OBSERVATION METHOD: A NEW TOOL FOR THE BRIDGE SCOUR ENGINEER

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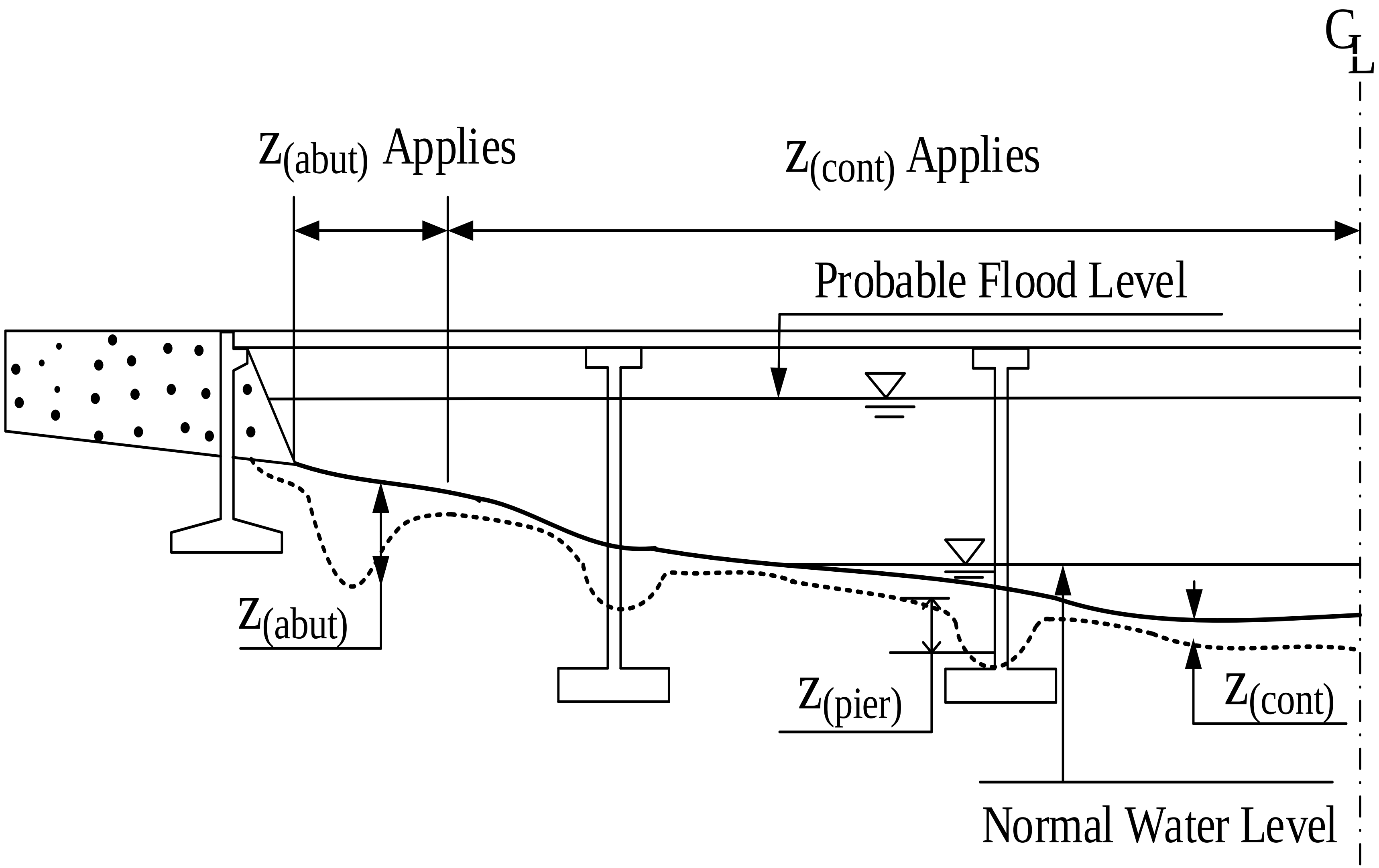
and President of FedIGS

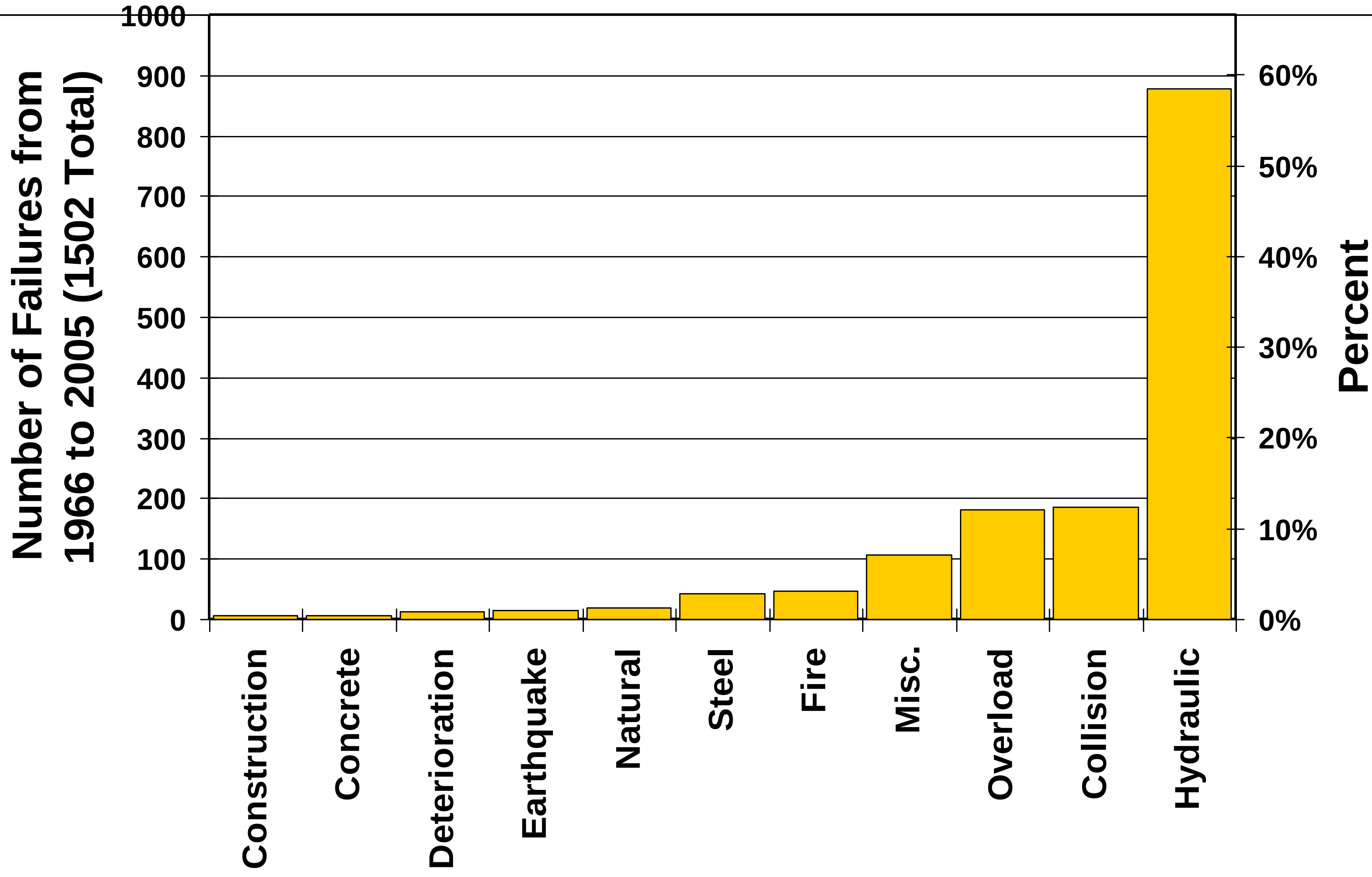
Acknowledgements

- Texas DOT (John Delphia)
- Massachusetts DOT (Rich Murphy)
- Dr. Chen, Dr. Oliveira
- Anand Govindasamy, Dekay Kim, Inwoo Jung

