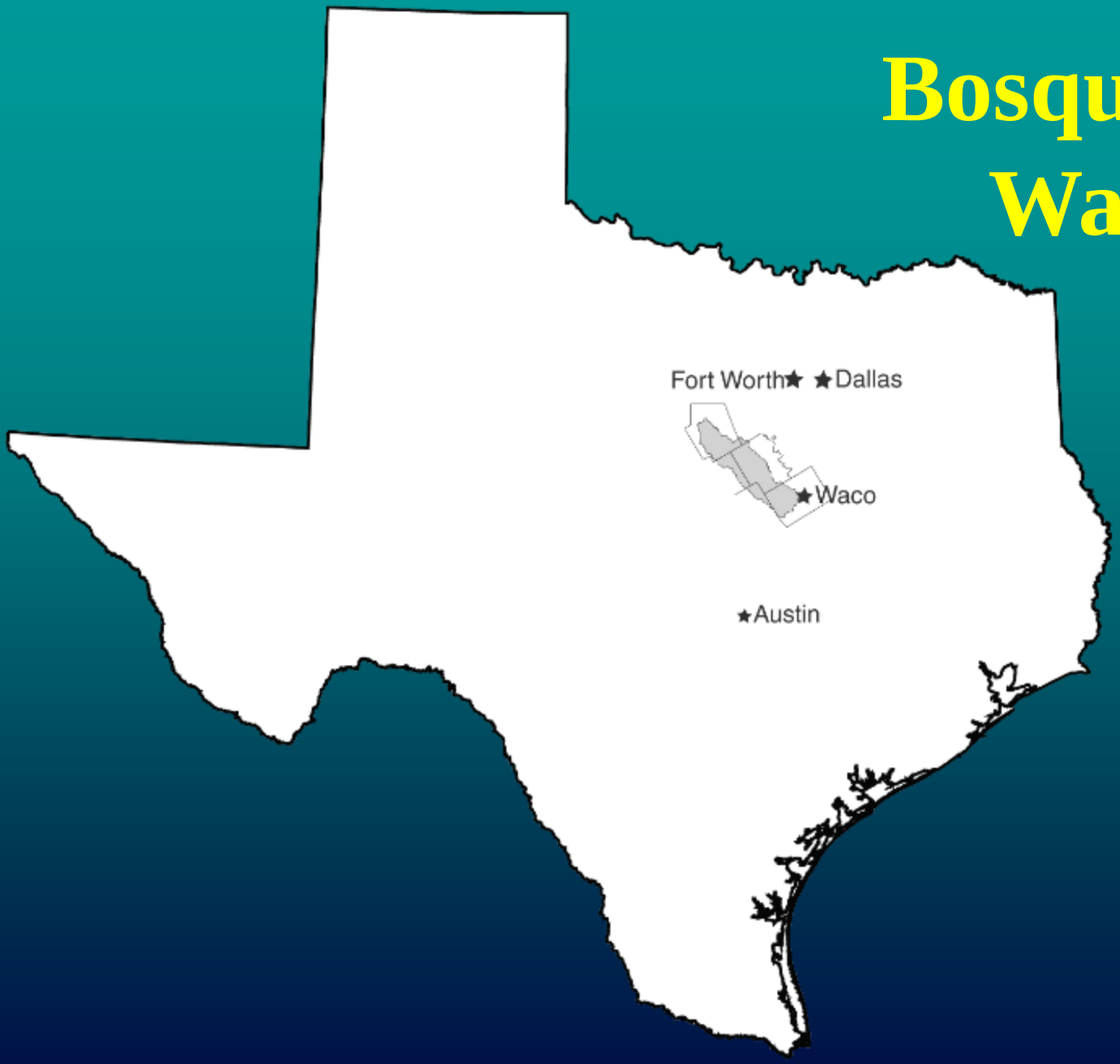
Bosque River Watershed



Source: TCEQ Status Report (Oct 2018)

