Enbridge Liquid Pipelines
Valve Considerations for Hazardous Liquid Pipelines – Operator Perspective

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Operational Risk Management

ENBRIDGE

Enbridge Liquid Pipelines

<u>Total System</u>

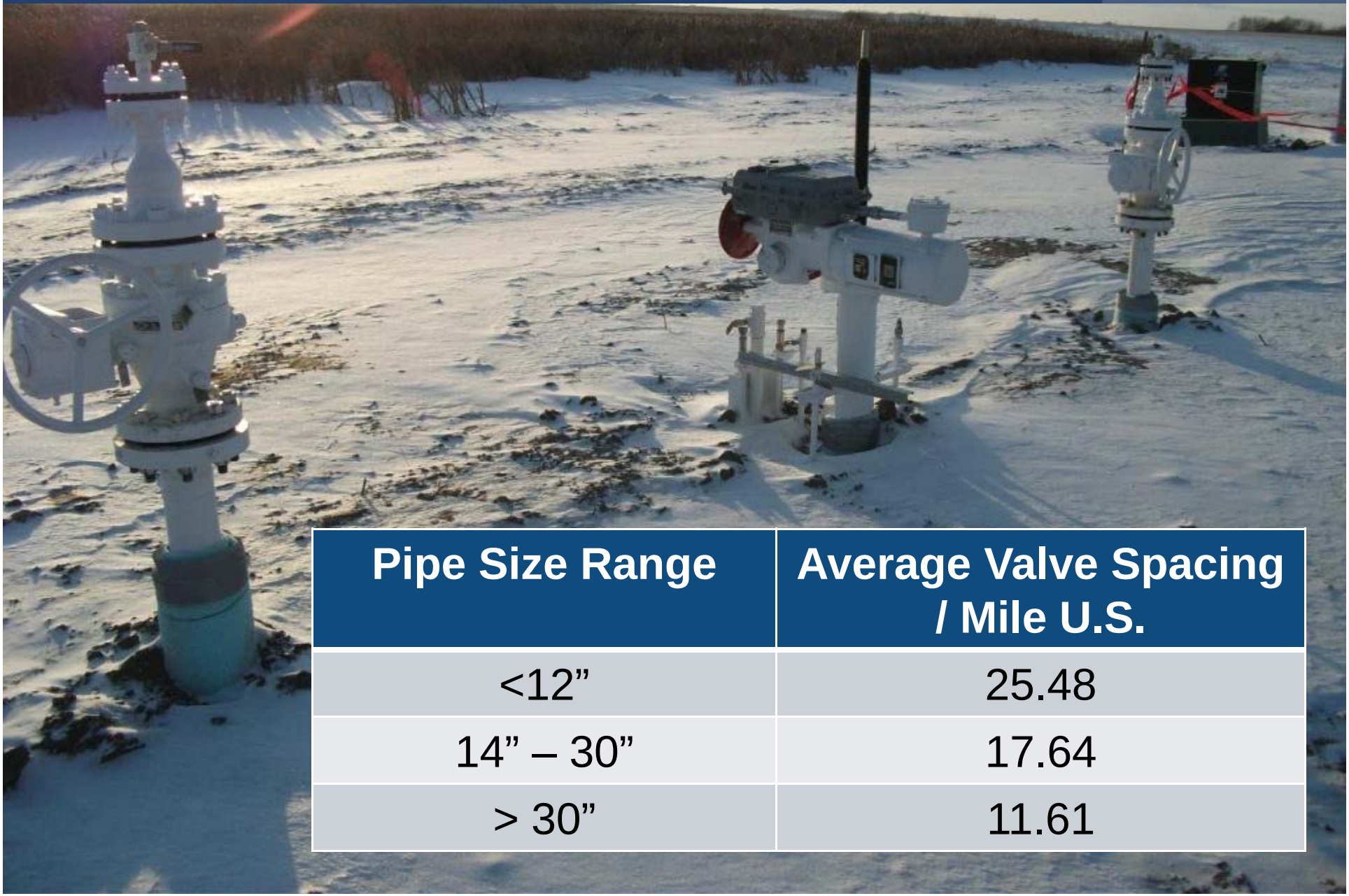
- +15000 Miles of Pipe
  *(Excluding gathering system)

- 1746 Mainline Valves
  - 974 Remote Controlled
  - 772 Hand Operated
  - 110 Check Valves