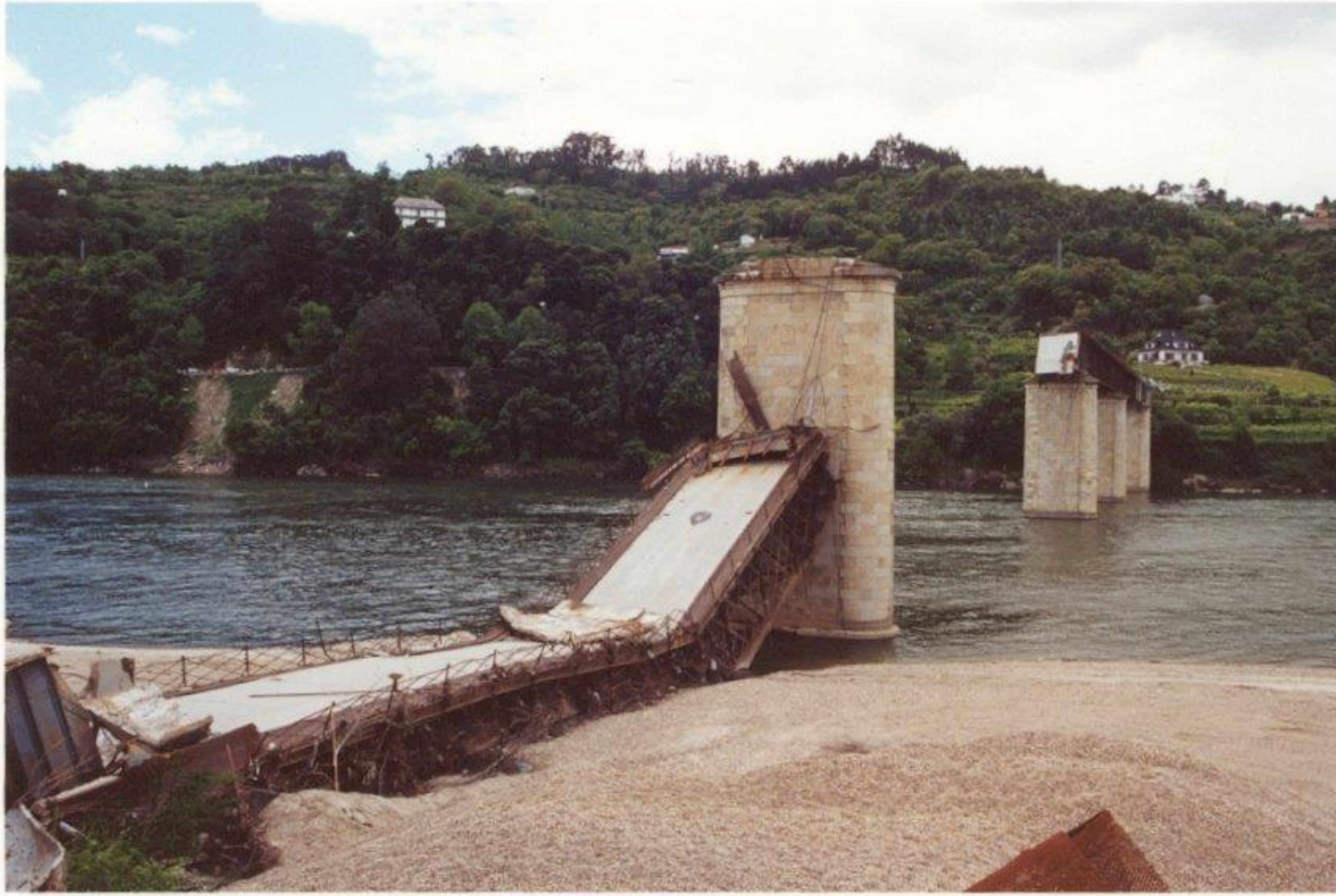
SCOUR DEPTHS



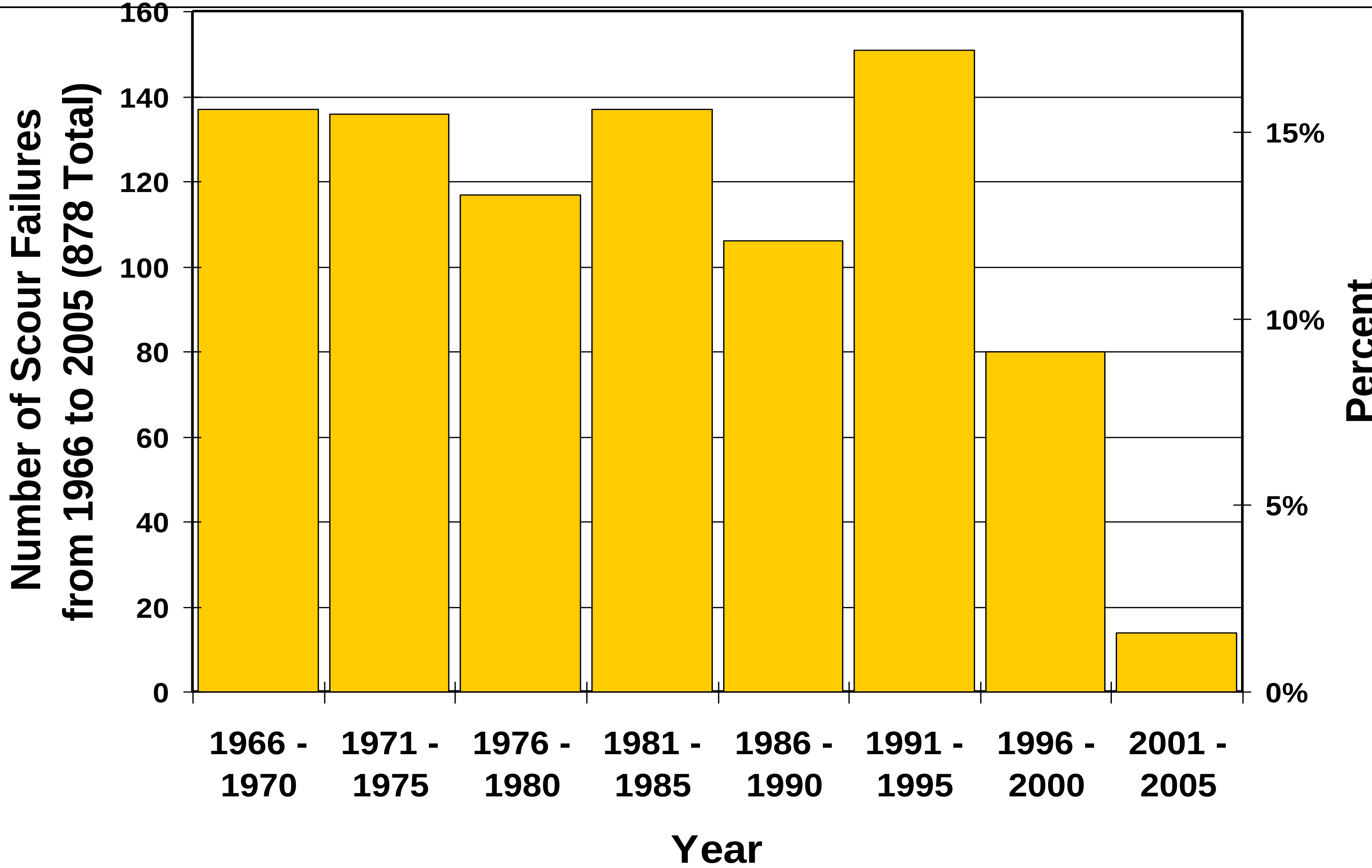
1 BRIDGE FAILS EVERY 10 DAYS



SCOUR = NO.1 KILLER OF BRIDGES



IT IS GETTING BETTER



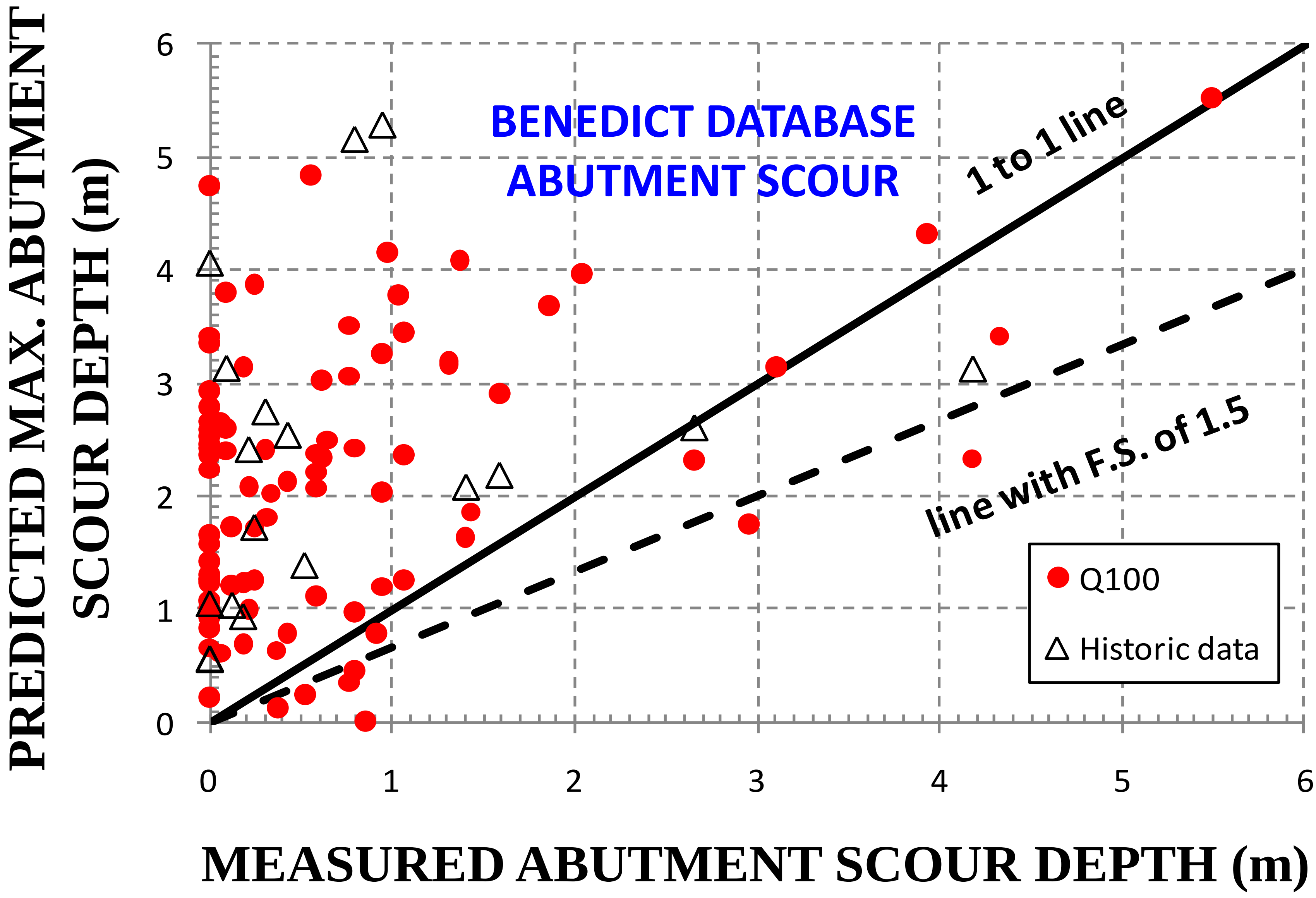
RESEARCH PAYS OFF

PROBLEM

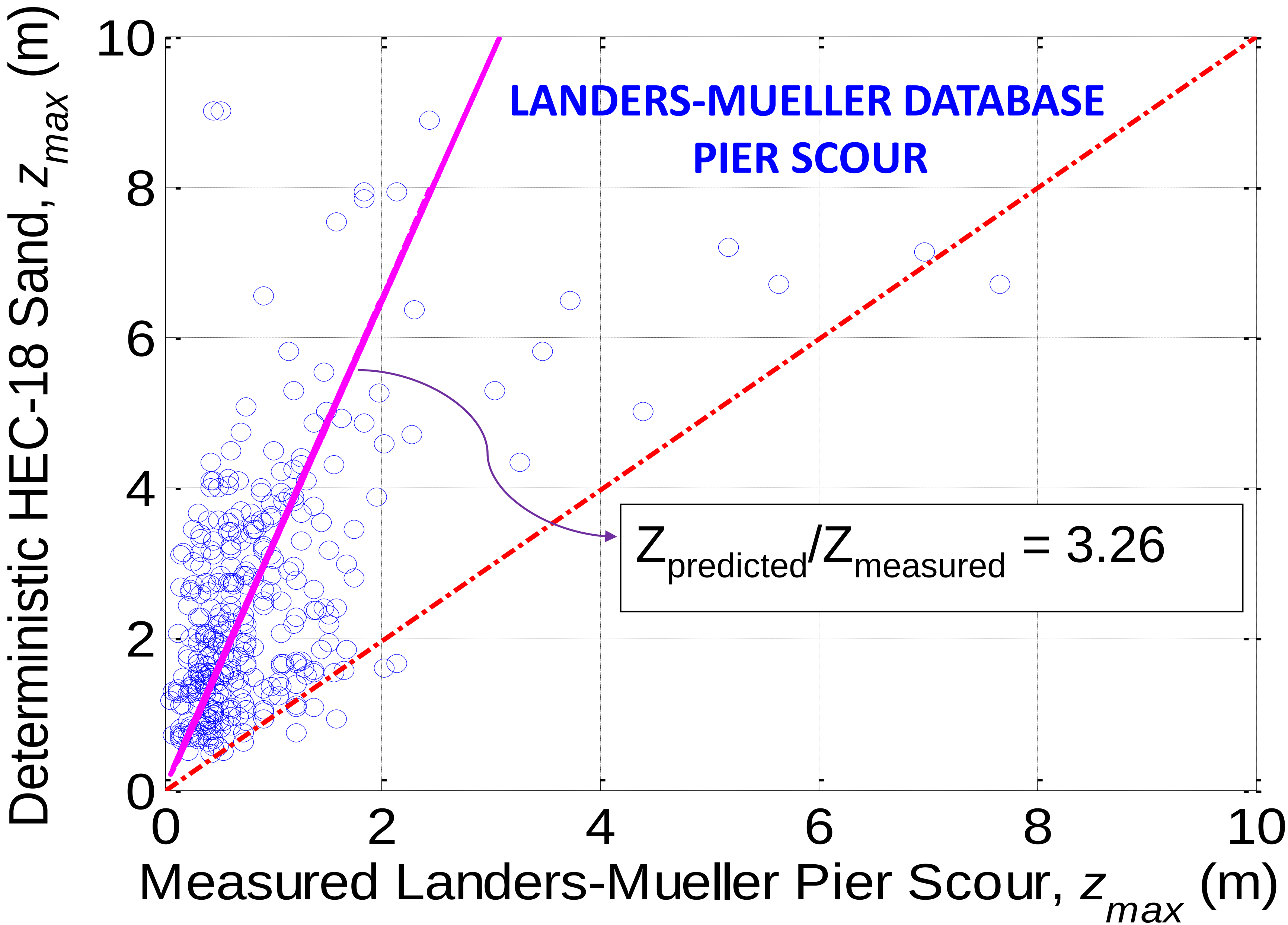
1. Comparison between measured and calculated scour depths by current method exhibits a lot of scatter