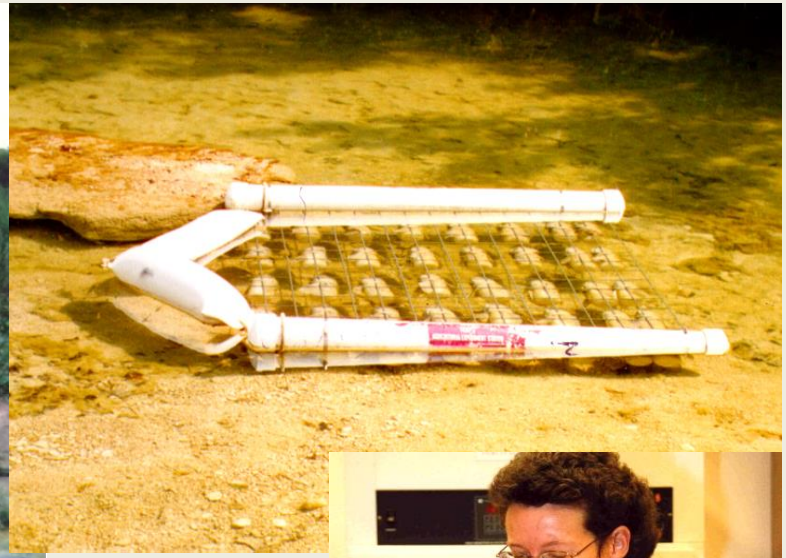
Impairment History

- 1990 – North Bosque identified as problem watershed
- 1992 – Listed as impaired on 303(d) List
- 1996 – Bosque River Advisory Committee formed
- 1998 – TMDL development initiated for excessive algae associated with high nutrients
- 2001 –TMDLs for phosphorus approved
- 2002 – Implementation Plan approved

North Bosque TMDL

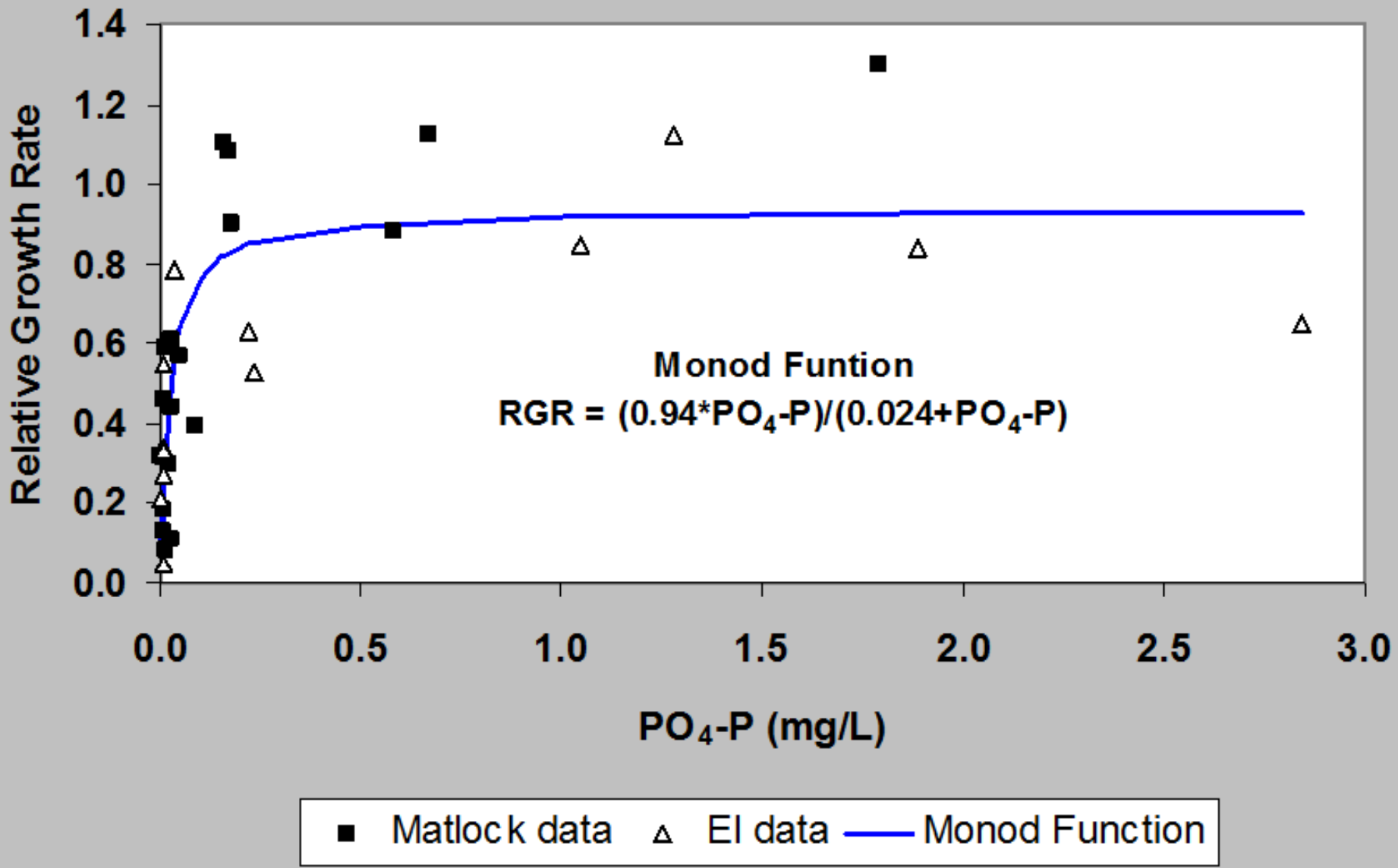
Narrative Criteria - excessive aquatic plant growth due to elevated nutrients