<u>U.S. Only</u>

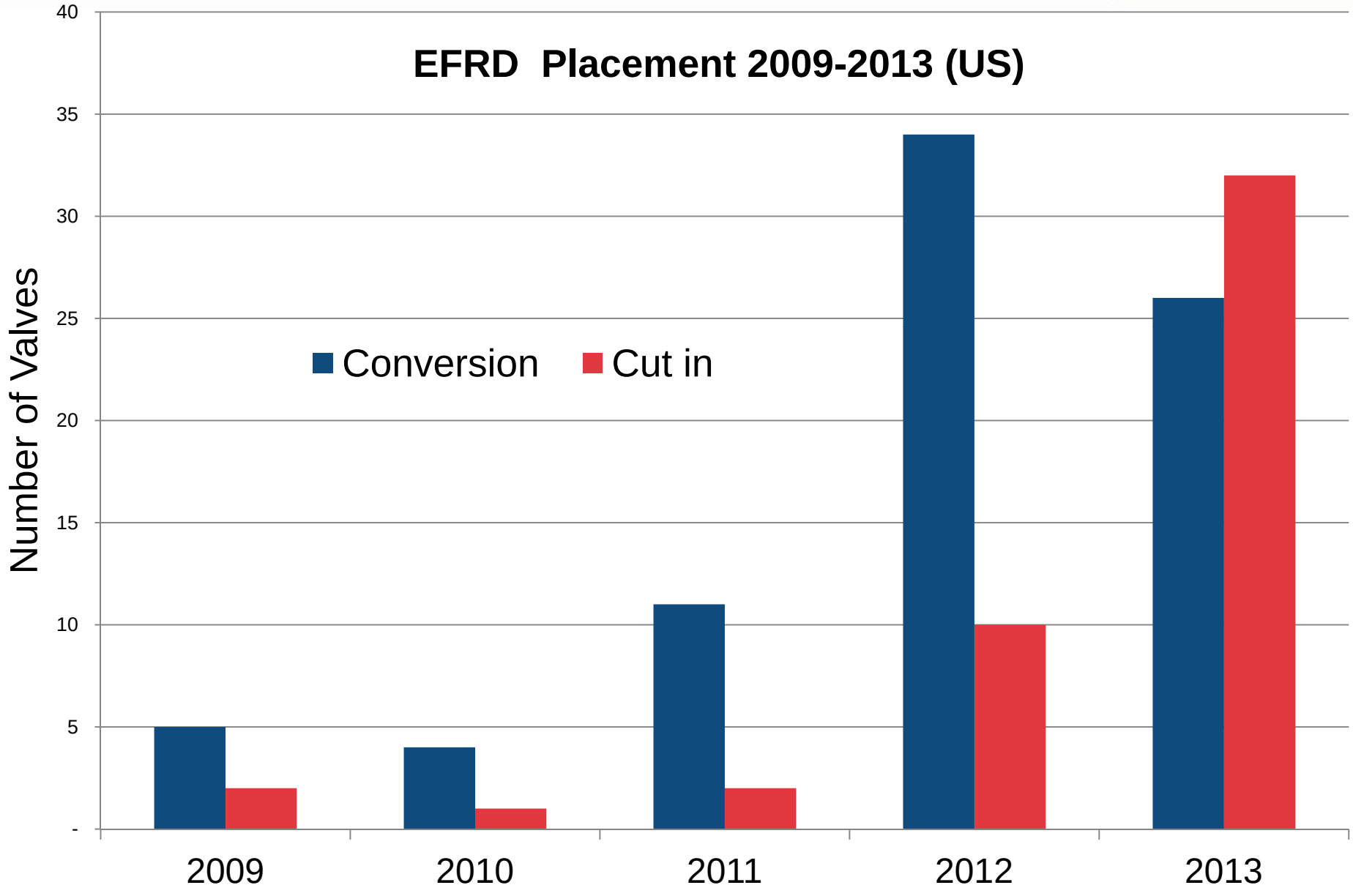
- 6658 Miles of Pipe (48.6%)
- 51.7% of Valves
  - 528 RCV
  - 374 HOV (MCV)
  - 42 Check Valves

Enbridge Liquid Pipelines



Pipe Size Range	Average Valve Spacing / Mile U.S.
<12”	25.48
14” – 30”	17.64
> 30”	11.61

