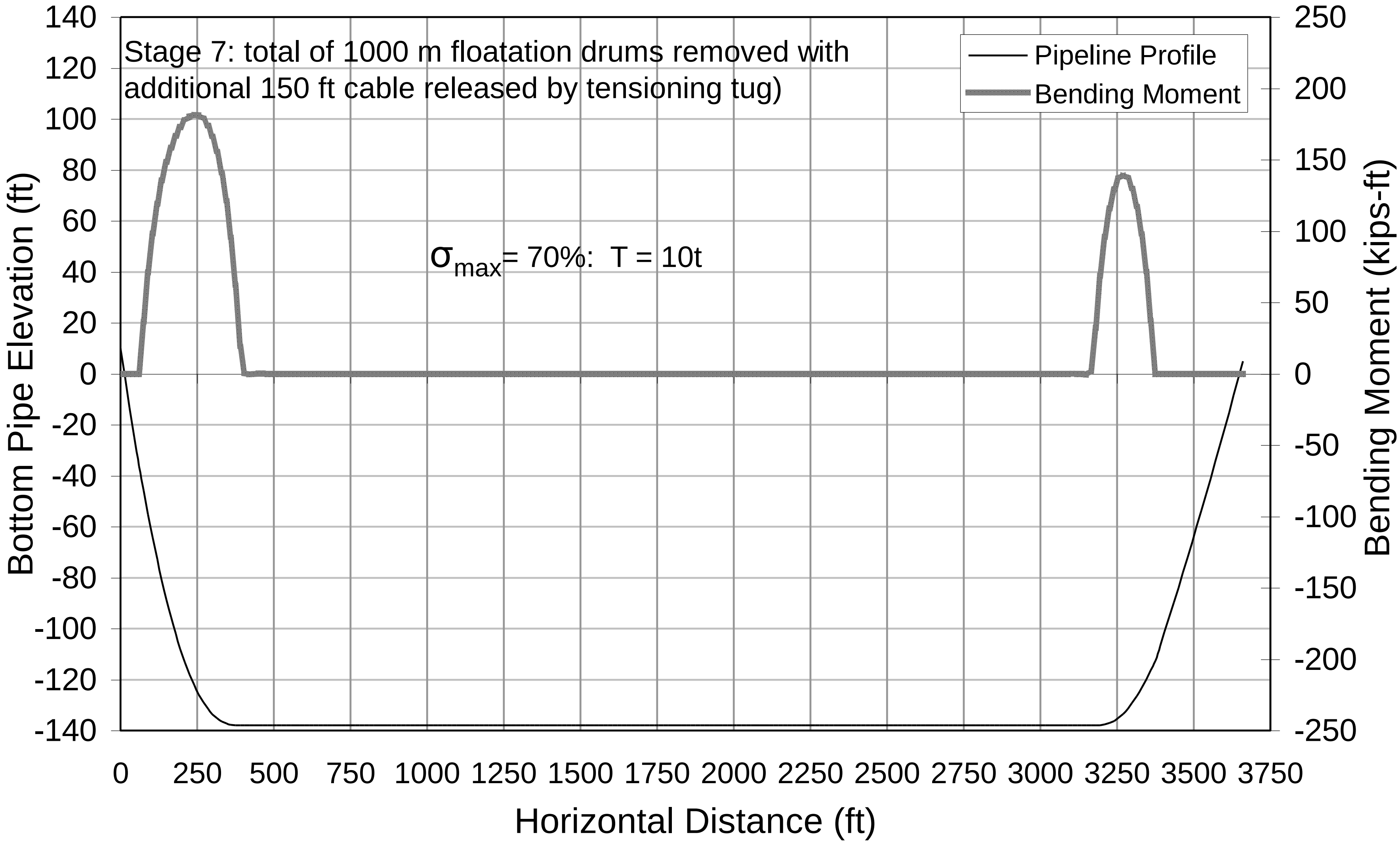


Stage 4: total of 500 m floatation drums removed
σ_{max}= 46%: T = 15t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
Pipeline Profile
Bending Moment
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600