Limiting Nutrient - Phosphorus



Instream & Laboratory Bioassays

Relationship between P & Algal Growth Rate



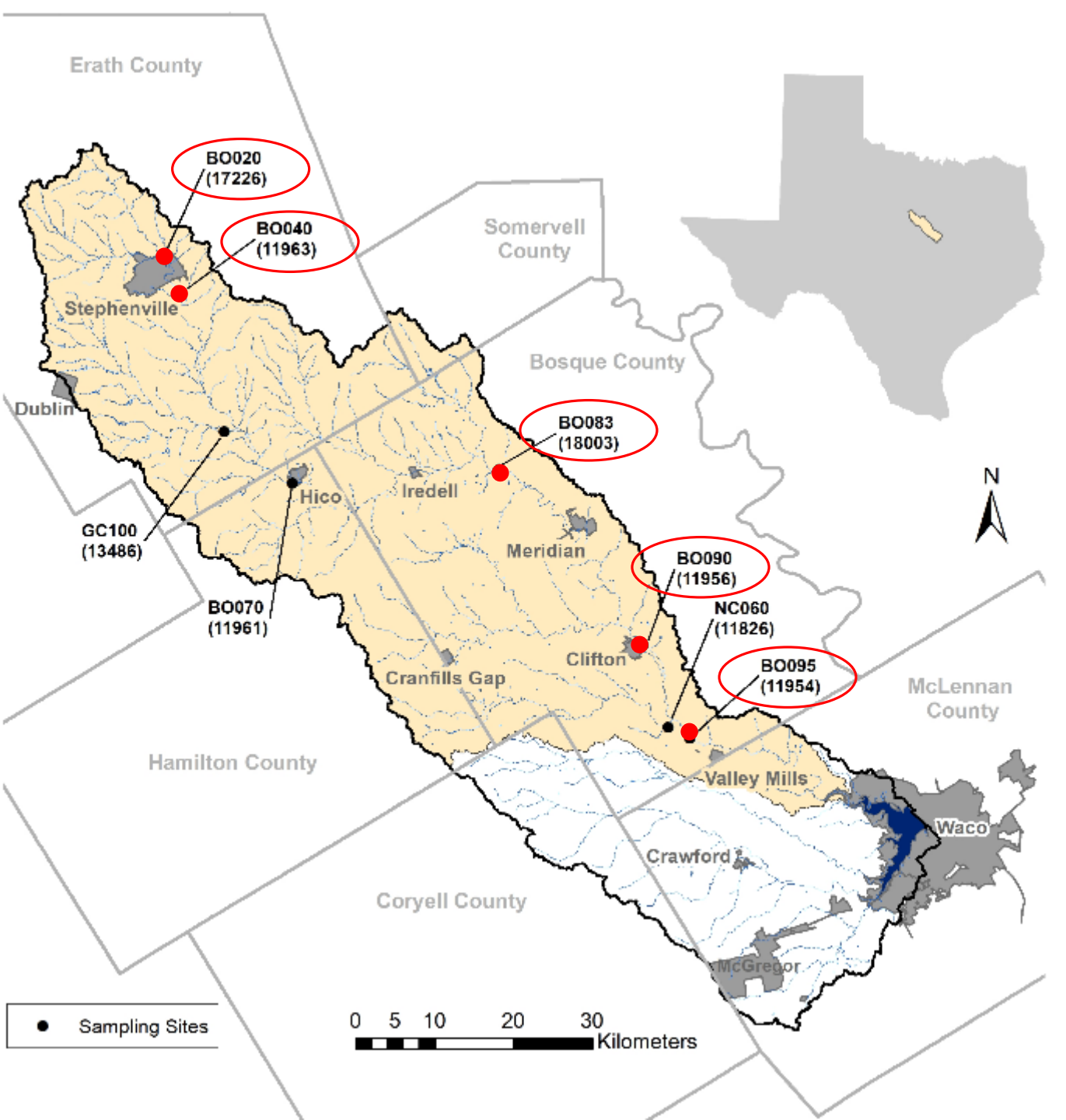
North Bosque River TMDL

- Approved by EPA December 2001
- Mandates about a 50% reduction in soluble reactive phosphorus (SRP)
- Target concentrations of PO_4-P about 0.03 mg/L as the river flows into Lake Waco

  (Target concentrations vary with Index Site from 0.448 mg/L below Stephenville to 0.028 mg/L at Valley Mills)

North Bosque Monitoring Stations

Index Stations circled in Red



North Bosque River TMDL Reduction Goals

Table 6. Average Annual-Average Soluble Phosphorus Concentration					
	Above Stephenville	**Below Stephenville**	**Above Meridian**	**Clifton**	**Valley Mills**
From 'Existing' scenario (ppb)	203.3	1,143.2	117.0	52.2	41.3
From 'TMDL-e' scenario (ppb)	114.2	448.1	54.5	30.3	27.5
% reduction	43.83 %	60.80 %	53.42 %	41.95 %	33.41 %
The decimal places shown in this table are artifacts of the estimation process, and should not be considered significant.					