Enbridge – IMP and EFRD



Conversion Candidate

Intelligent Valve Placement

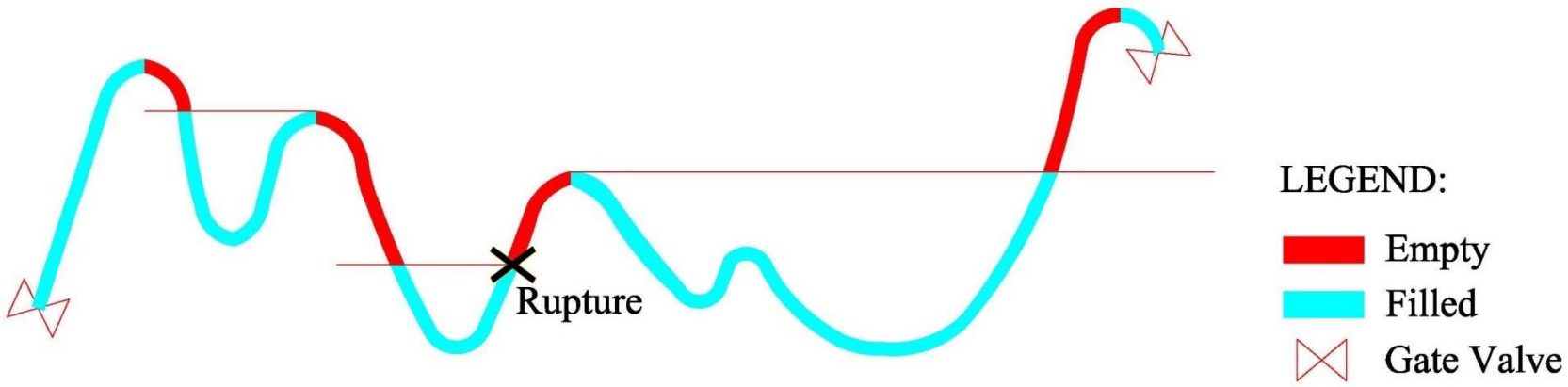
- Enbridge valve placement program looks solely at installation of remote controlled sectionalizing (or gate) valves
- Enbridge Engineering Design Standard requires 3 minutes closure time for remotely activated valves
- Automatic Control Valves (ACV) – Not considered
- Check valves issues
  - Not easy to test; Not able to visually confirm
  - May damage in-line inspection tools
  - May not hold their seal