2. Comparison between measured and calculated scour depths by current method shows excessive conservatism on the average

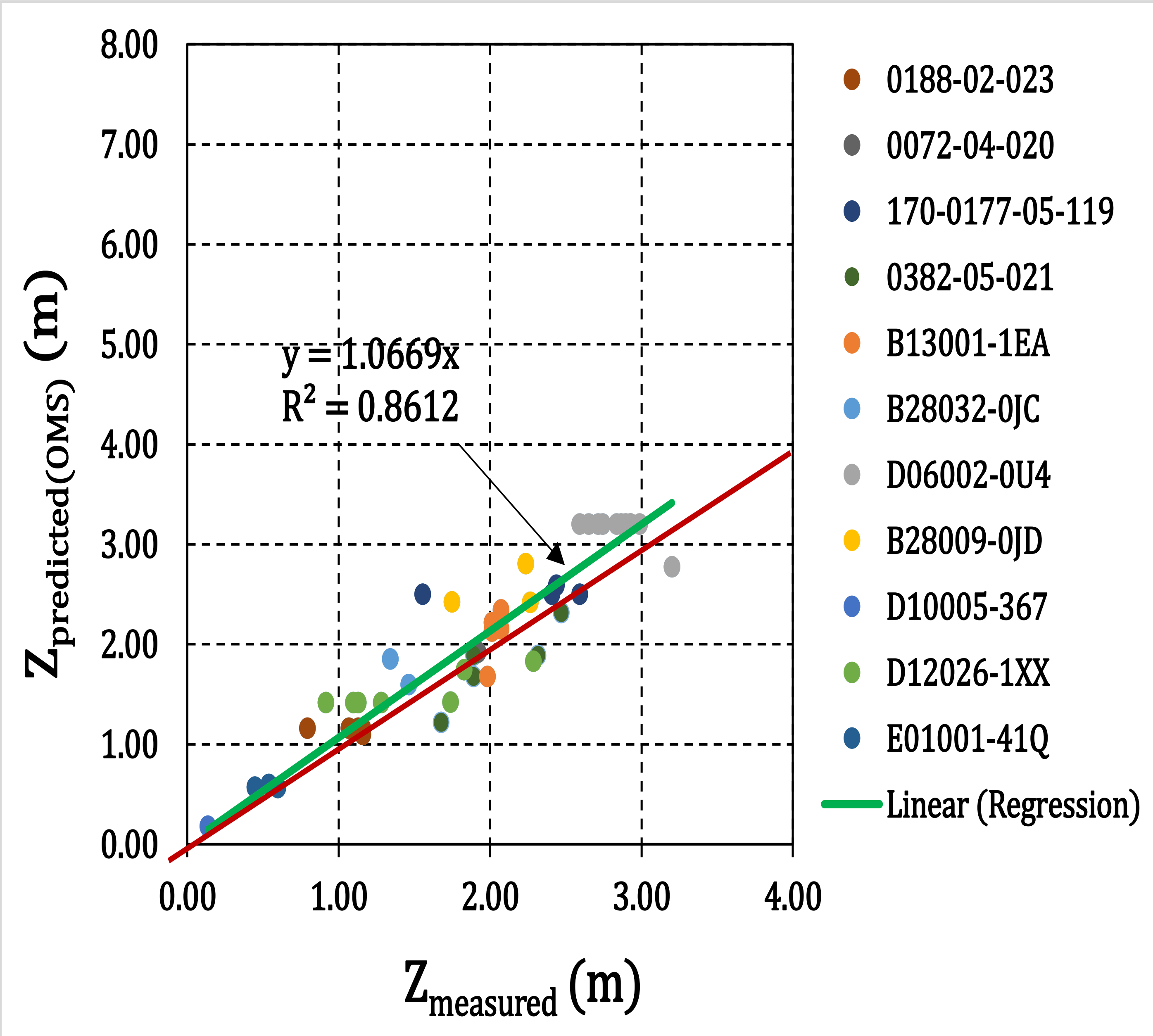
HEC-18 RESULTS



HEC-18 RESULTS

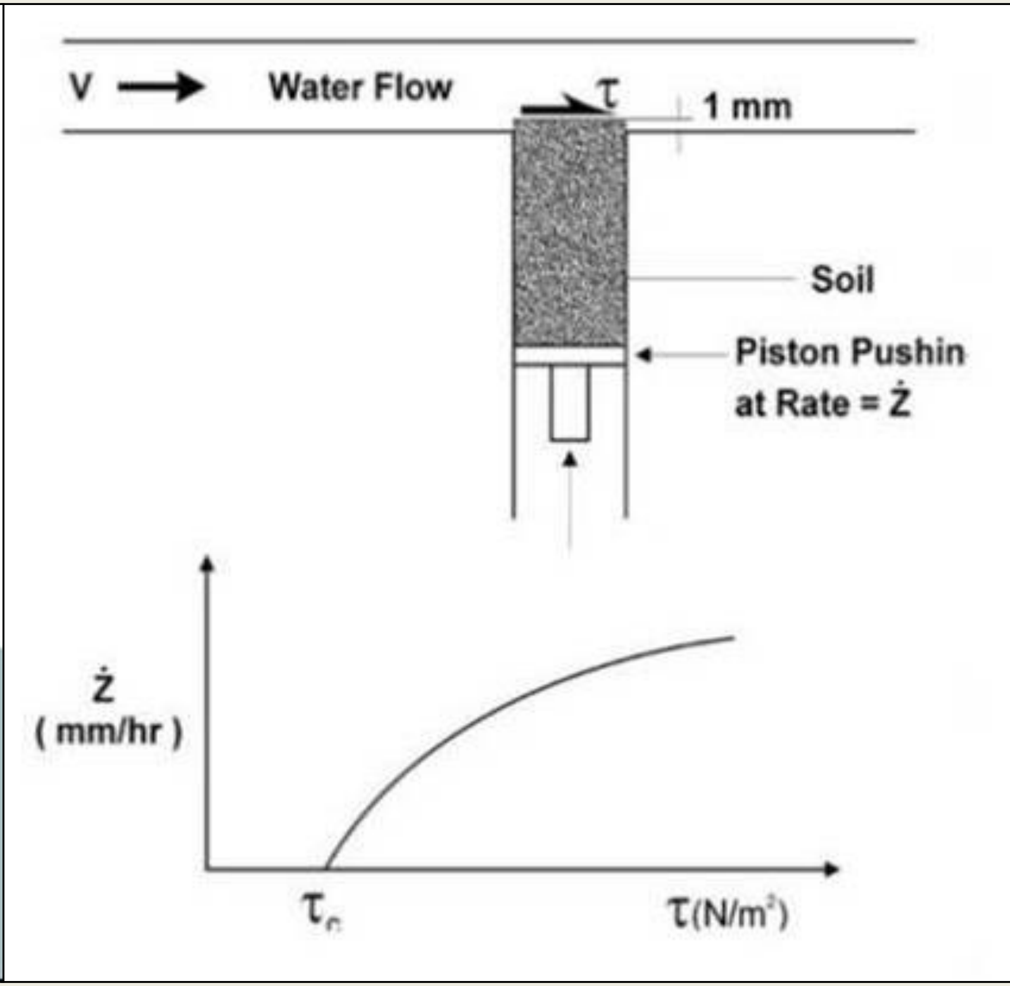


OMS-TEXAS & MASSACHUSETTS



J.-L. Briaud, Texas A&M University

EFA - EROSION FUNCTION APPARATUS

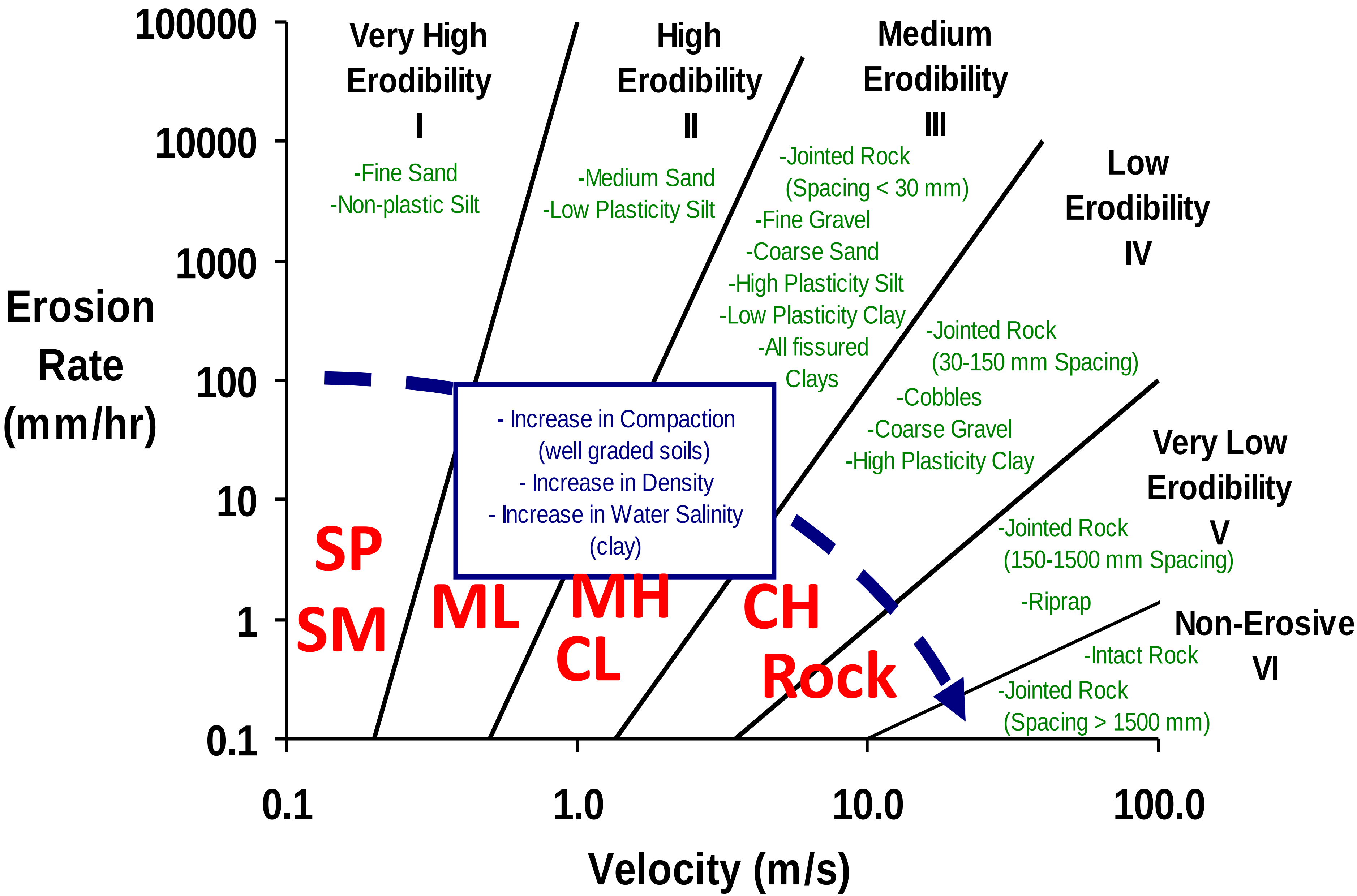


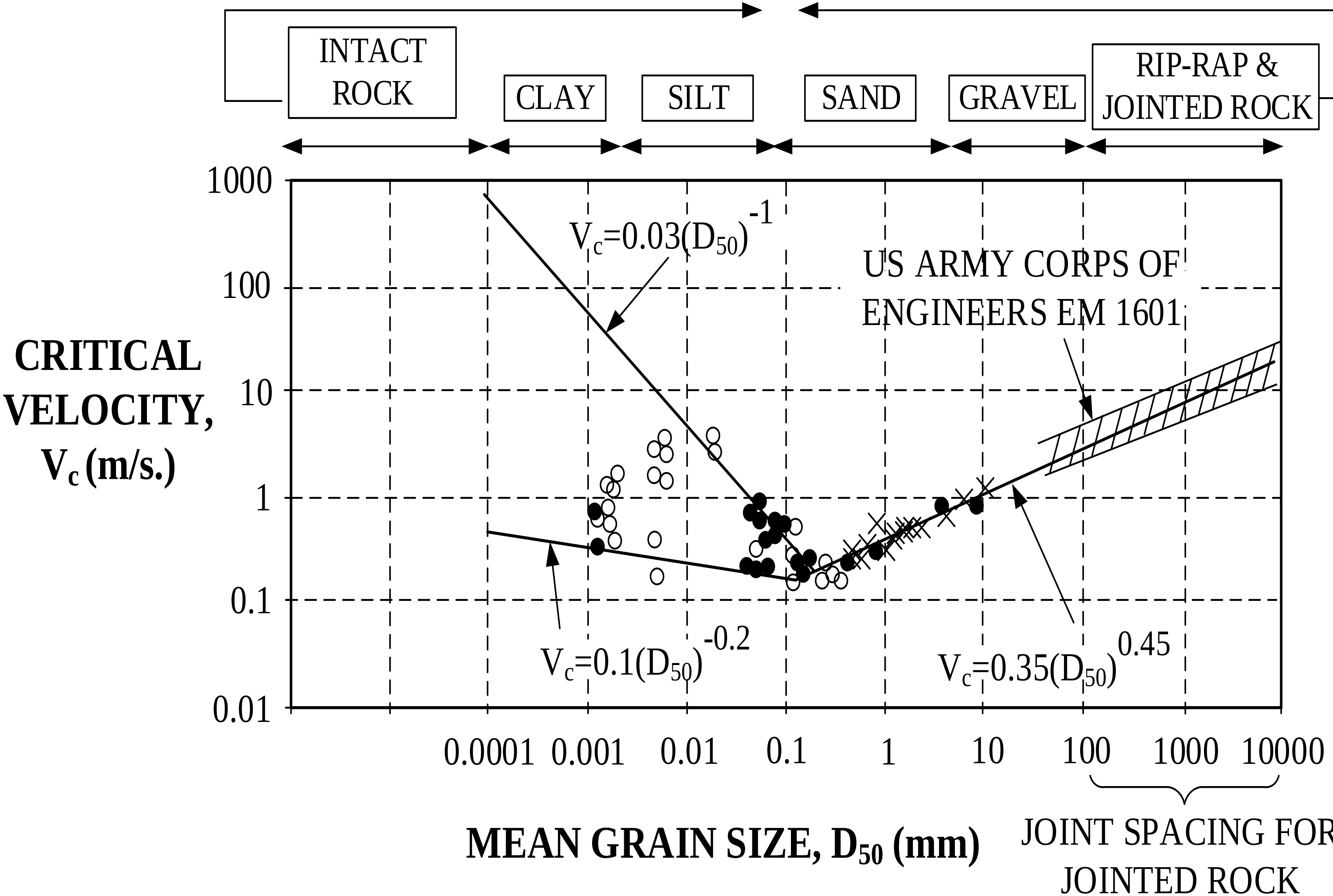
POCKET ERODOMETER

PET test result = Depth of hole in mm after 20 squirts at 8 m/s

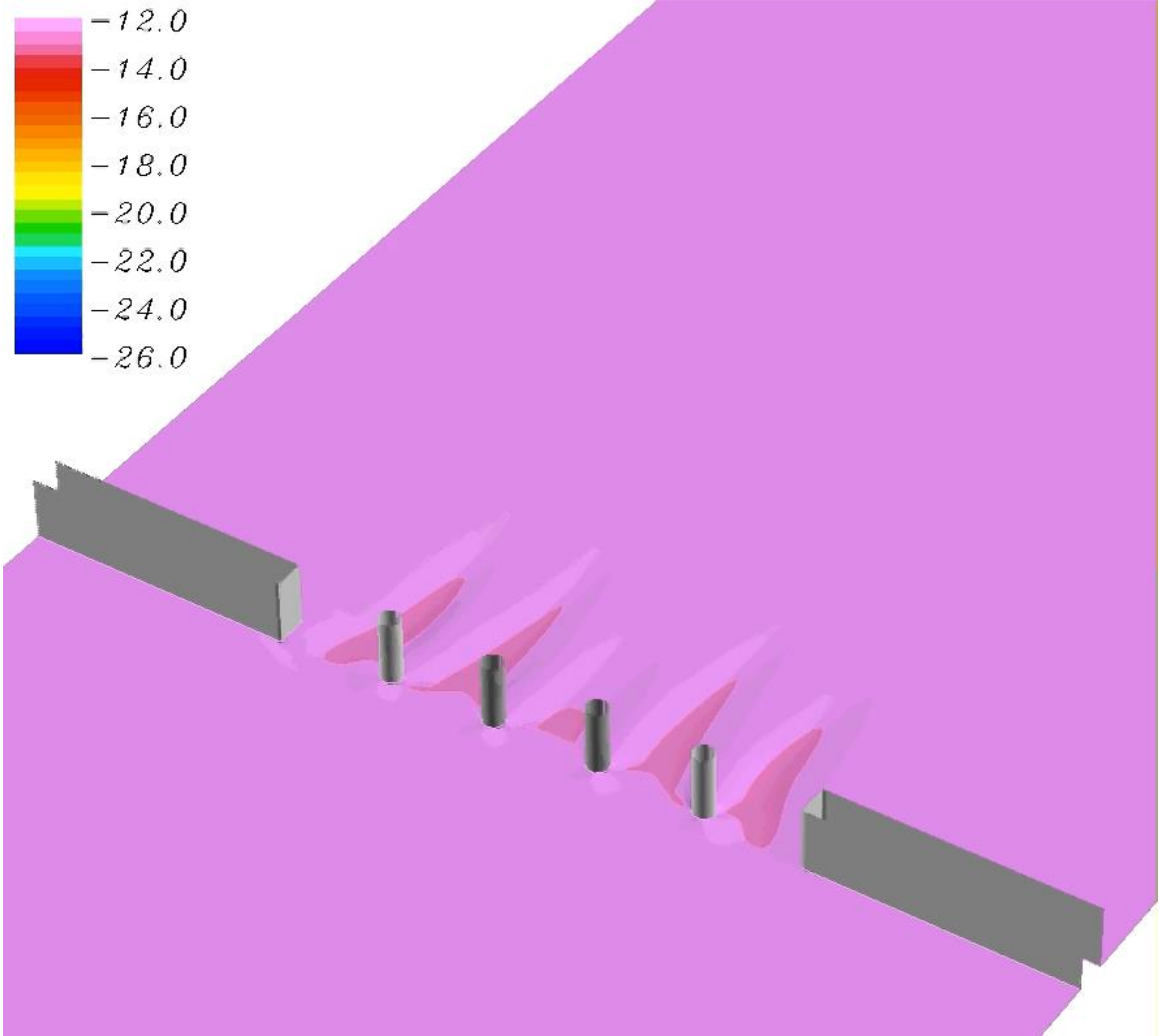
$0.49 at WalMart

EROSION CLASSIFICATION

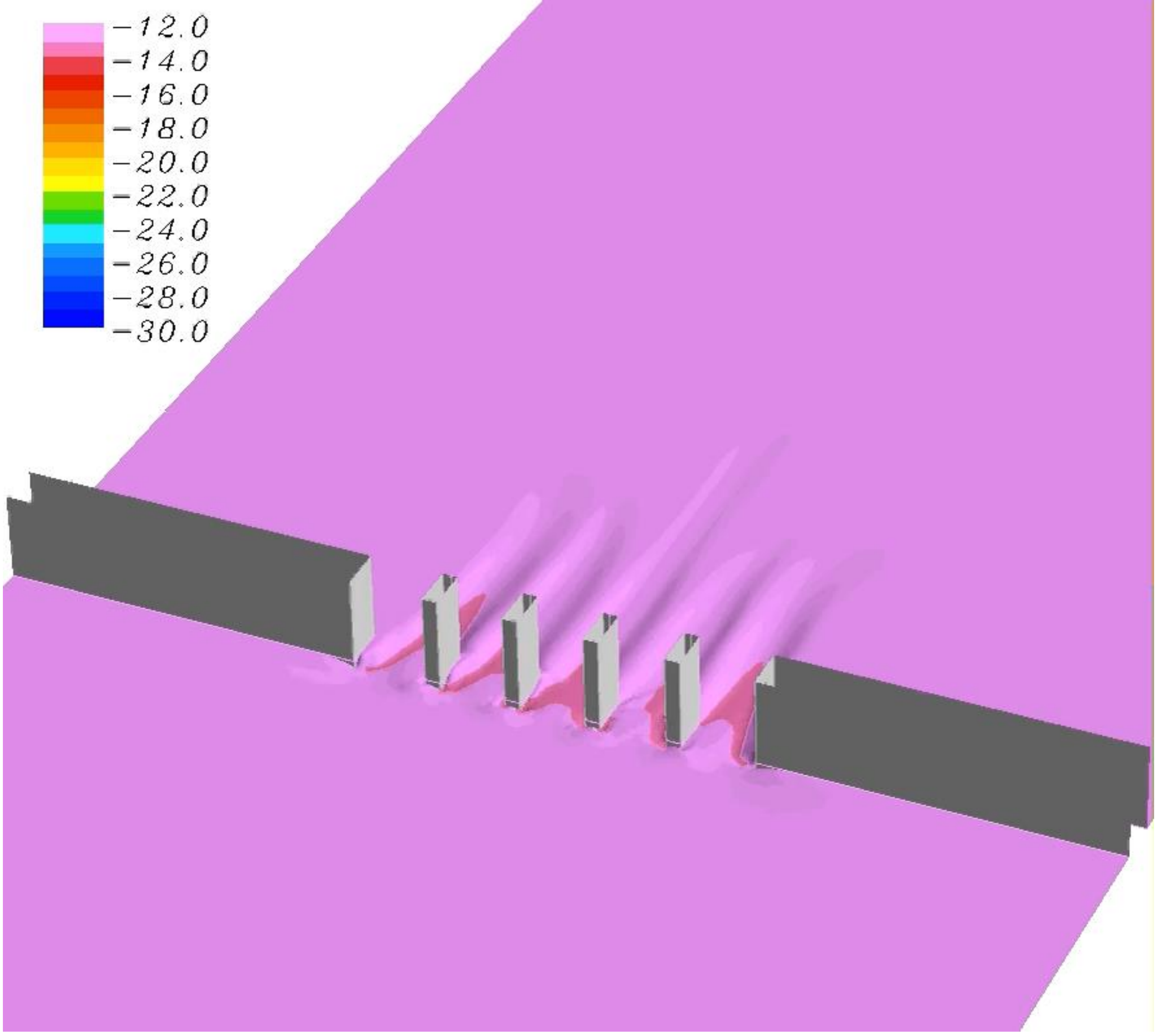




INTACT ROCK
CLAY
SILT
SAND
GRAVEL
RIP-RAP & JOINTED ROCK
CRITICAL VELOCITY, V_c (m/s.)
1000
100
10
1
0.1
0.01
$V_c=0.03(D_{50})^{-1}$
US ARMY CORPS OF ENGINEERS EM 1601
$V_c=0.1(D_{50})^{-0.2}$
$V_c=0.35(D_{50})^{0.45}$
0.0001
0.001
0.01
0.1
1
10