North Bosque River TMDL

Identified two major sources of SRP

- Wastewater Treatment Facilities
- Dairy Waste Application Fields

Phosphorus Sources

Table 3. Estimated Percent of Total Gross Annual Load by Source Type					
Source	**Above Stephenville**	**Below Stephenville**	**Above Meridian**	**Clifton**	**Valley Mills**
urban runoff	2 %	6 %	6 %	6 %	6 %
row crop	0 %	0 %	2 %	4 %	5 %
non-row crop	2 %	2 %	2 %	1 %	1 %
pasture	9 %	5 %	7 %	8 %	9 %
wood/range	7 %	5 %	18 %	22 %	24 %
WWTP	0 %	28 %	10 %	9 %	10 %
WAF	80 %	54 %	55 %	50 %	45 %
Column totals (%)	100 %	100 %	100 %	100 %	100 %

Implementation Practices

WWTF Discharges

- Phosphorus Discharge Limits focused on two largest municipalities (Stephenville & Clifton)
- Monitoring of Phosphorus at all WWTFs within Watershed

Dairy Operations (CAFOs)

- Nutrient Management Planning
- Soil Testing for Phosphorus
- Use of Composting as Alternative to direct Land Application

Municipal WWTFs

Two Largest Required P Control

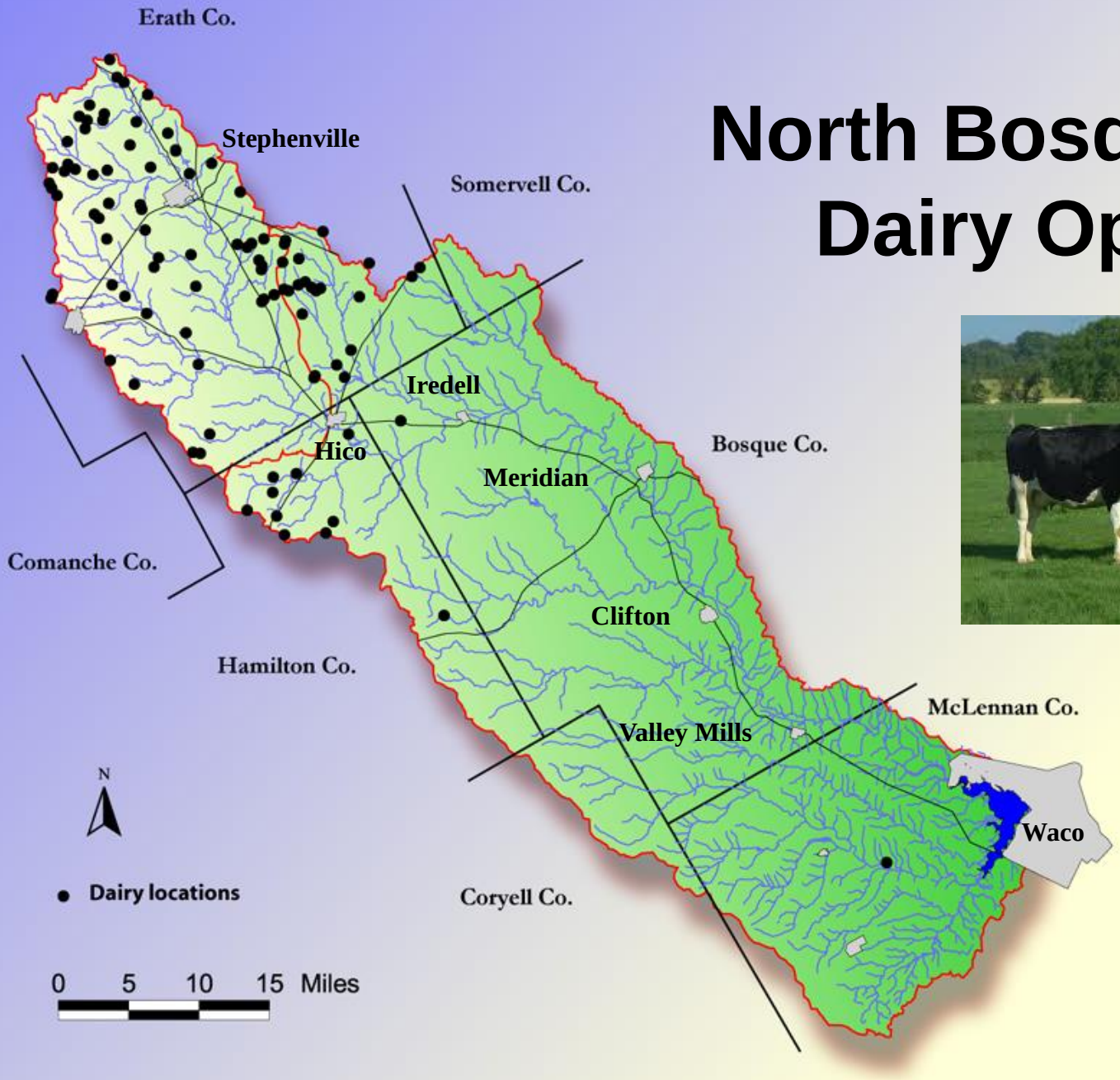
- **Stephenville** (1.5 MGD) implemented biological & chemical P control fall 2005
- **Clifton** (0.3 MGD) implemented chemical P control spring 2005