Volume Out Calculation

Total Volume Out = Initial Volume Out + Stabilization Loss

Design Flow Rate
x 13 Minutes

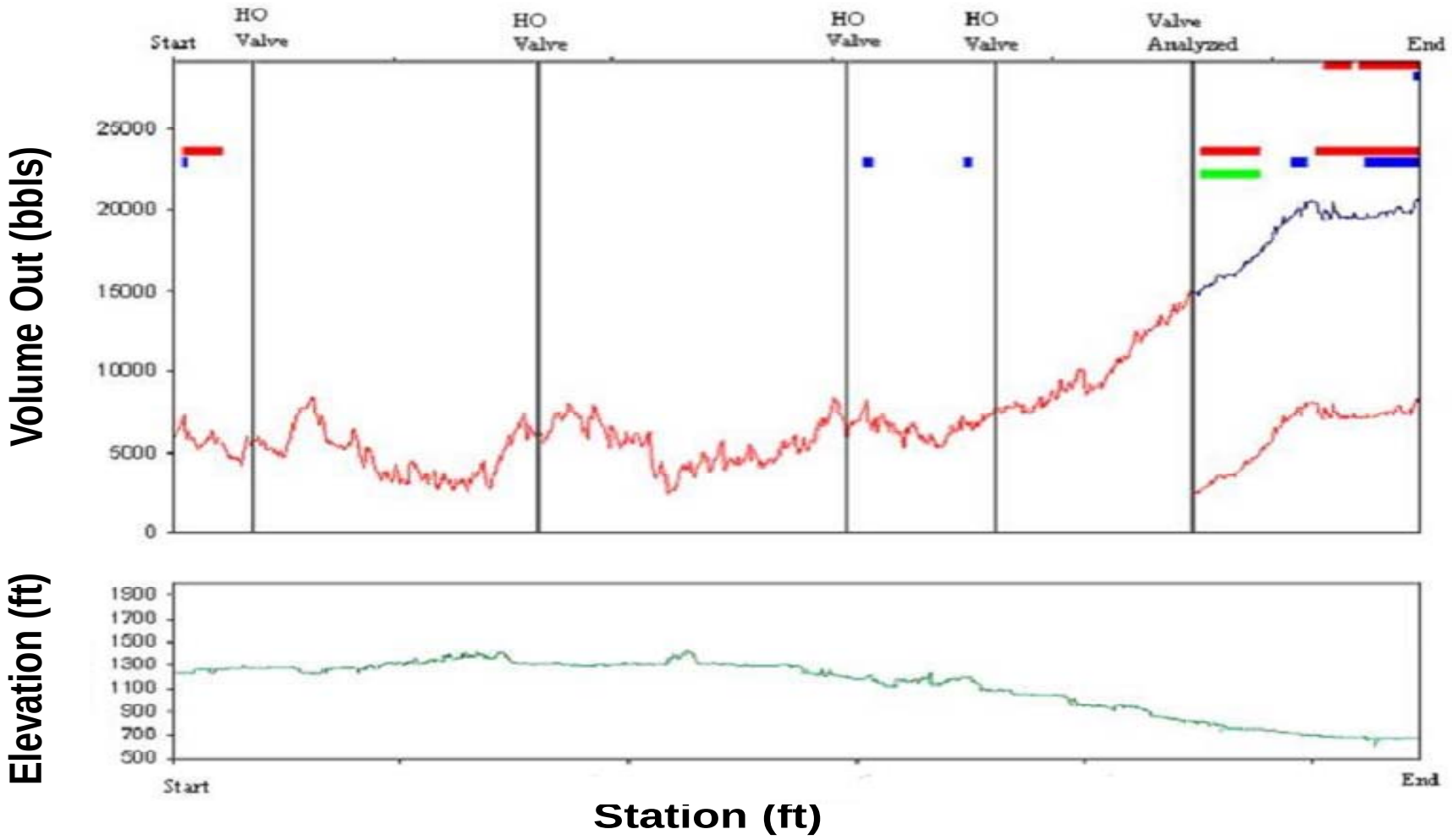
All product at a higher elevation not isolated by elevation or remote control valves. Flat pipe excluded.



Note: Valve Placement does not Mitigate Initial Volume Out

Prior to 2006

- Valve placement based on ability to reduce volume out to identified sensitive areas



From 2006-2007

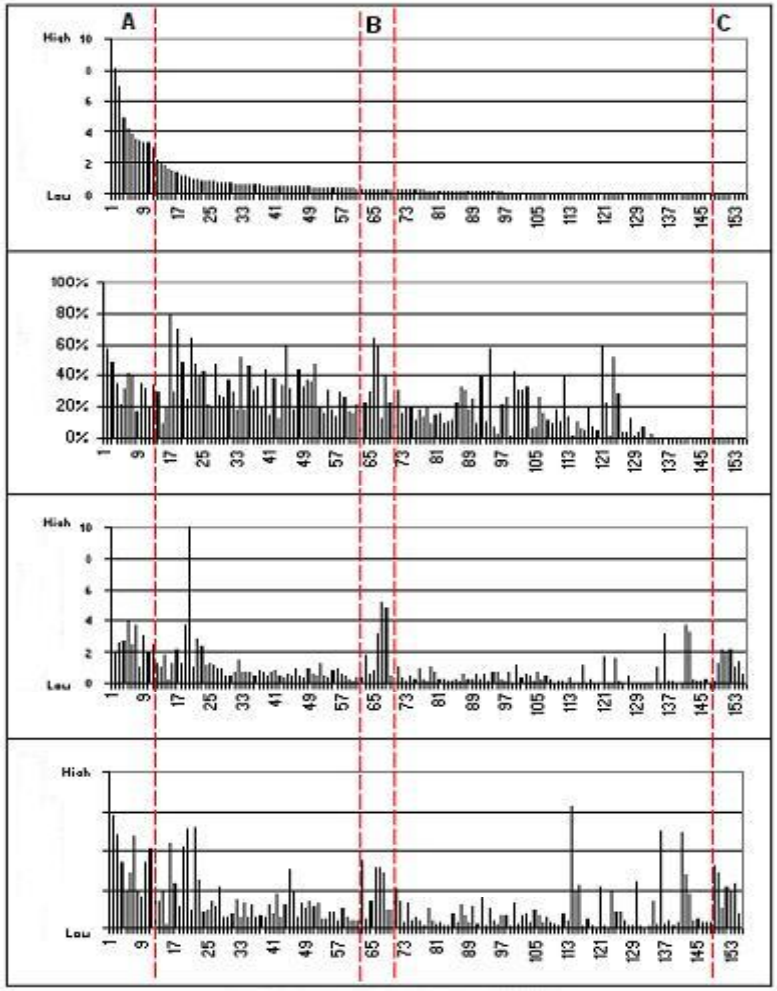
- Valve placement based on a combination of the following four factors:

Effectiveness

Efficiency

Total Volume Out Reduction

Average Volume Out Reduction



Valves Ranked by Effectiveness

Factors 1, 2 (2006-2007)

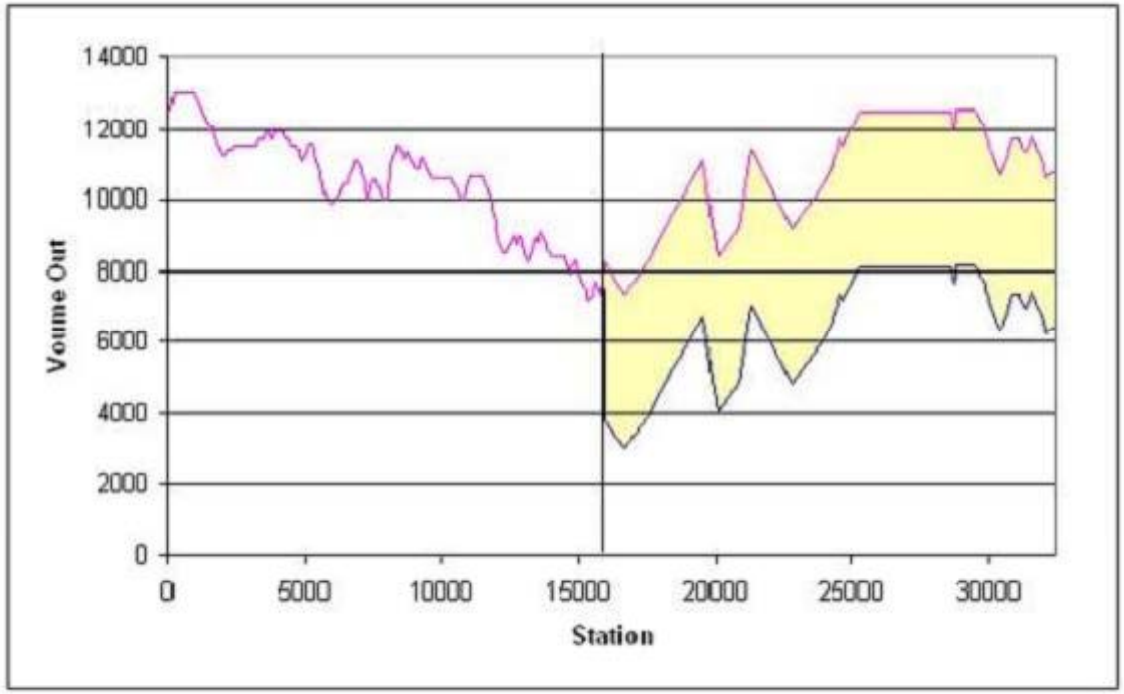
$$\text{Effectiveness} = \sum\left[\begin{pmatrix}\text{Average Volume}\\ \text{Reduction for an HCA}\end{pmatrix}\times\begin{pmatrix}\text{HCA}\\ \text{Length}\end{pmatrix}\times\begin{pmatrix}\text{HCA Type}\\ \text{Score}\end{pmatrix}\right]$$

$$\text{Efficiency} = \sum\left[\frac{(\%\ \text{Reduction for a given HCA})\times(\text{HCA Length})}{(\text{Total HCA Length by Valve})}\right]$$