100
1000
10000
MEAN GRAIN SIZE, D_{50} (mm)
JOINT SPACING FOR JOINTED ROCK



−12.0
−14.0
−16.0
−18.0
−20.0
−22.0
−24.0
−26.0



−12.0
−14.0
−16.0
−18.0
−20.0
−22.0
−24.0
−26.0
−28.0
−30.0

OBSERVATION METHOD FOR SCOUR

- Developed at Texas A&M University for TxDOT
- Because of experience with calculating scour depths that seemed unreasonably large compared to observations by inspectors in the field

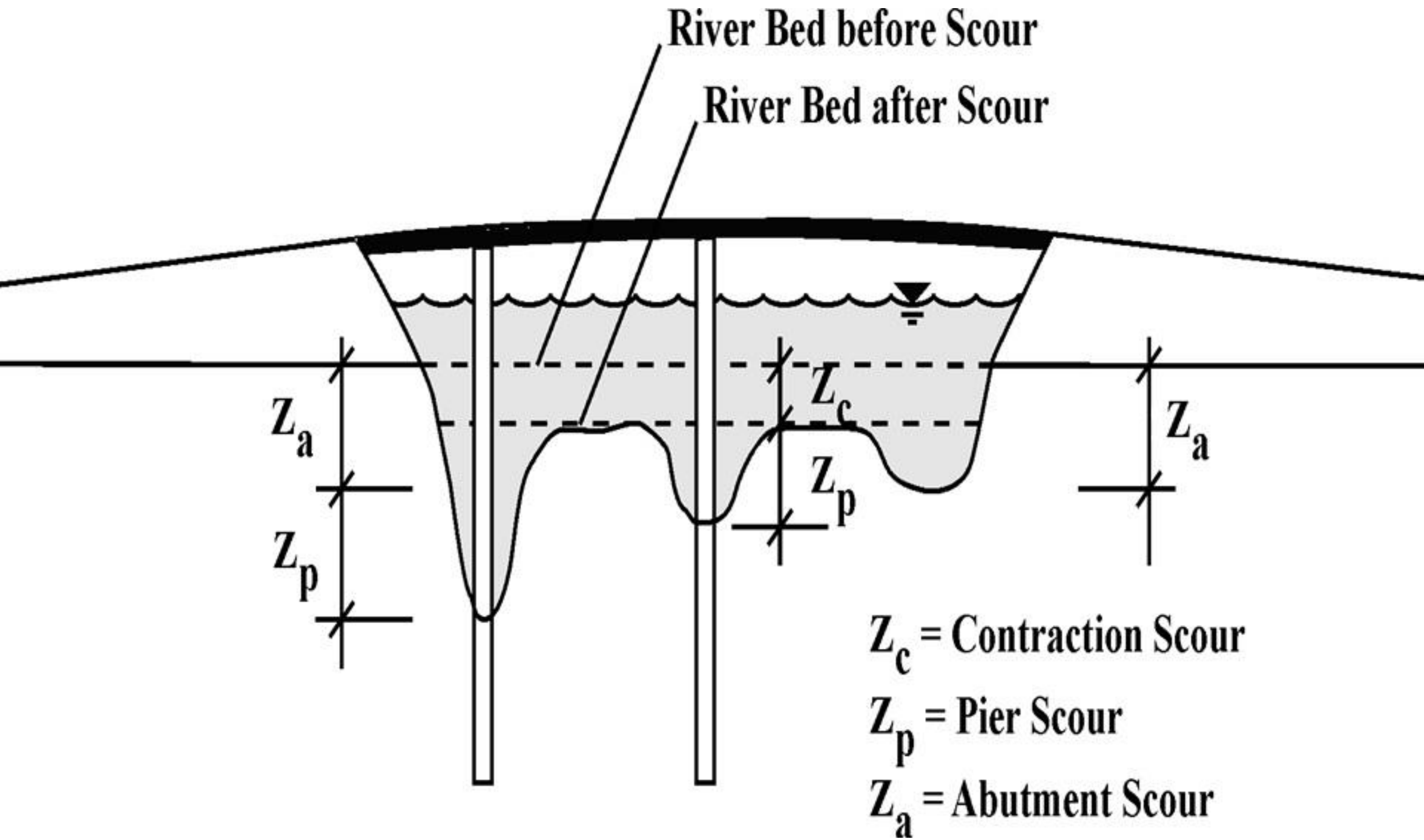
OBSERVATION METHOD FOR BRIDGE SCOUR

- Step 1: Observe maximum scour depth = Zmo
- Step 2: Find out the maximum flood the bridge has been subjected to : Collect gage data, RI from TAMU-OMS, Qmo/Q100, Vmo/V100
- Step 3: Extrapolate field measurements to predict future scour depth

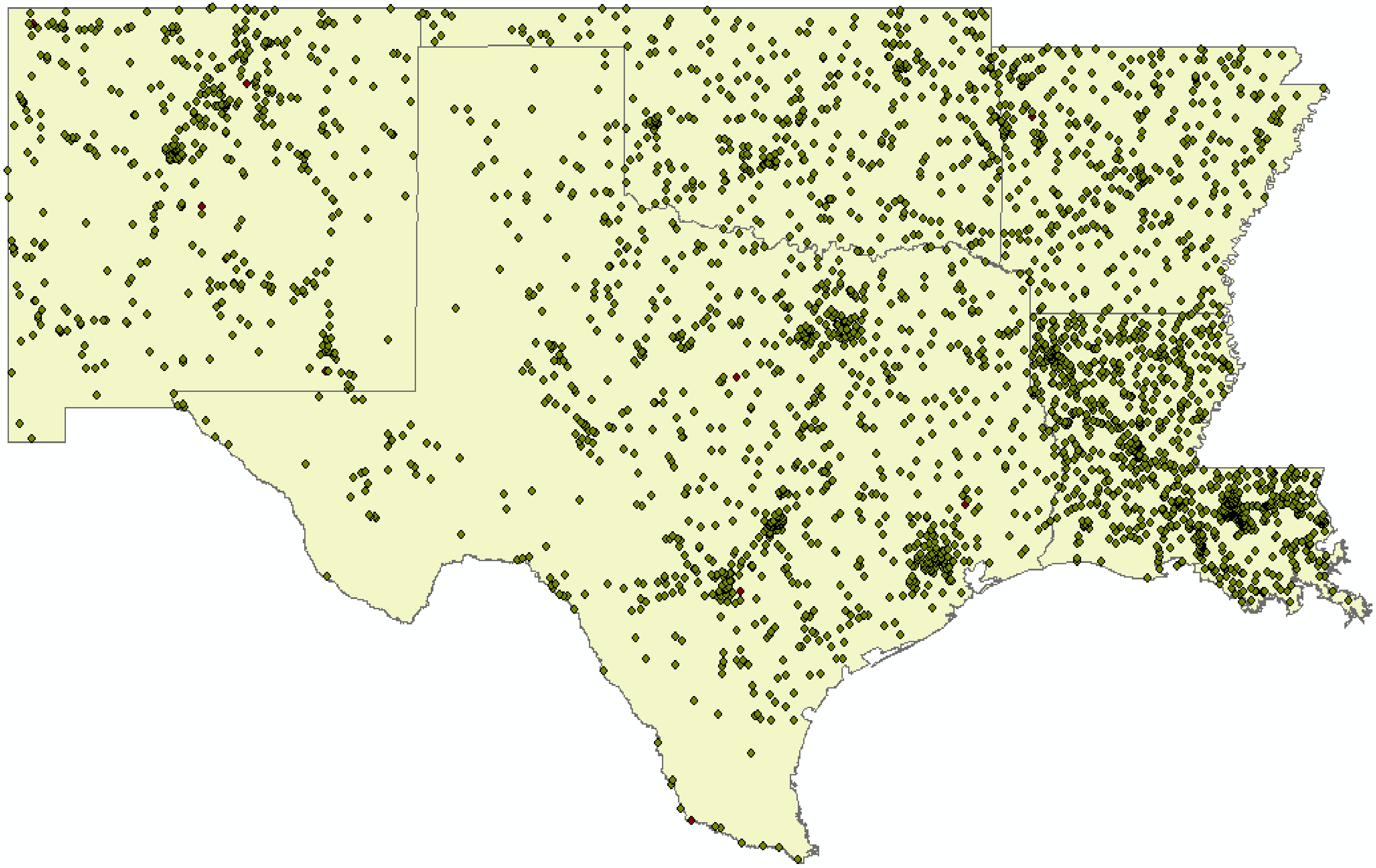
$$Zfut / Zmo = F (Vfut / Vmo)$$

- Step 4: Compare future scour depth to foundation depth (pier) $Zfut < Zfound / 2$