Decrease in Total-P in Effluent:

Pre-Treatment often > 3mg/L

Post-Treatment generally < 1 mg/L

North Bosque River Dairy Operations



Dairy Waste Application Fields

Comprehensive Nutrient Management Plans (CNMPs) -

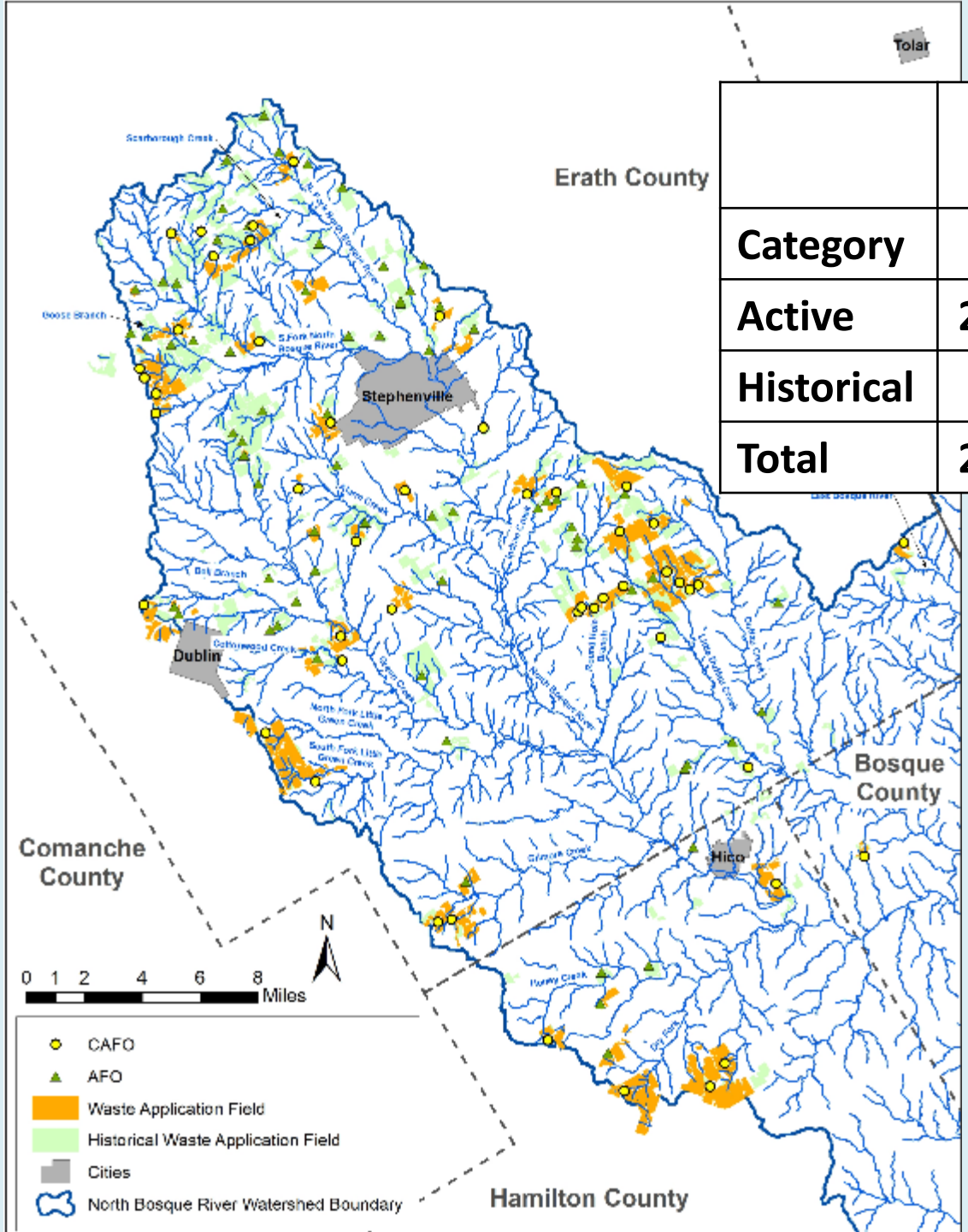
- Required by new Concentrated Animal Feeding Operations (CAFOs) regulations – permitted facilities