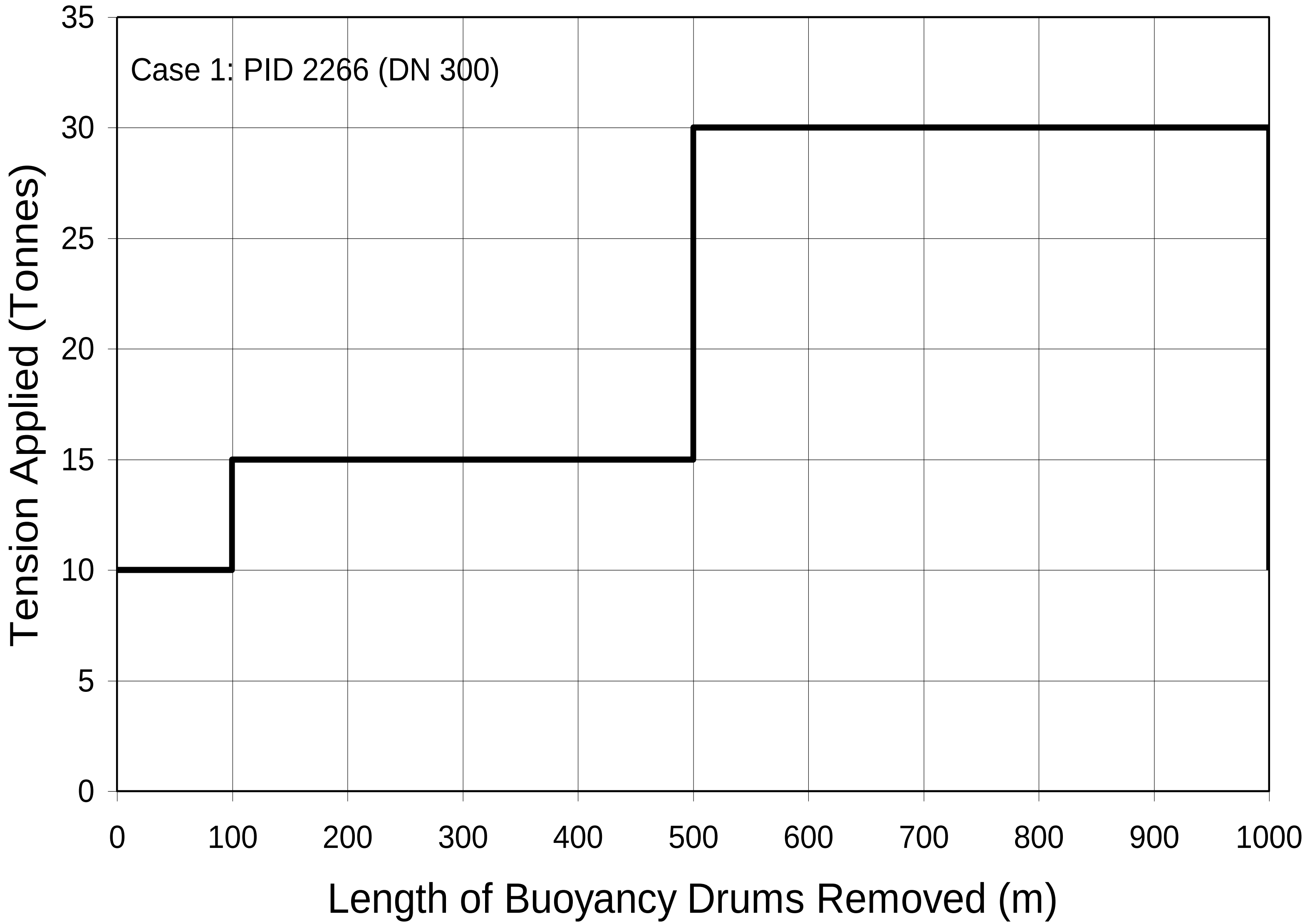

Stage 5: total of 900 m floatation drums removed
Pipeline Profile
Bending Moment
σ_{max}= 28%: T = 30t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600



Stage 6: total of 1000 m floatation drums removed
Pipeline Profile
Bending Moment
σmax= 28%: T = 30t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0
400
800
1200
1600
2000
2400
2800
3200
3600



Stage 7: total of 1000 m floatation drums removed with additional 150 ft cable released by tensioning tug)
Pipeline Profile
Bending Moment
σ_{max}= 70%: T = 10t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
250
200
150
100
50
0
-50
-100
-150
-200
-250
0 250 500 750 1000 1250 1500 1750 2000 2250 2500 2750 3000 3250 3500 3750



Proposed Tension Requirement for Each Stage of Rentis Installation For Case 1: 12″ (DN 300) Pipeline

Case 2: 6” Pipeline

- The results show that the 6.625-inch pipeline can be installed safely by the Rentis Method.
- The buoyancy drums requirement is 10 nos. per joint.
- The bending moment diagrams and the pipeline profiles at each stage are shown below.

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Case 2: 6” Pipeline (cont’d)

TABLE 2 – SUMMARY OF RENTIS ANALYSIS (PID 2254 DN 150)				
No. of Floatation Drums Used	**Stage**	**Tension Applied (tons)**	**Max. Depth of Floatation Drums[2] (m)**	**Max. Pipe Stress (%SMYS)**
10 drums per pipe joint [1]	1 (total of 50 m floatation drums removed)	10 (98 kN)	-2.4	33
	2 (total of 100 m floatation drums removed)	10 (98 kN)	-8.3	34
	3 (total of 200 m floatation drums removed)	15 (147 kN)	-20.6	25
	4 (total of 500 m floatation drums removed)	15 (147 kN)	-22.3	25
	5 (total of 900 m floatation drums removed)	15 (147 kN)	-22.3	25
	6 (total of 1000 m floatation drums removed)	15 (147 kN)	-	25
	7 (total of 1000 m floatation drums removed with additional 150 ft cable released by tensioning tug)	10 (98 kN)	-	33