Step 1: Observe maximum scour depth = Zmo

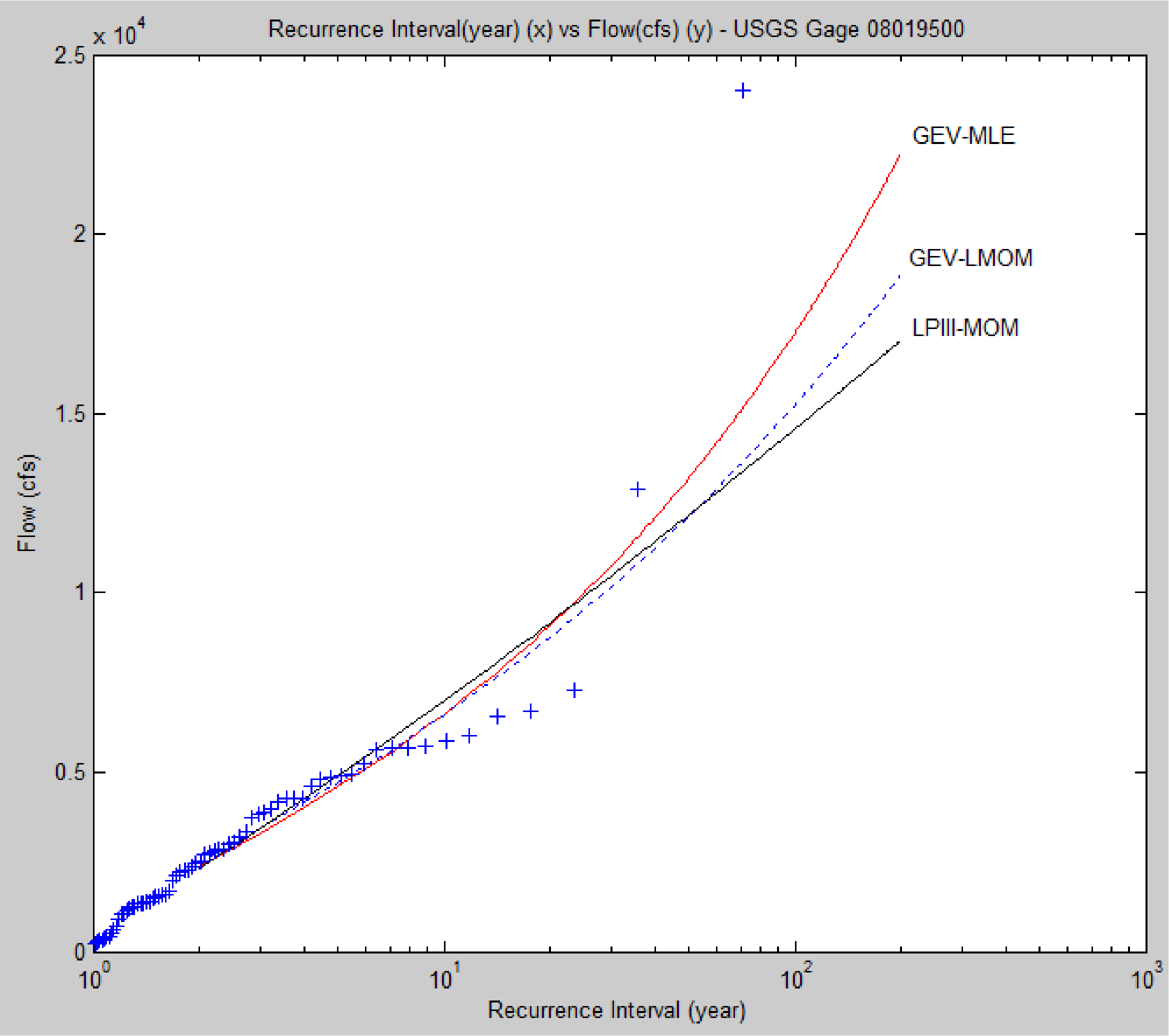


Step 2: Find out the maximum flood the bridge has been subjected to = Vmo



930 Flow Gages in Texas

Step 2: Find out the maximum flood the bridge has been subjected to = Vmo

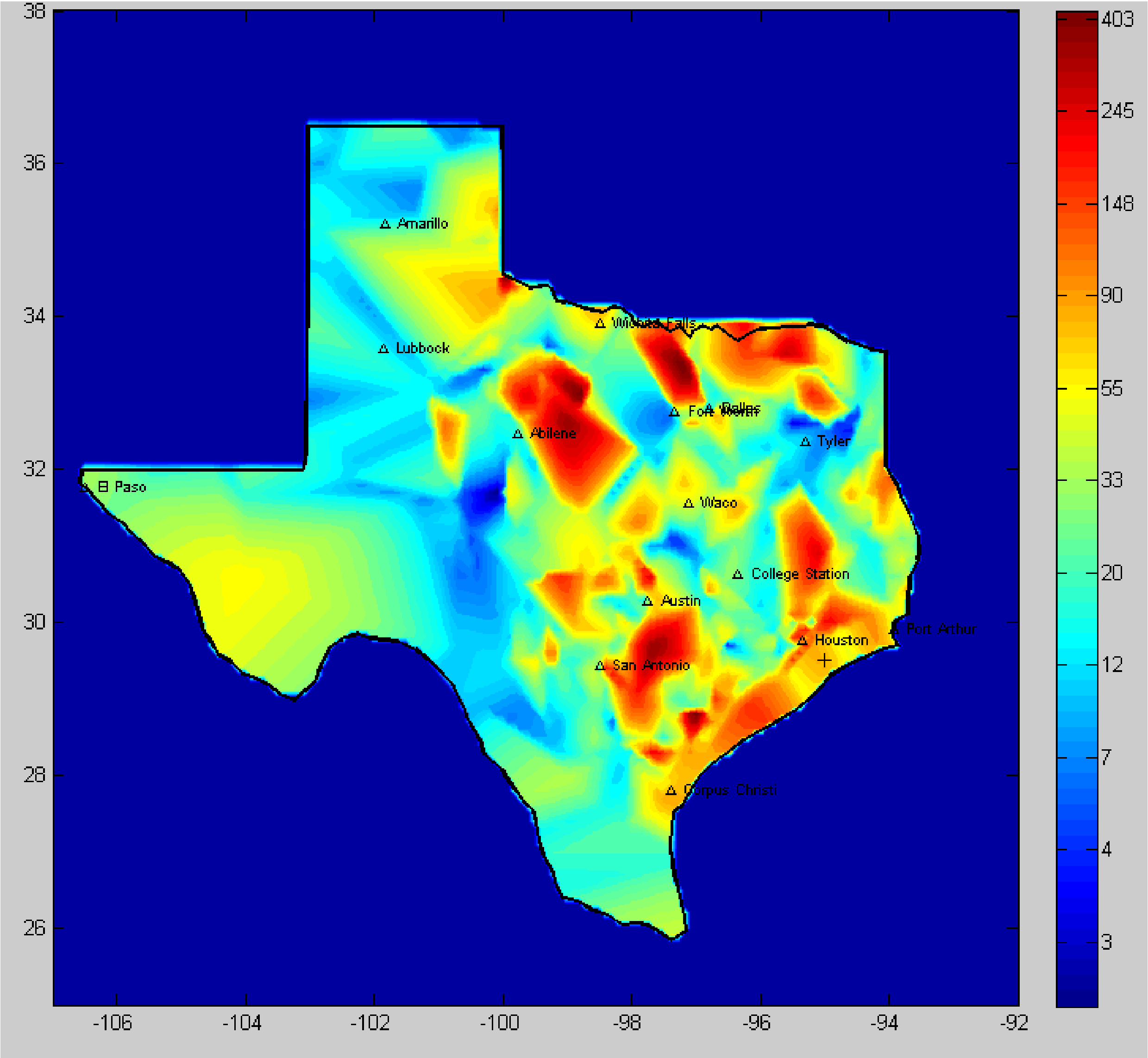


Maximum flood analysis

Step 2: Find out the maximum flood the bridge has been subjected to = Vmo

Maximum RI map between 1970 and 2005

Automated with TAMU-FLOOD software



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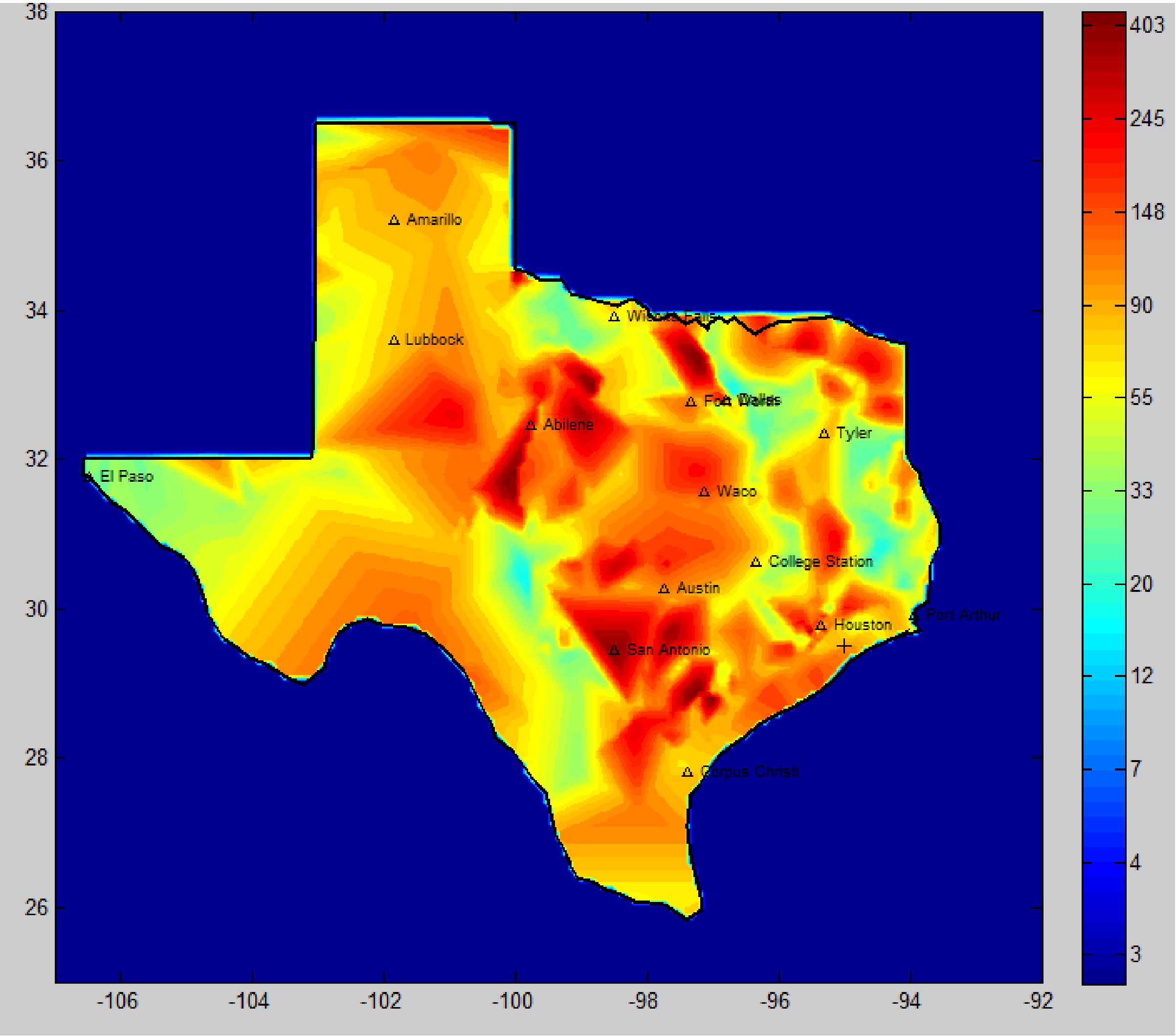
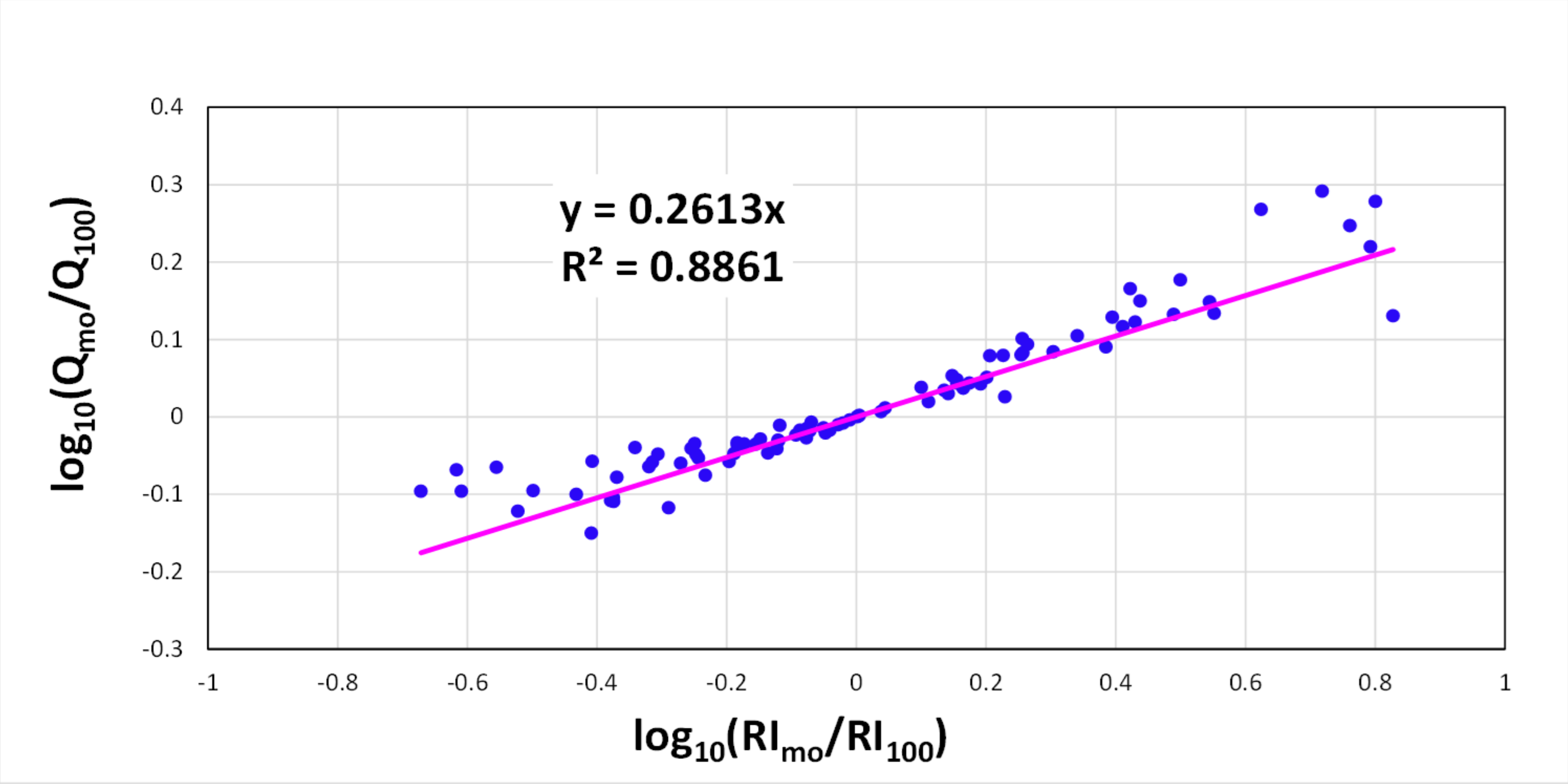
Step 2: Find out the maximum flood the bridge has been subjected to = Vmo