Water Quality Management Plans (WQMP) -

- Voluntary for AFOs

Dairy Manure Export Support Project - TSSWCB

Composted Manure Incentive Project - TCEQ

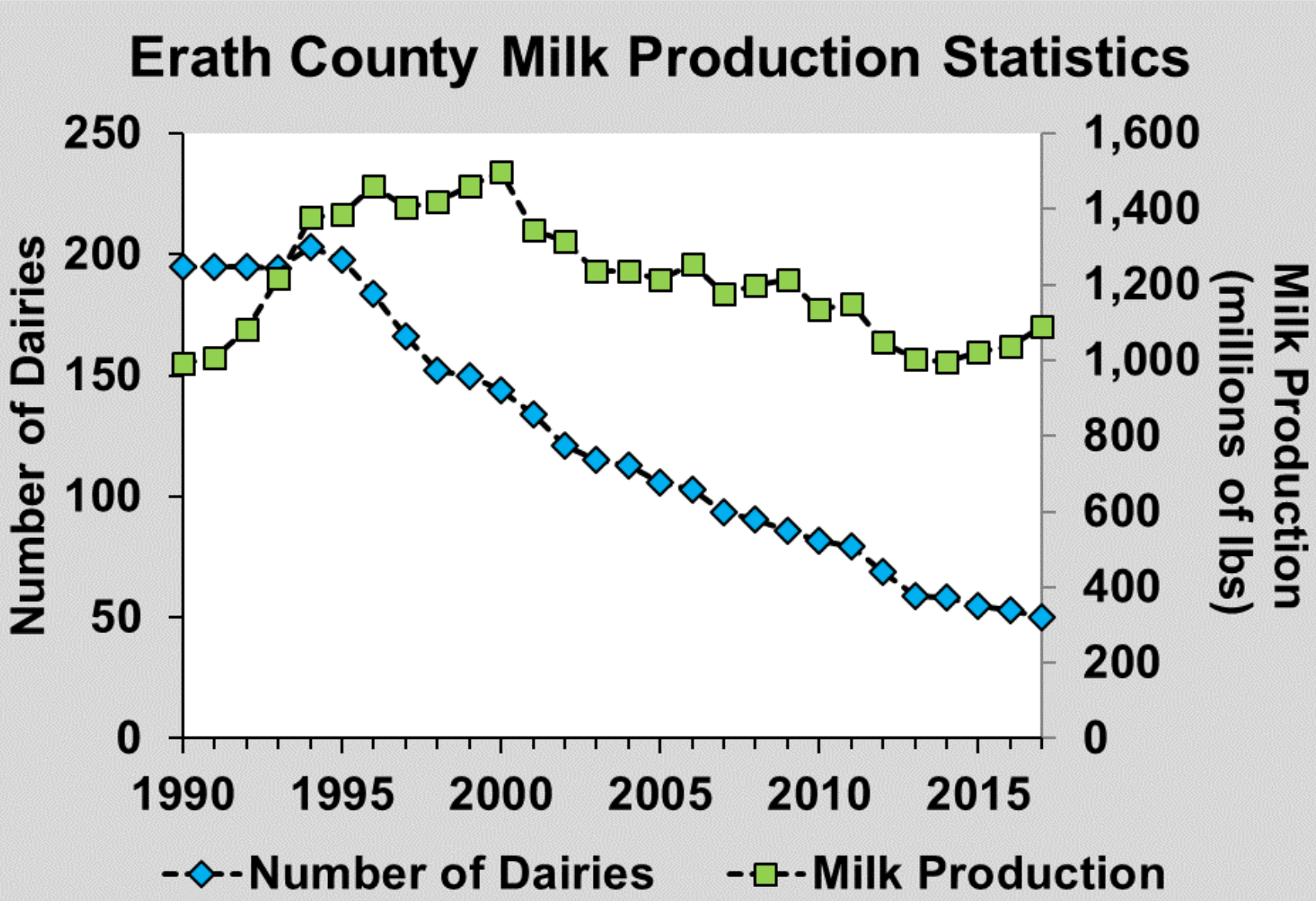


	2000 WAFs	2017 WAFs	
Category	Acres	Acres	Change
Active	24,554	13,741	-44%
Historical	2,142	18,812	778%
Total	26,696	32,553	22%