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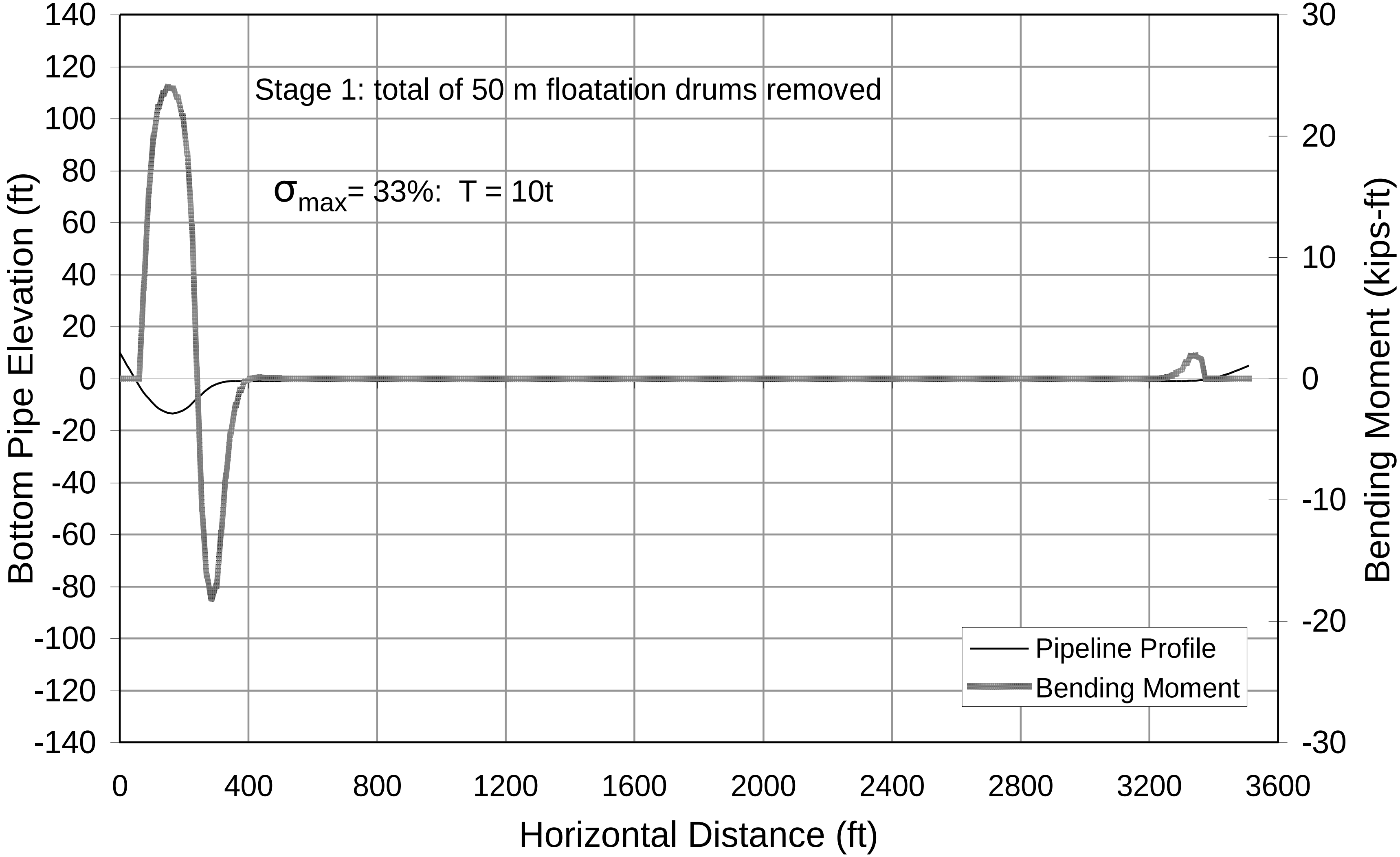
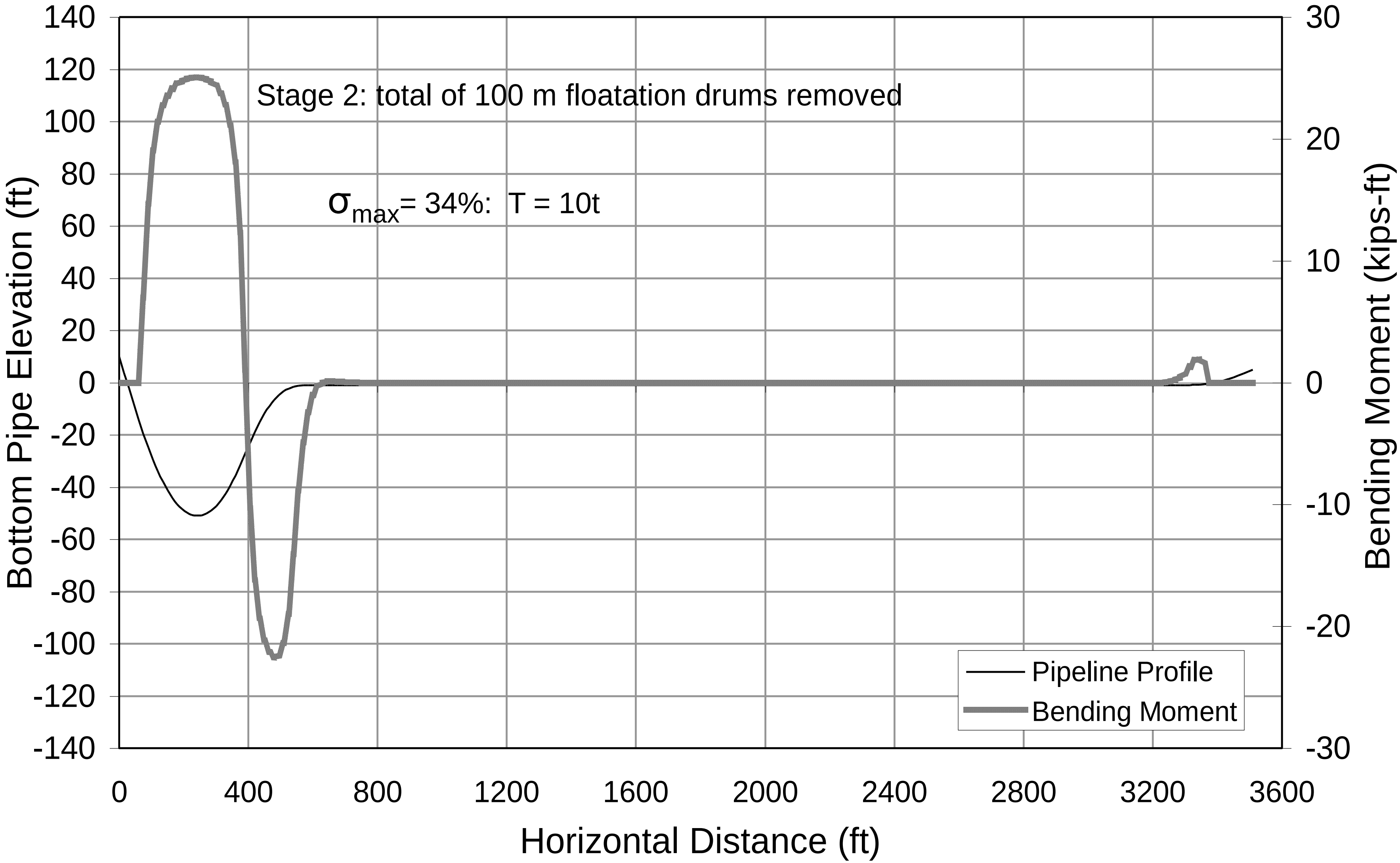
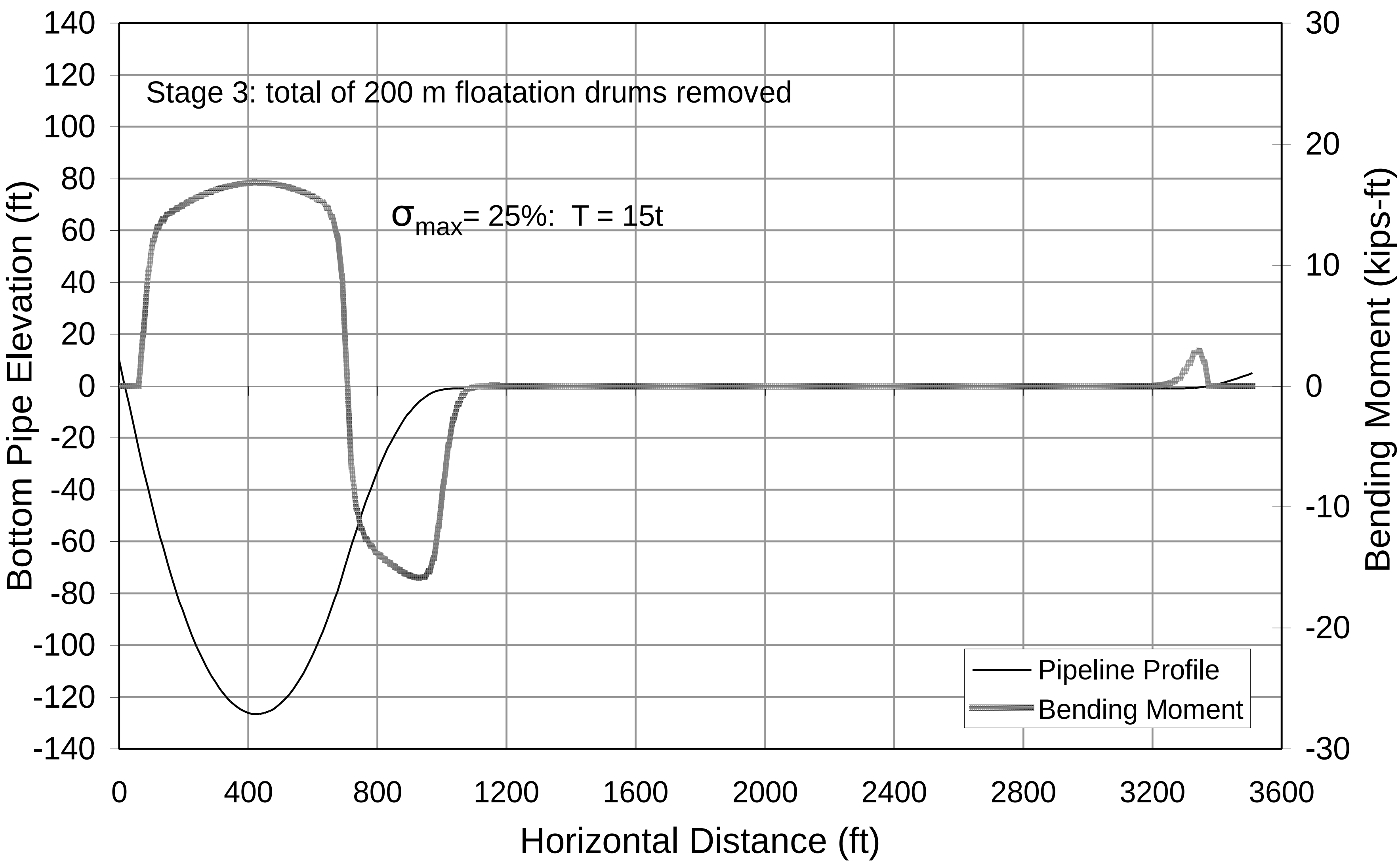