Maximum RI map between 1920 and 2005

Automated with TAMU-FLOOD software



GETTING Q_{MO}/Q_{FUT} FROM RI_{MO}/RI_{FUT}



GETTING V_{MO}/V_{FUT} FROM Q_{MO}/Q_{FUT}

$$\frac{V_{mo}}{V_{100}} = \left(\frac{Q_{mo}}{Q_{100}}\right)^{0.25\sim0.4}$$

Wide channel = 0.4

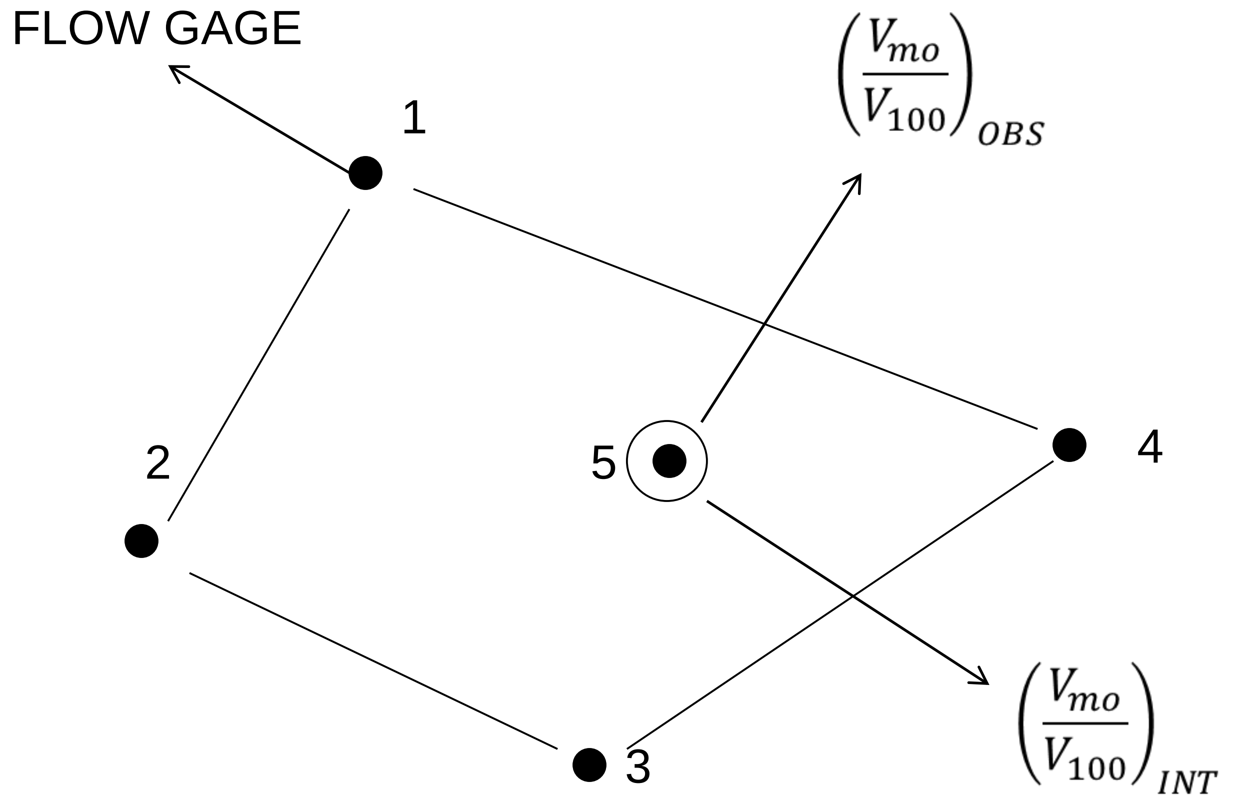
Narrow channel = 0.25

Most likely value = 0.35

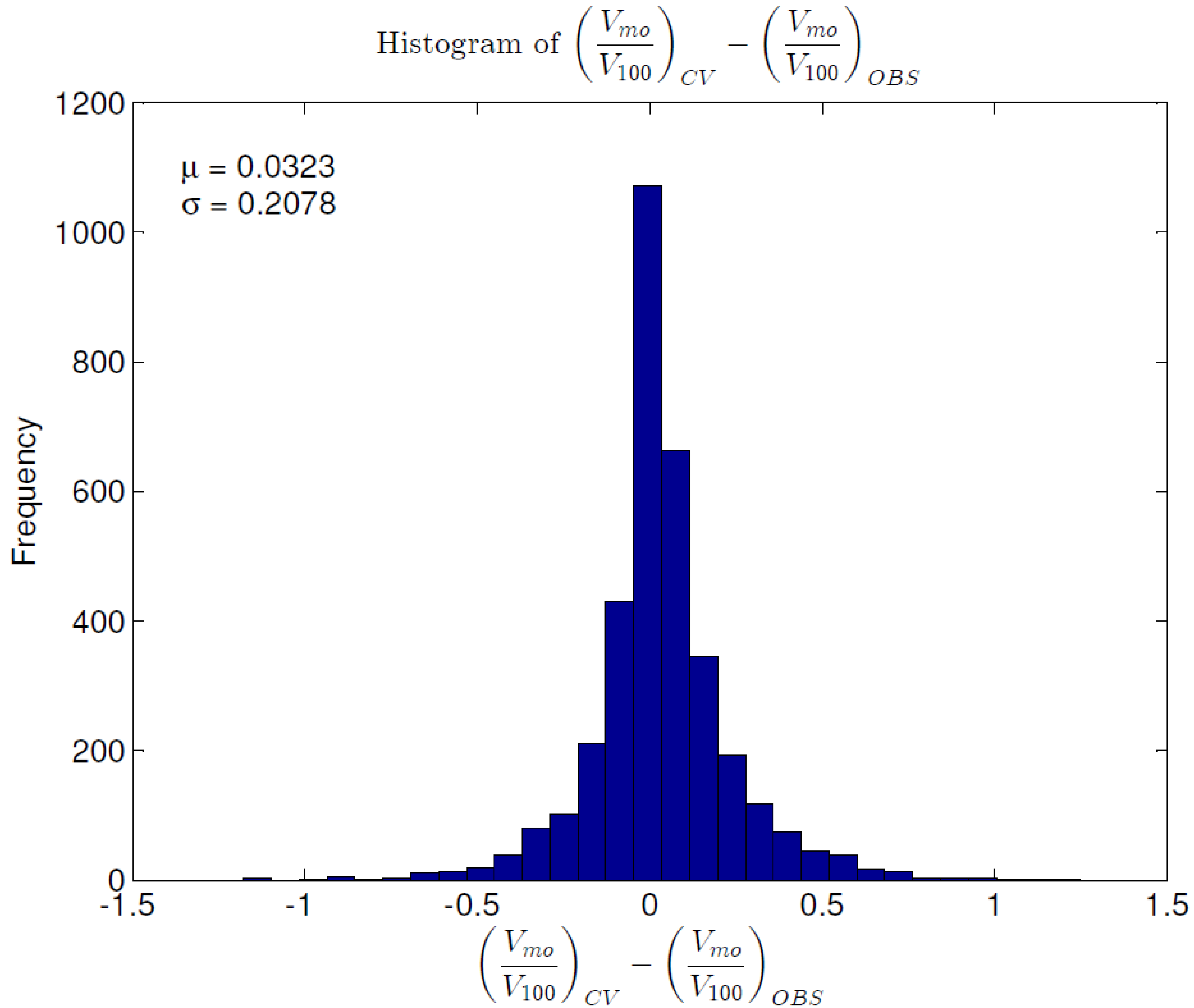
GETTING THE VELOCITY RATIO FROM THE RECURENCE INTERVAL RATIO

$$\left(\frac{v}{v_{100}}\right)=\left(\frac{Q}{Q_{100}}\right)^{0.35}=\left(\left(\frac{RI}{RI_{100}}\right)^{0.261}\right)^{0.35}=\left(\frac{RI}{RI_{100}}\right)^{0.091}$$

EVALUATING TAMU-FLOOD PRECISION



PRECISION OF TAMU-FLOOD



Step 3: Extrapolates field measurements to predict future depth

$$Z_{fut} / Z_{mo} = F\ (V_{fut} / V_{mo})$$

- Known = Z_{mo} and V_{mo}
- Choose V_{fut}
- Obtain Z_{fut} from charts

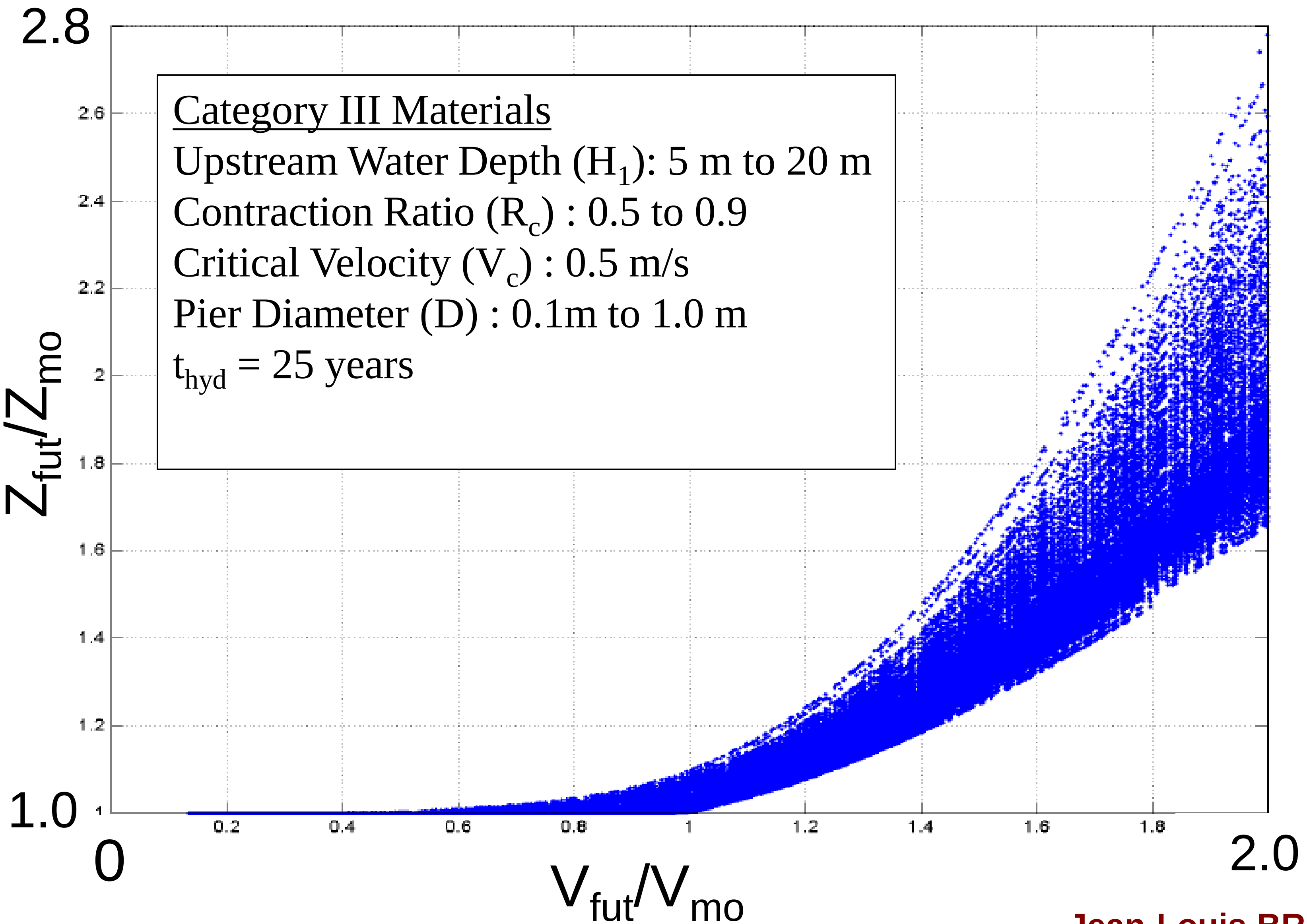
Step 3: Extrapolates field measurements to predict future depth Zfut

$$Z_{fut} / Z_{mo} = F\ (V_{fut} / V_{mo})$$

The Z-Future Charts were developed by performing a large number (~350,000) of HEC-18 Clay simulations using

- Varying pier, contraction & Abutment scour geometry
- Varying soil conditions
- Varying velocities
- Varying age of the bridge

Step 3: Extrapolates field measurements to predict future scour depth Zfut/Zmo = Vfut/Vmo