HCA = High Consequence Areas or Other Areas of Concern

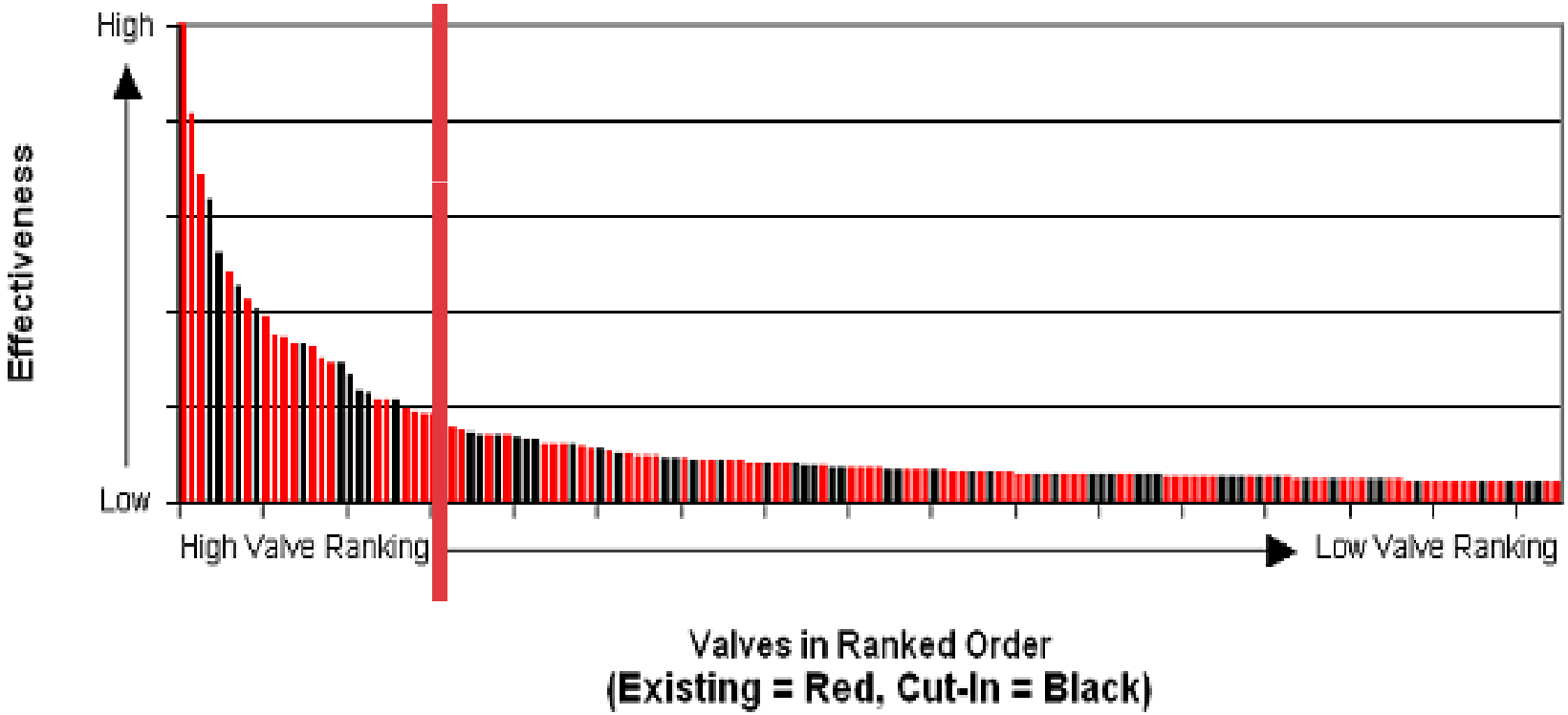
Factors 3, 4 (2006-2007)

- **Total Volume Out**
  - The area between the two volume out profiles
- **Average Volume Out**
  - The average of potential volume reduction