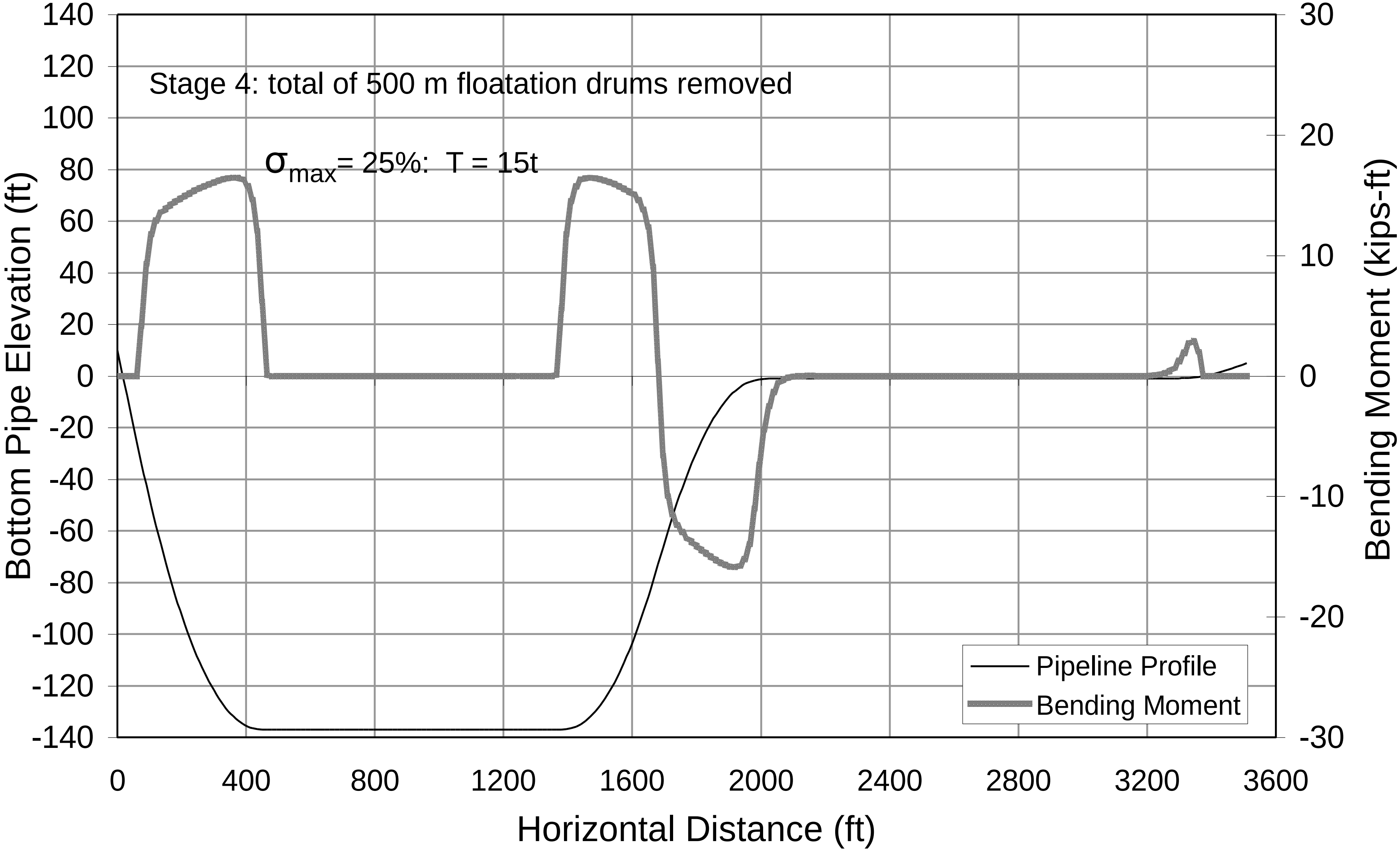
Stage 1: total of 50 m floatation drums removed
σ_{max}= 33%: T = 10t
Bottom Pipe Elevation (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
Bending Moment (kips-ft)
30
20
10
0
-10
-20
-30
0
400
800
1200
1600
2000
2400
2800
3200
3600
Horizontal Distance (ft)
Pipeline Profile
Bending Moment