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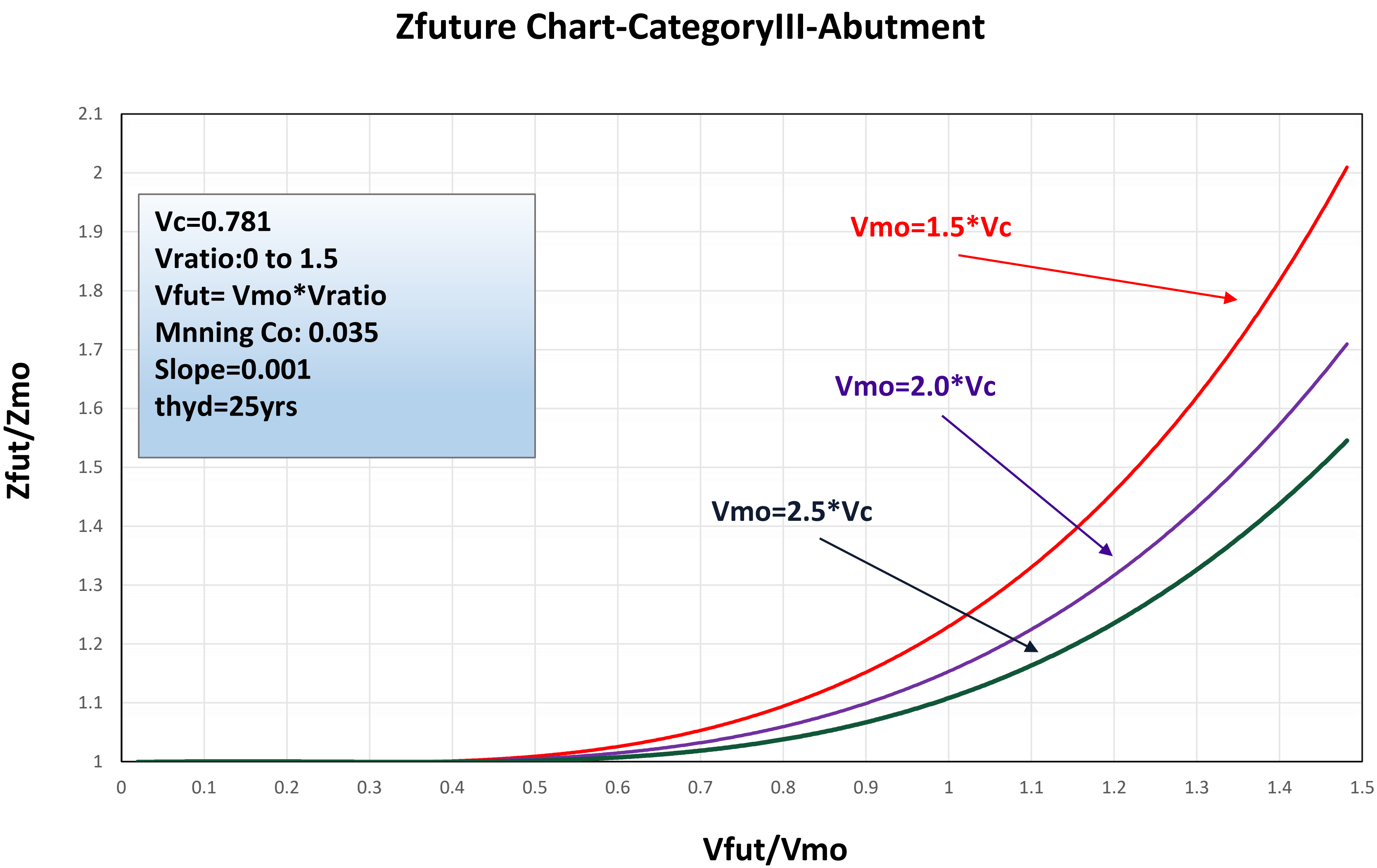
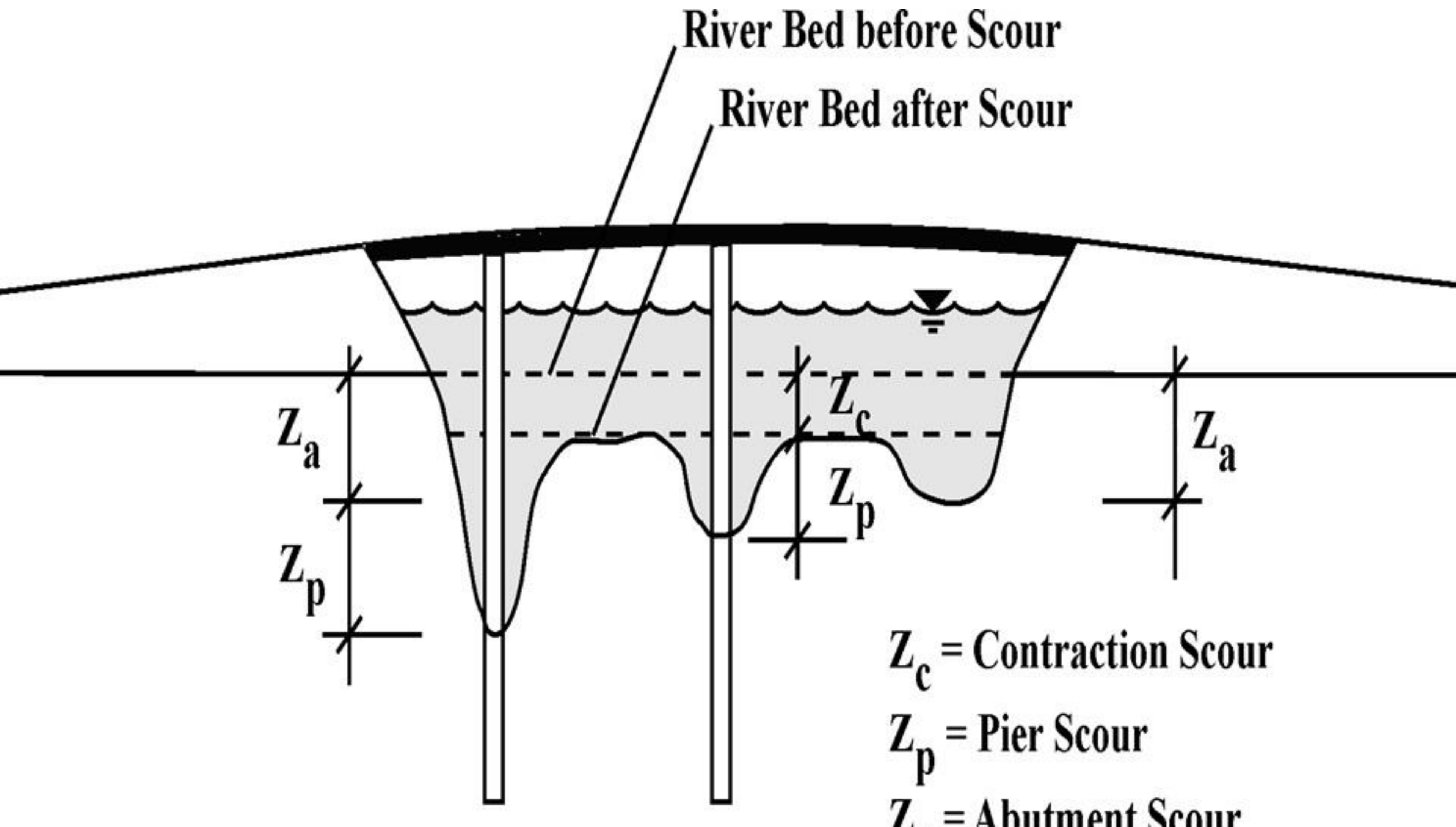
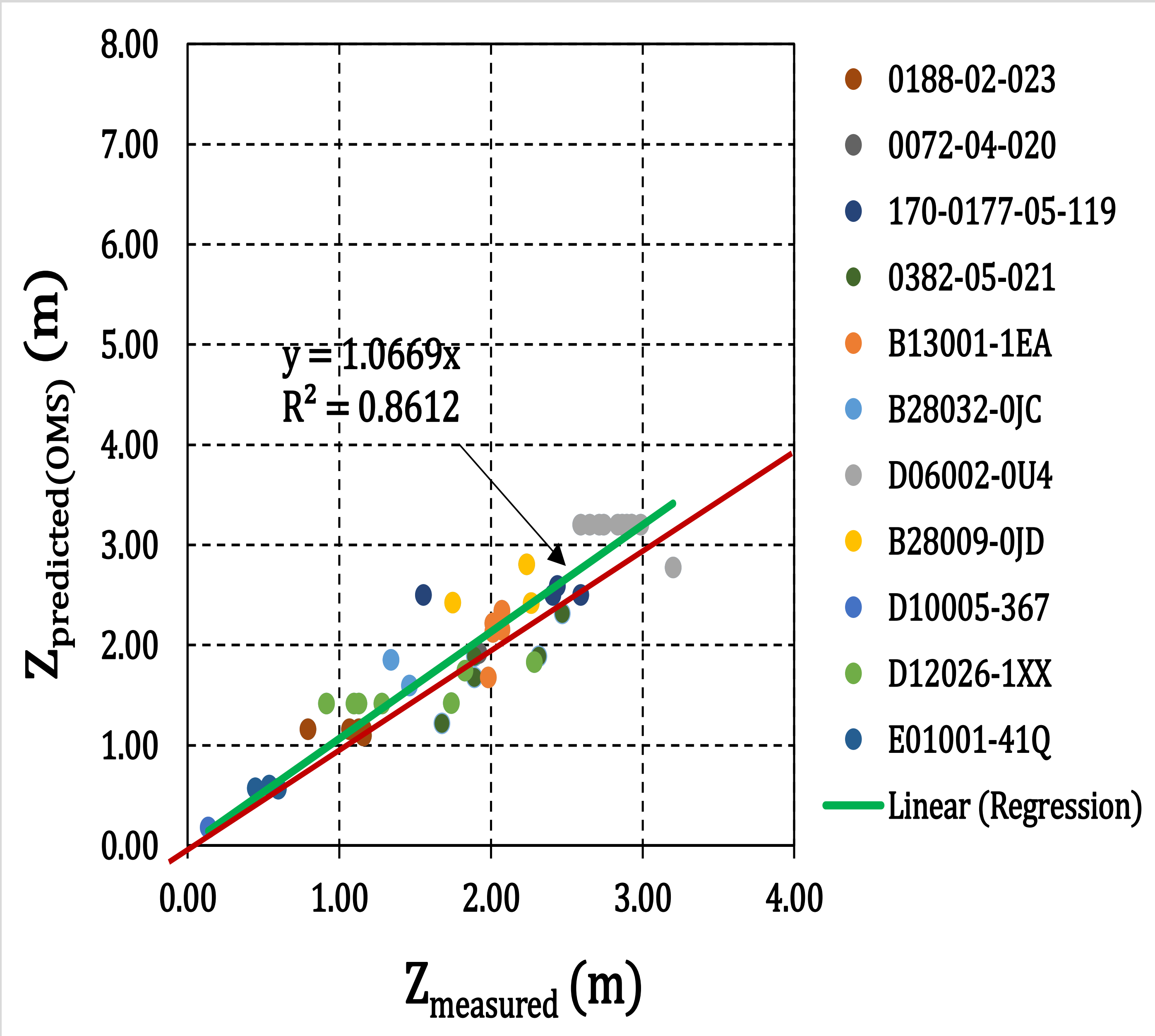
Step 3: Extrapolates field measurements to predict future scour depth Zfut/Zmo = F(Vfut/Vmo)



Step 4: Compare future scour depth to foundation depth Zfut < Zfound / 2



OMS-TEXAS & MASSACHUSETTS



Limitations

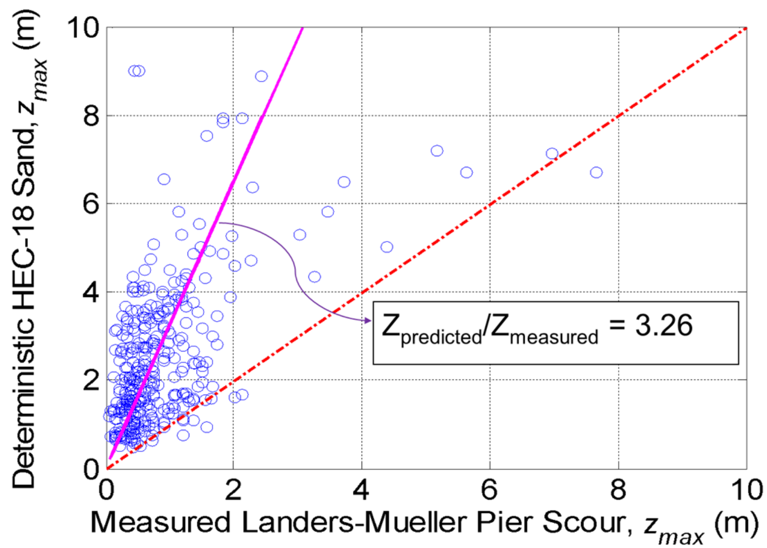
- Requires a good network of flow gages (and rain gages). Interpolation could be refined
- Cannot be used directly for new bridges but lessons learned (database) can be useful for new bridges
- Estimate in filling (USGS research and a TxDOT survey have found that it was rare (10% of the time) and ranged from 2 to 4 ft)
- Not yet developed for layered soil (be careful with thin hard layer over soft layer)

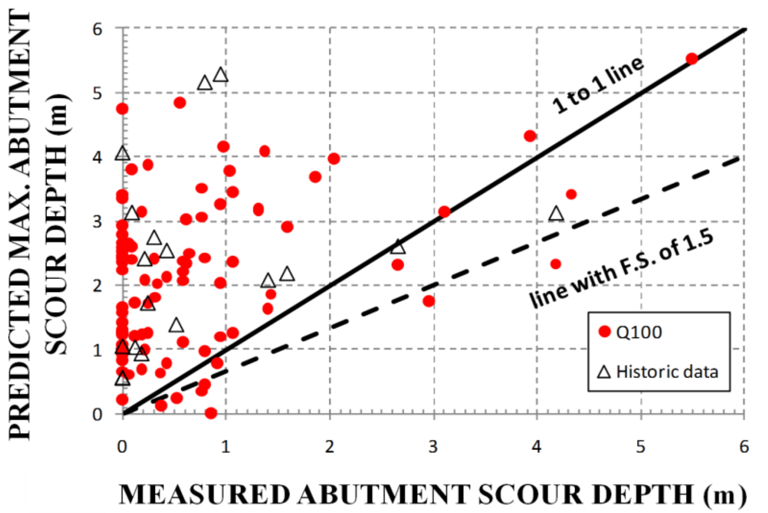
Advantages

- Valuable tool to prioritize bridge repairs, countermeasure decisions, asset management
- Can serve as an input to FHWA risk approach
- Part of the practical design concept
- No need for erosion testing
- Actual soil
- Actual flow history
- Actual geometry
- Based on observed measurements