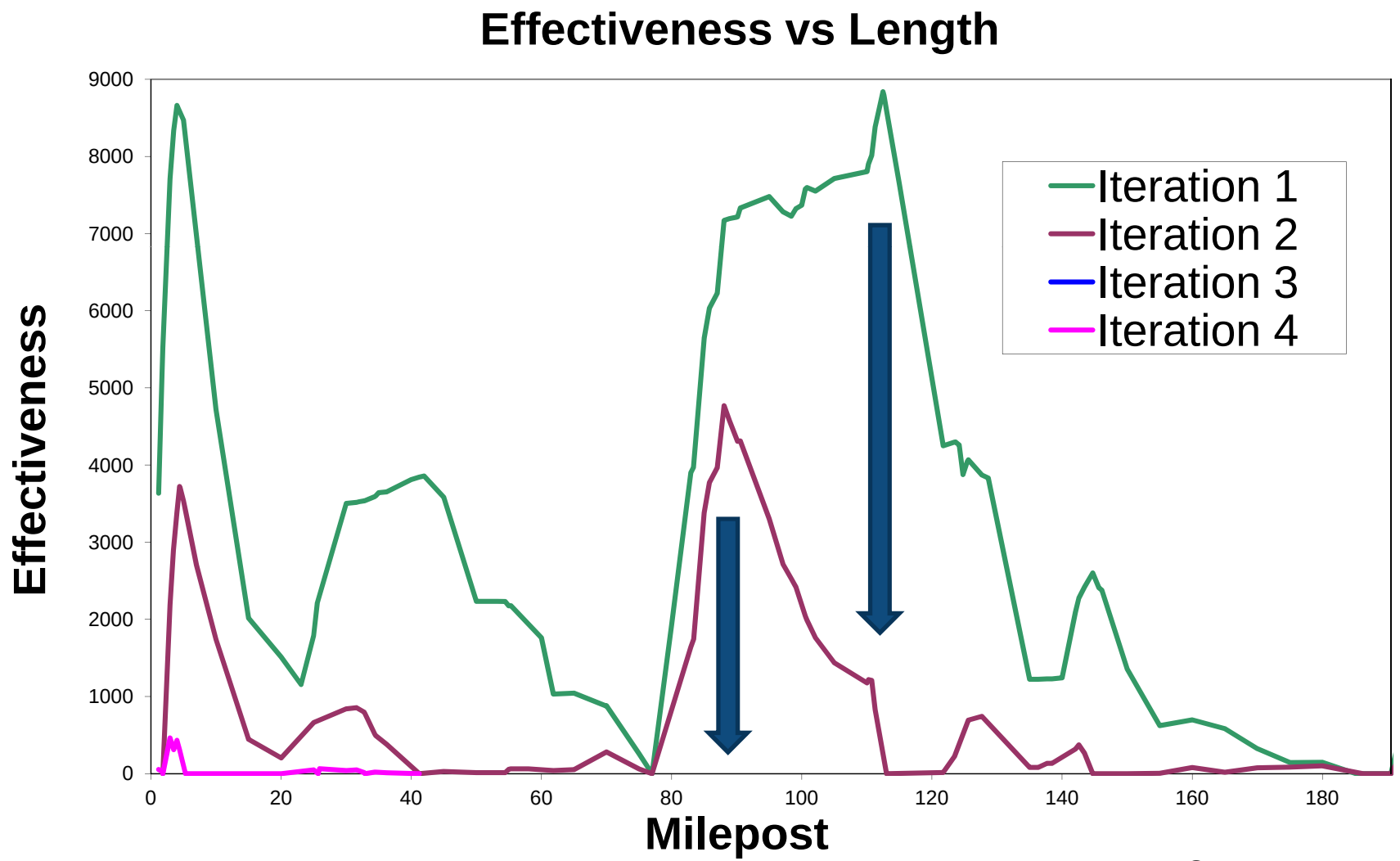
From 2007- 2008

- Valve Placement based on solely on Effectiveness



Valve Placement 2008-10

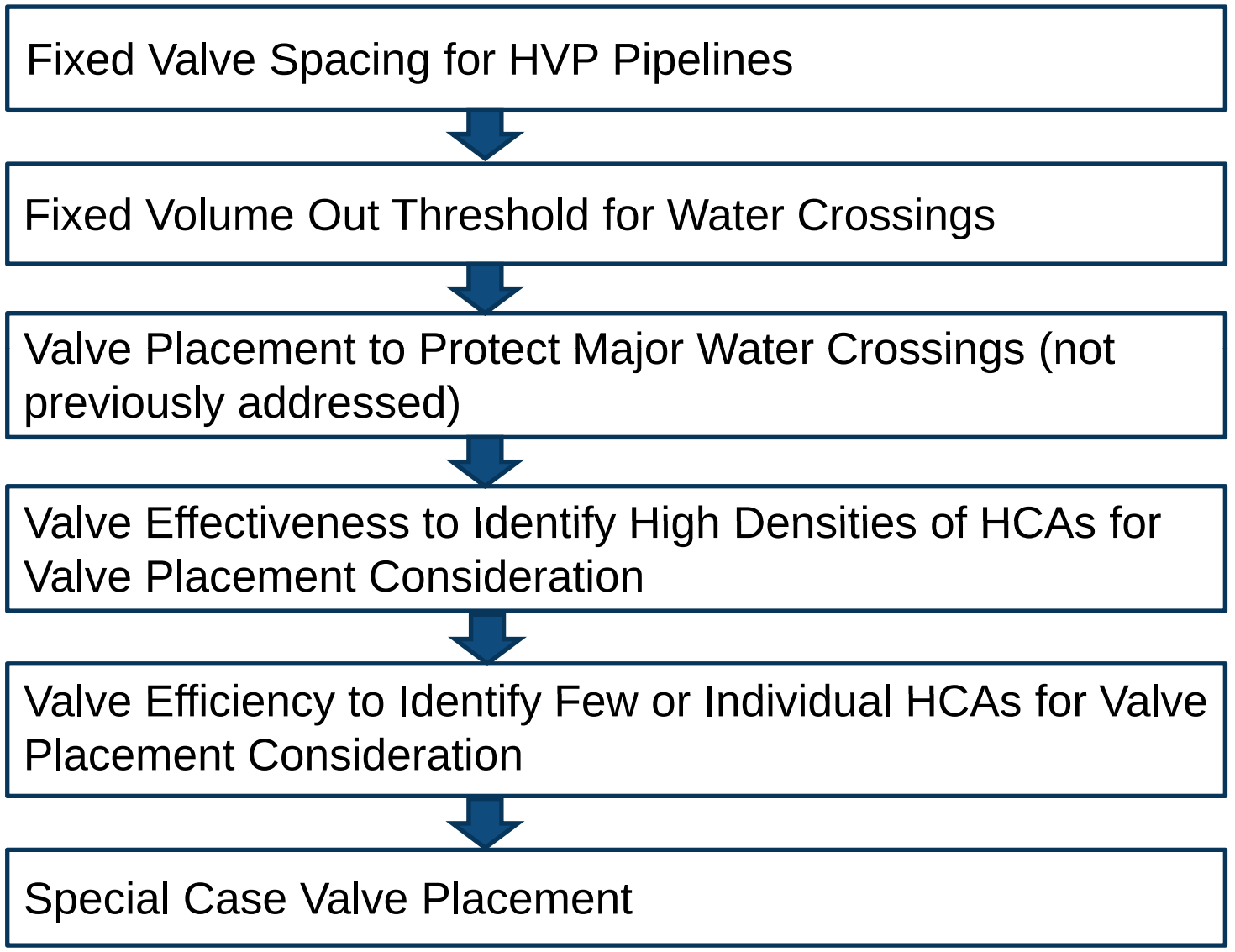
- Valve Placement based solely on Effectiveness Curve



Valve Placement 2010-11

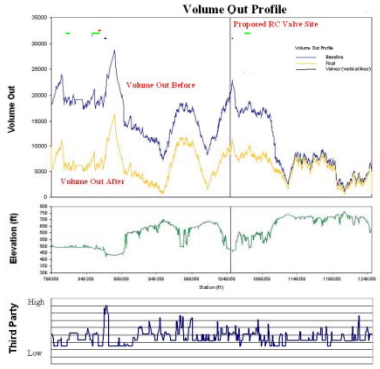
- Valve Placement based on:
  - Company identified worst case scenarios
  - Top Risk Areas
  - Major Water Crossings
  - IVP Analyses Results

Valve Placement 2012+



Procedure

Identify Requirements



Intelligent Valve Placement Analysis

Field Verification

Project Execution

Major Water Crossings

Field Verification

The optimal locations are then evaluated for:

- Constructability
- Power Availability
- Terrain
- Availability of Land
- Location of existing valves

Valve Costs U.S.

- Existing system
  - Cut in $1.5 M
  - Conversion $0.5 M

- New Pipeline

Diameter (in)	Price $
12	250K
20	315K
34	420K
48	520K

Valve Performance

- Check Valves
  - Unknown damage by a pig
  - Sediment wear on the seats and guides
- RCV (usually below grade with top side actuator)
  - Debris in the seat
  - Actuator failure
  - Power or communication loss
- MCV (Manual)
  - Less failure modes but require person present
  - Cold weather operations

Field Installation

Valve Actuate Times

- Check Valve
  - Close in seconds
- RCV
  - Typically 3 minutes
  - Fast Closure systems available
- MCV
  - 30 minutes to several hours to a day or more

Human Factor Issues

- Valve closure based on human trigger
  - Operator has to recognize some event (alarm)
  - Then trigger the valve close
- Control Center Operations gets lots of practice thru regular valve function tests
- Manual Valves are regularly functioned by operations so procedures are well understood
- Largest issue is communication.
  - Locating the correct valve
  - Accessing the site to close the valve
  - Addressed thru practice and field exercises

Conclusions

Placement of remote control valves can reduce the impact of an unplanned release by reducing the drain down volume