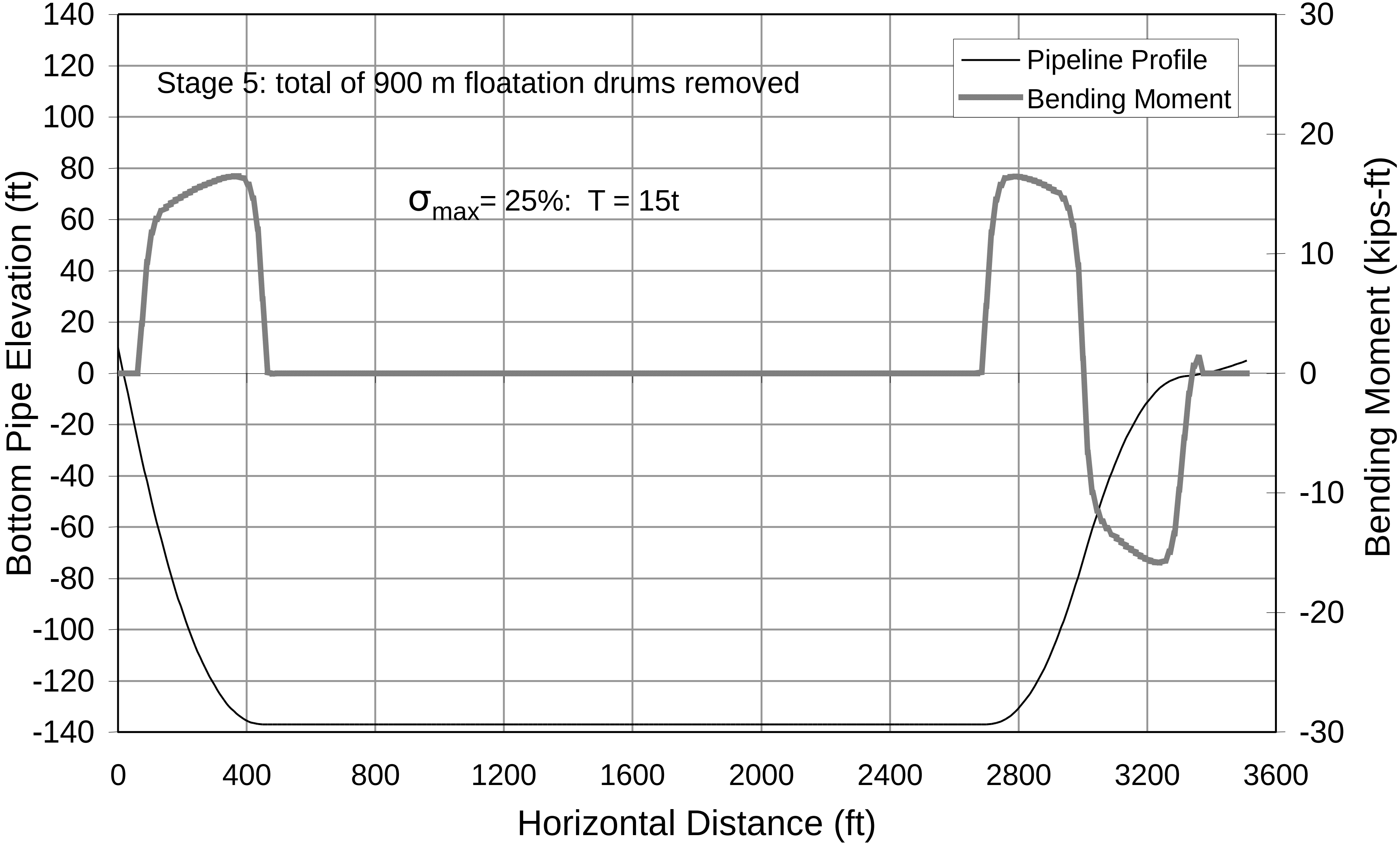
Stage 2: total of 100 m floatation drums removed
σ_{max}= 34%: T = 10t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
Pipeline Profile
Bending Moment
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
30
20
10
0
-10
-20
-30
0
400
800
1200
1600
2000
2400
2800
3200
3600