Changes in Land Use

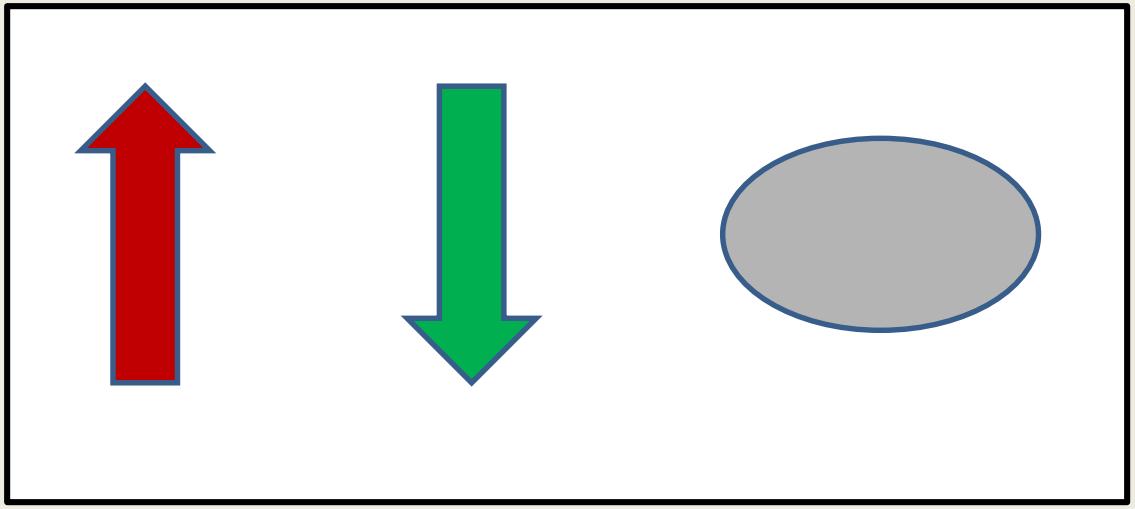
Map represents conditions as of fall 2017

WAF = waste application field


Erath County Milk Production Statistics
Number of Dairies
250
200
150
100
50
0
1,600
1,400
1,200
1,000
800
600
400
200
0
Milk Production (millions of lbs)
1990
1995
2000
2005
2010
2015
Number of Dairies
Milk Production