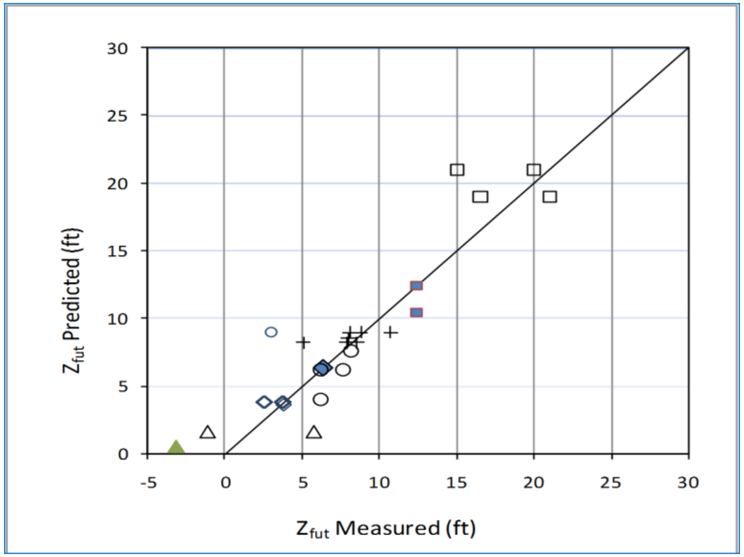
COMPARISON

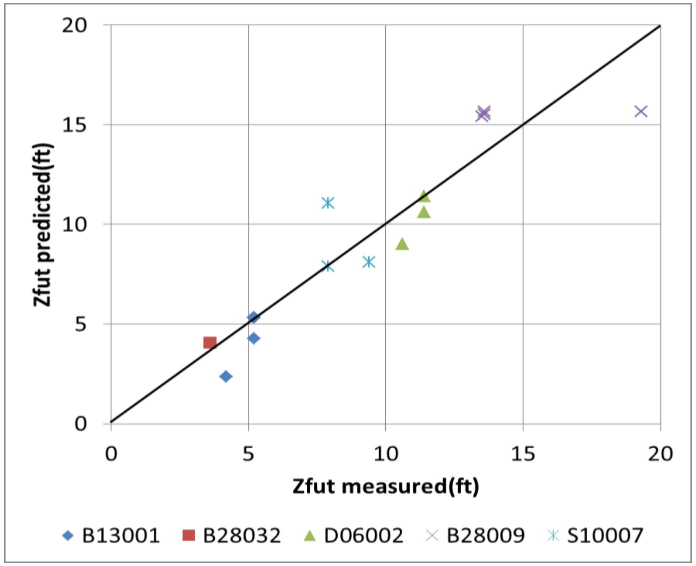
HEC 18





OMS

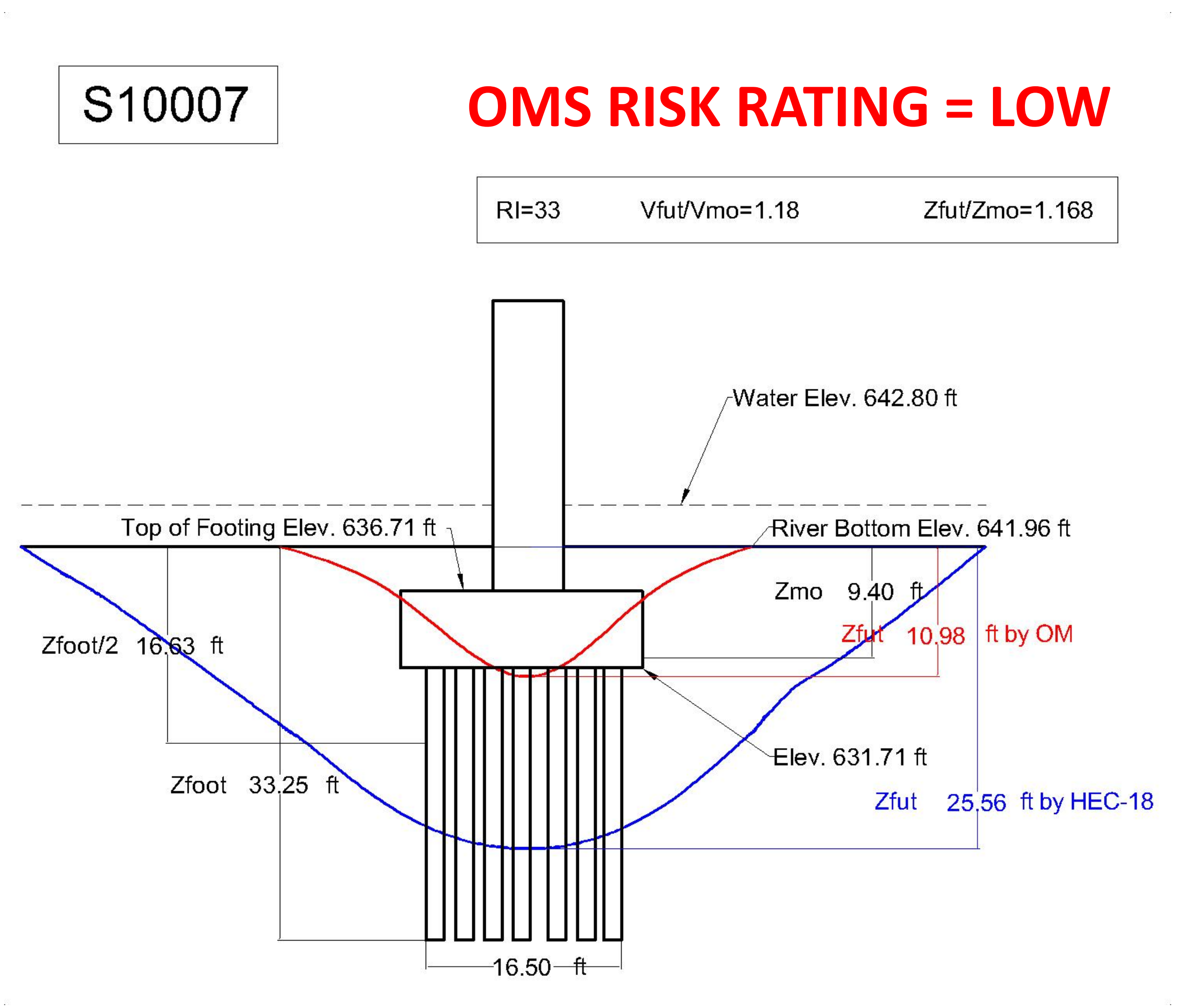




DIFFERENCES BETWEEN HEC 18 AND OBSERVATION METHOD

HEC 18	***OMS***
Flume tests (scale pb?)	Full scale
Wrong worst soil (Fine sand)	Right soil
Simplified geometry	Exact geometry
Simplified single velocity	Exact velocity hydrograph

CITY: SHEFFIELD HIGHWAY: MAPLE AVE RIVER: WATER HOUSATONIC RIVER

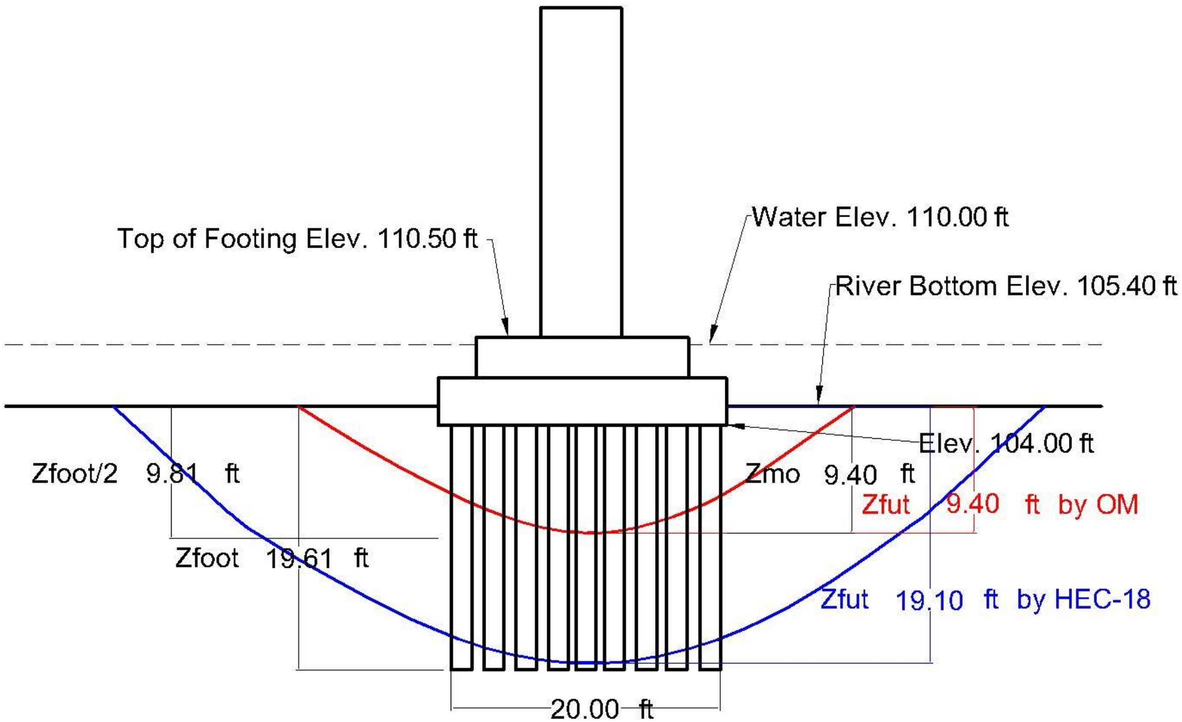


CITY: DEERFIELD HIGHWAY: US 5 RIVER: WATER DEERFIELD RIVER

D06002

OMS RISK RATING = MEDIUM

RI=179	Vfut/Vmo=1.00	Zfut/Zmo=1.00



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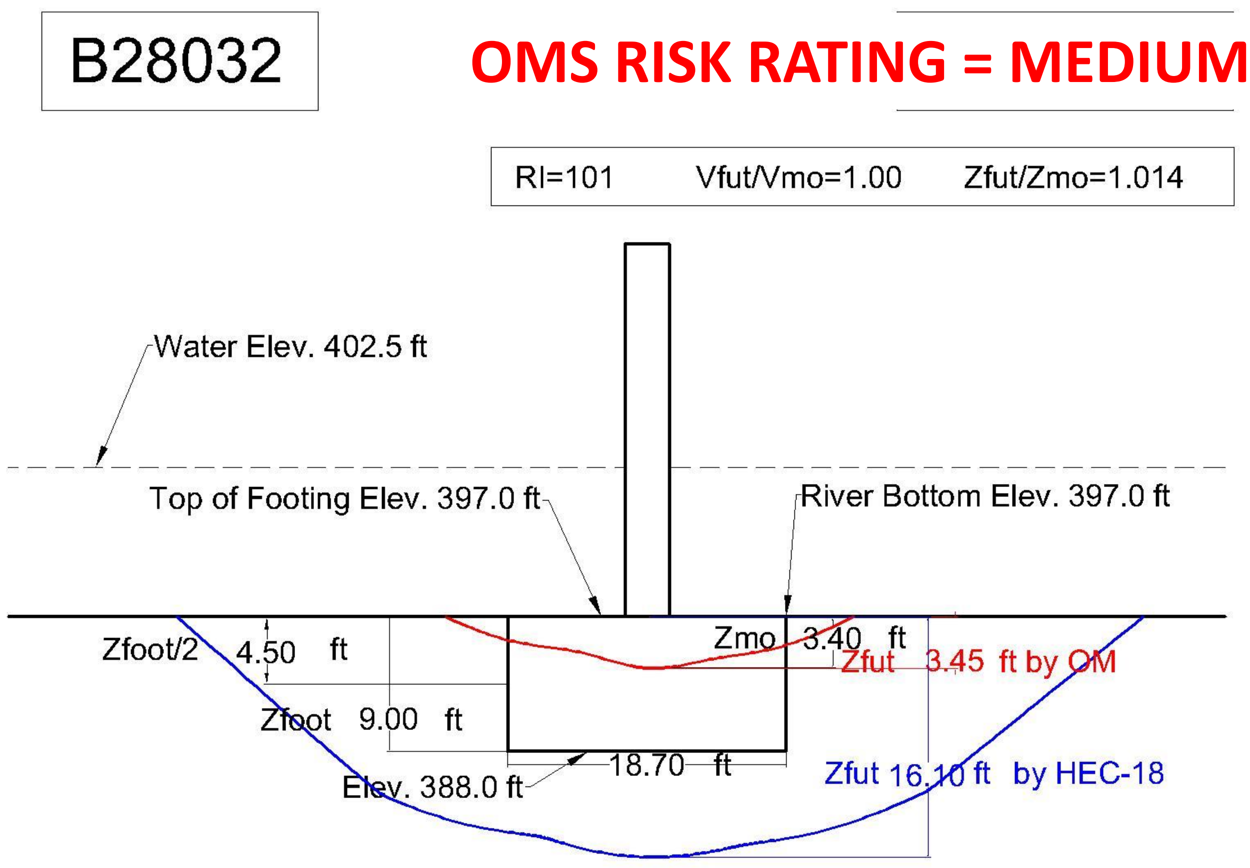
CITY: BUCKLAND HIGHWAY: STATE ROUTE 2 RIVER: DEERFIELD RIVER



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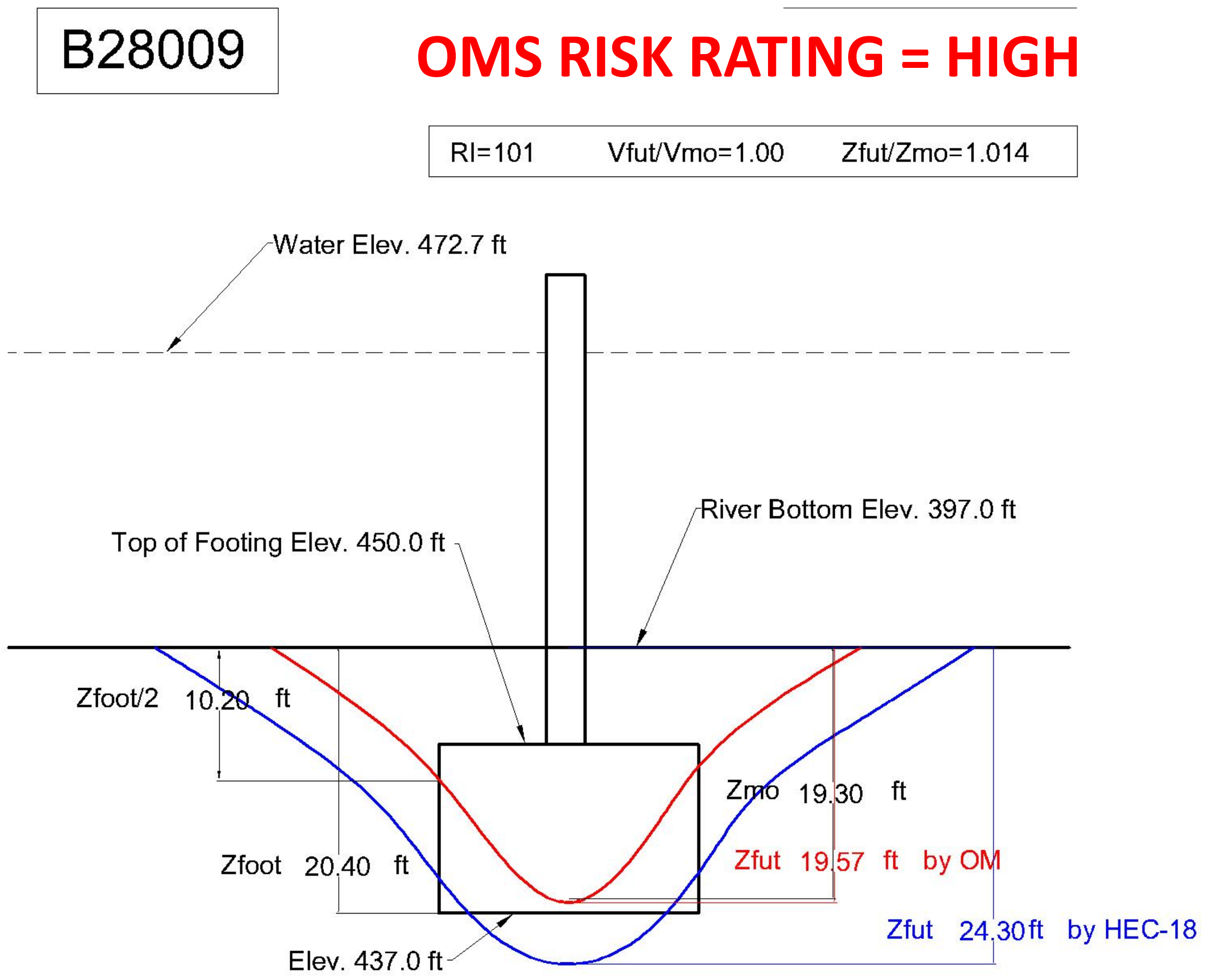
CITY: BUCKLAND HIGHWAY: STATE ROUTE 2 RIVER: DEERFIELD RIVER



1. TAMU-OMS significantly decreases the scatter between measured and calculated scour depths
2. TAMU-OMS eliminates the excessive conservatism
3. TAMU-OMS is a valuable new tool for the bridge scour engineer (e.g.: can be used to prioritize repairs, to evaluate risk, as a management tool, for practical design)
4. TAMU-OMS is available for all states in the country