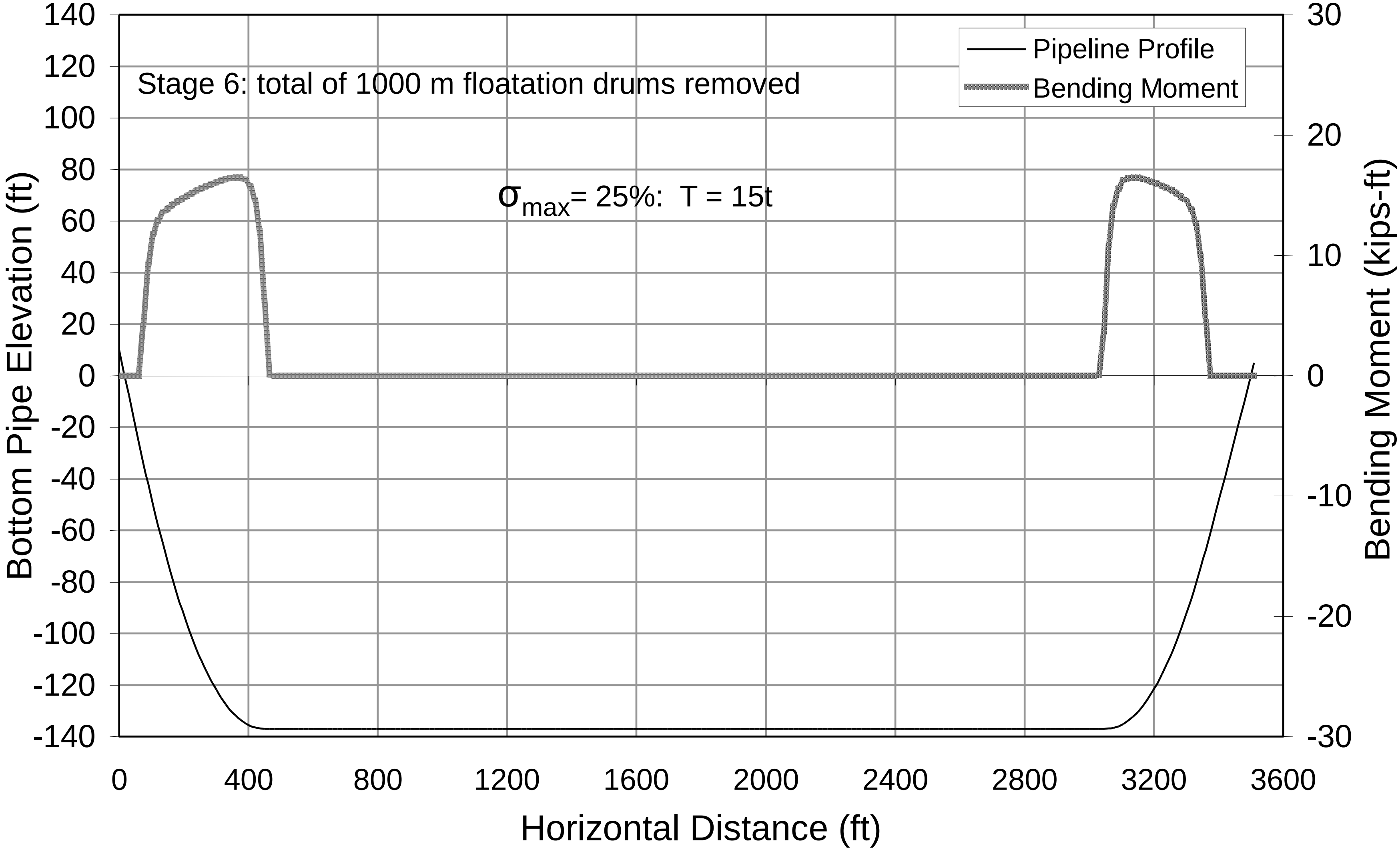
Stage 3: total of 200 m floatation drums removed
σ_{max}= 25%: T = 15t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
Pipeline Profile
Bending Moment
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
30
20
10
0
-10
-20
-30
0
400
800
1200
1600
2000
2400
2800
3200
3600



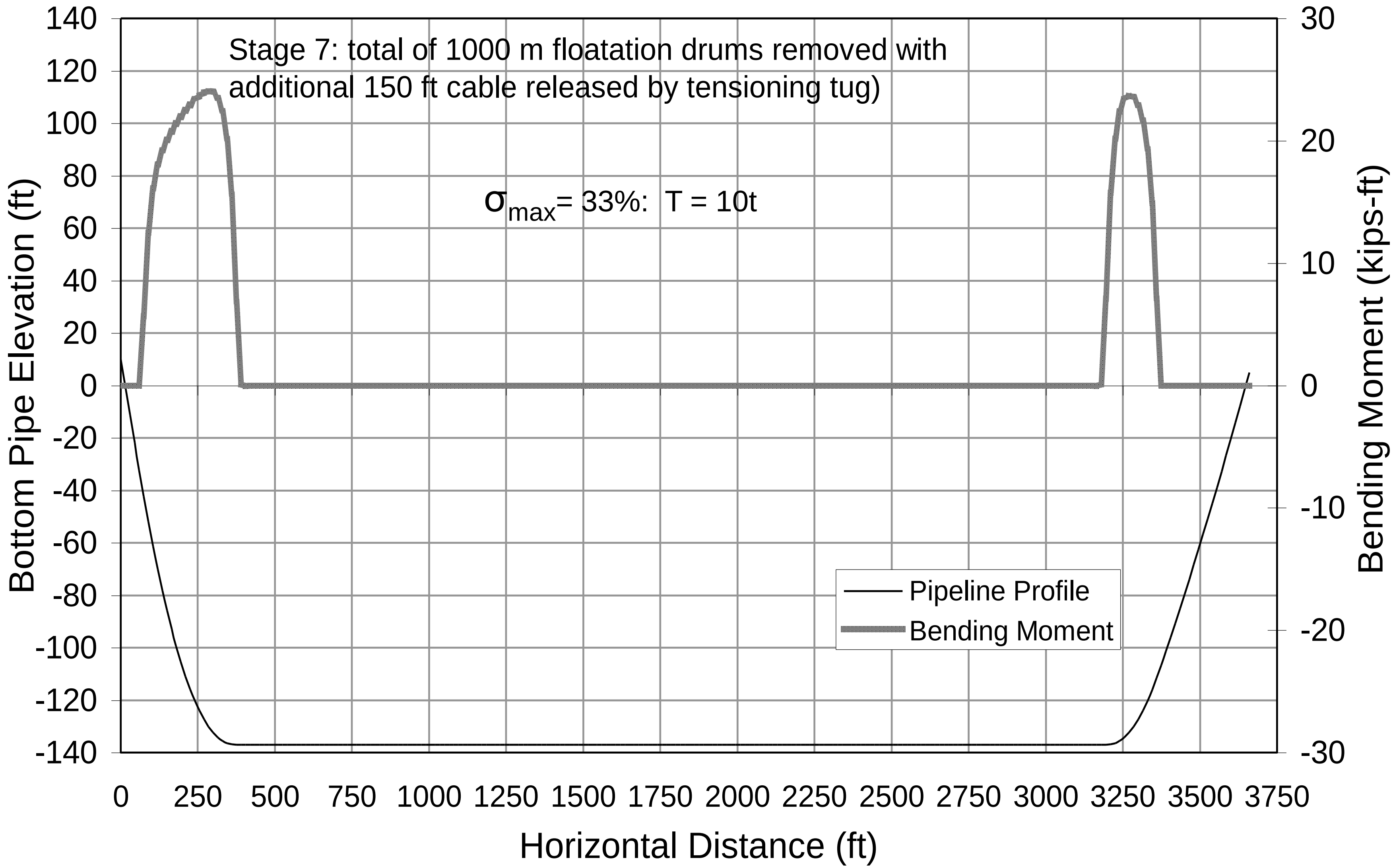
Stage 4: total of 500 m floatation drums removed
σ_{max}= 25%: T = 15t
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
Pipeline Profile
Bending Moment
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
30
20
10
0
-10
-20
-30
0
400
800
1200
1600
2000
2400
2800
3200
3600



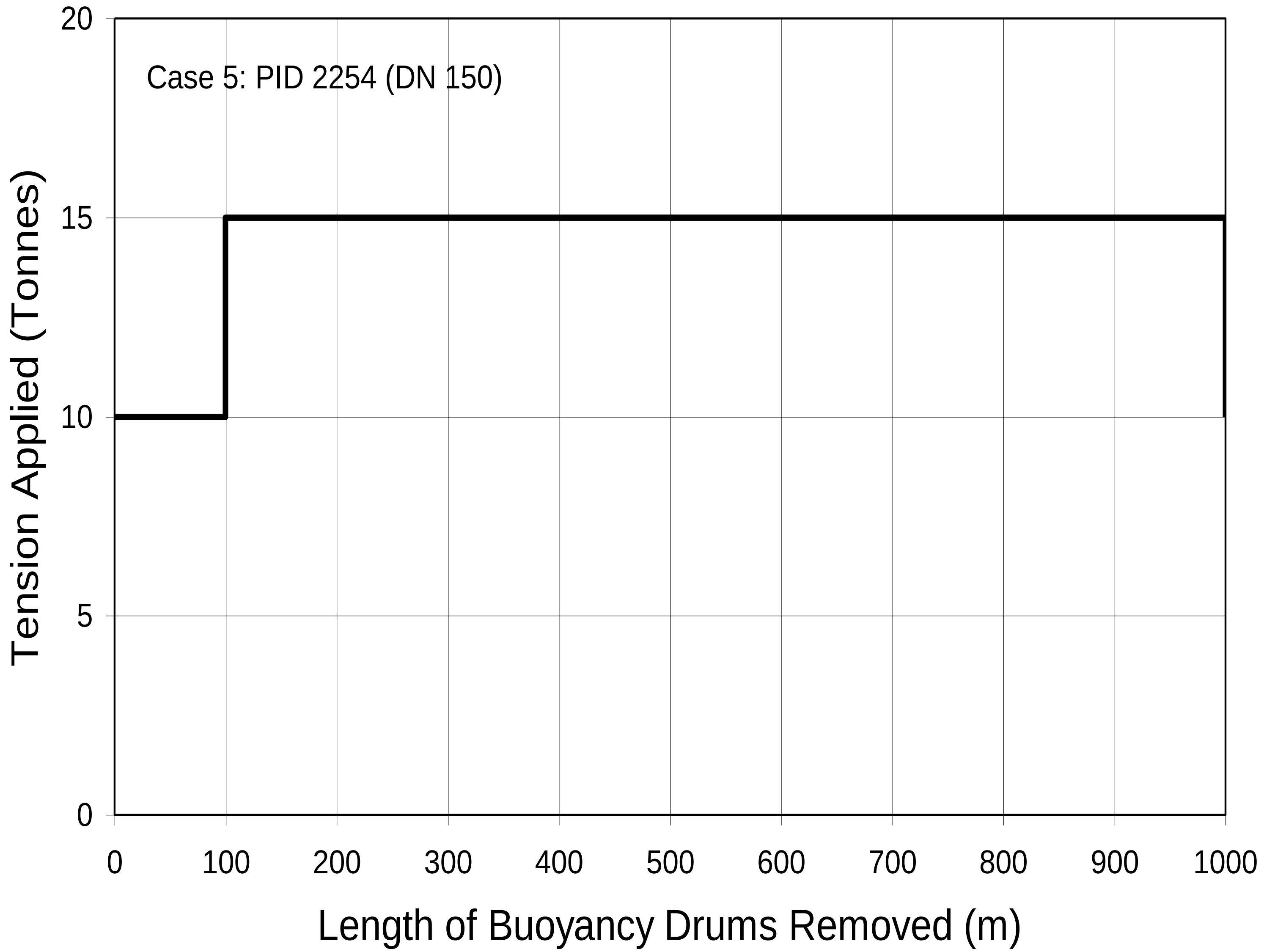
Stage 5: total of 900 m floatation drums removed
σ_{max}= 25%: T = 15t
Pipeline Profile
Bending Moment
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
30
20
10
0
-10
-20
-30
0
400
800
1200
1600
2000
2400
2800
3200
3600



Stage 6: total of 1000 m floatation drums removed
σ_{max}= 25%: T = 15t
Pipeline Profile
Bending Moment
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
30
20
10
0
-10
-20
-30
0
400
800
1200
1600
2000
2400
2800
3200
3600



Stage 7: total of 1000 m floatation drums removed with additional 150 ft cable released by tensioning tug)
σ_{max}= 33%: T = 10t
Pipeline Profile
Bending Moment
Bottom Pipe Elevation (ft)
Bending Moment (kips-ft)
Horizontal Distance (ft)
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
30
20
10
0
-10
-20
-30
0 250 500 750 1000 1250 1500 1750 2000 2250 2500 2750 3000 3250 3500 3750



Proposed Tension Requirement for Each Stage of Rentis Installation For Case 2: 6” (DN 150) Pipeline

The End

QUESTIONS??