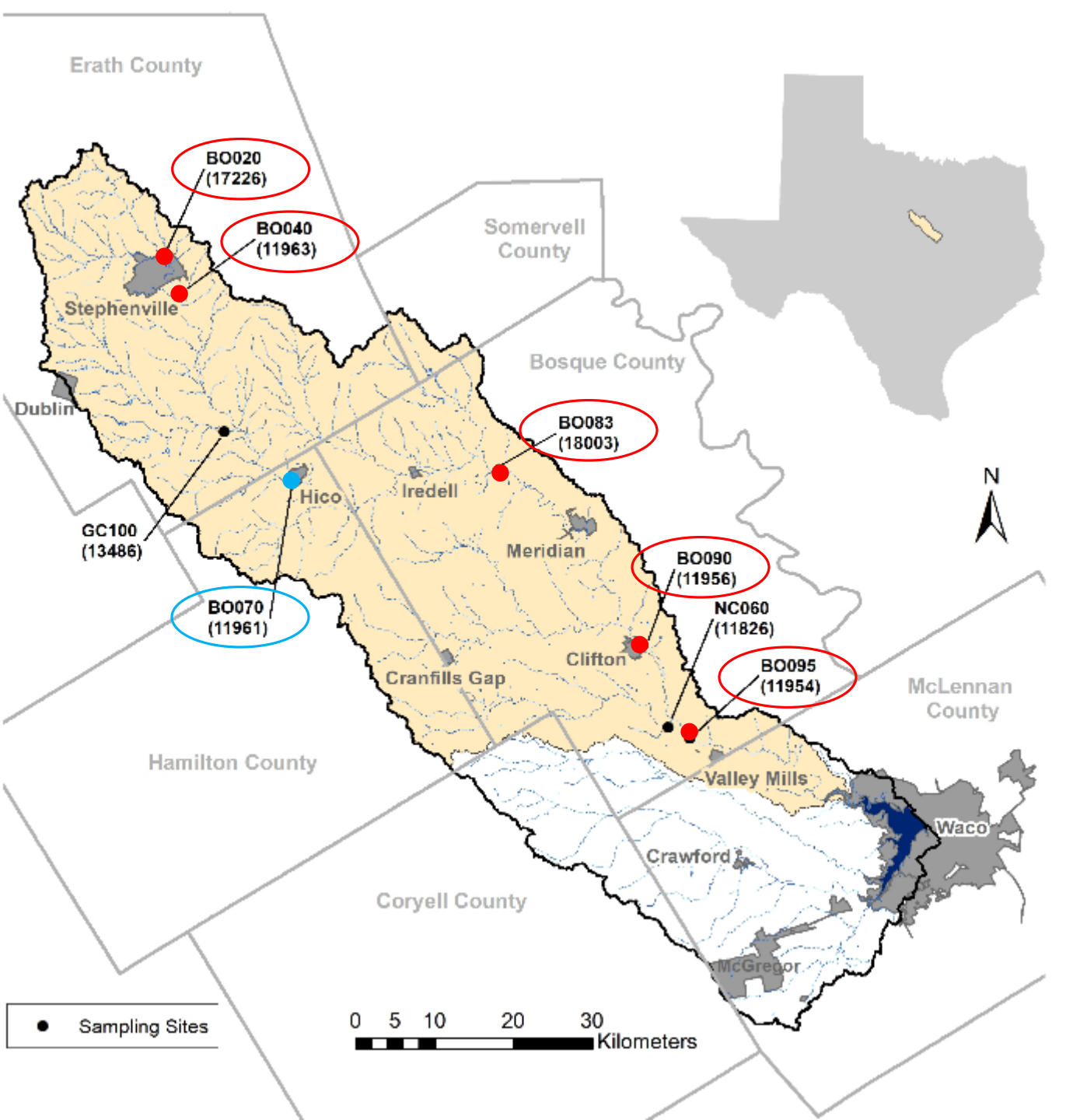
Trends -

Is water quality improving?



North Bosque Monitoring Stations

Index Stations circled in Red



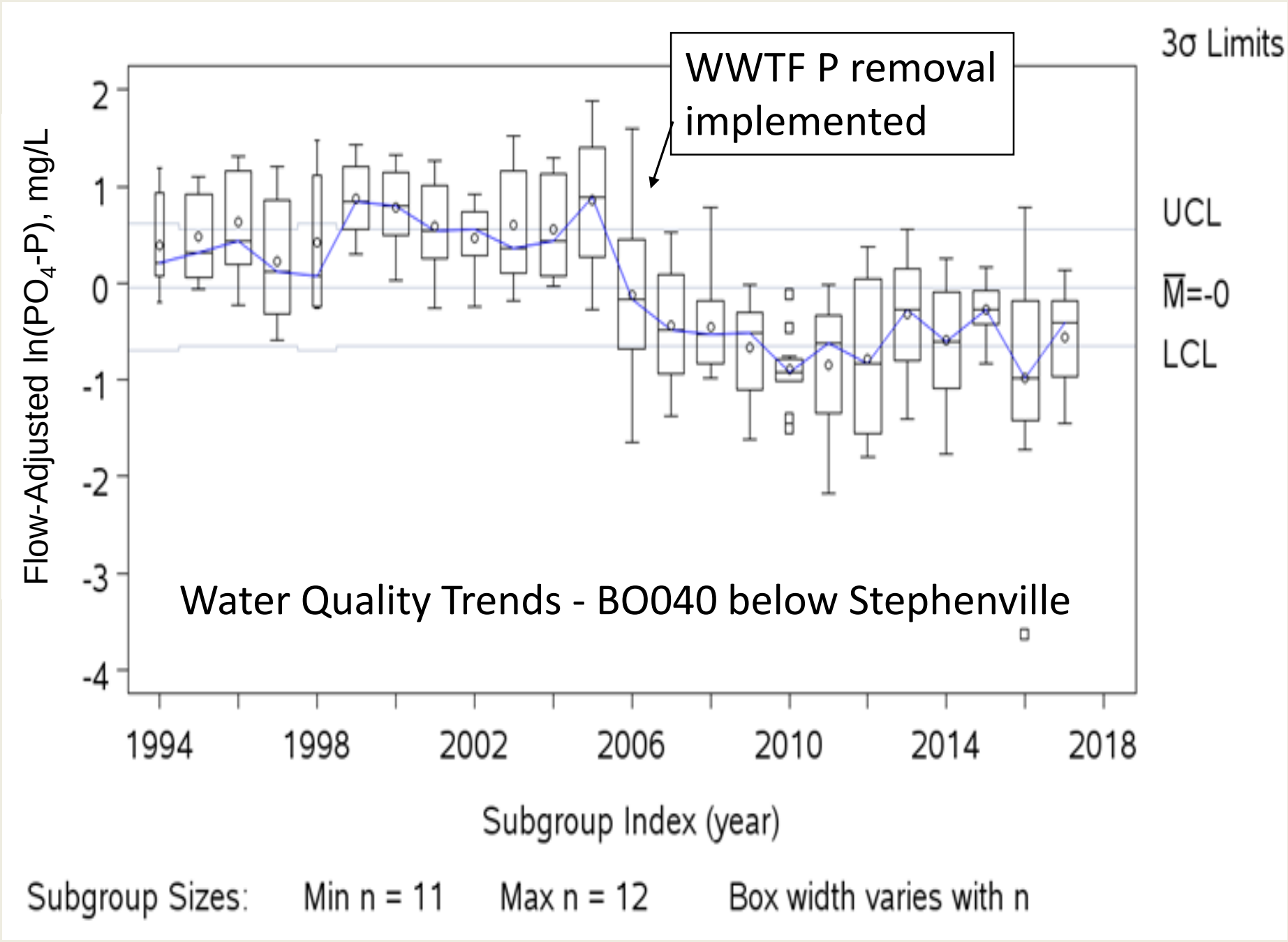
Phosphorus Trends

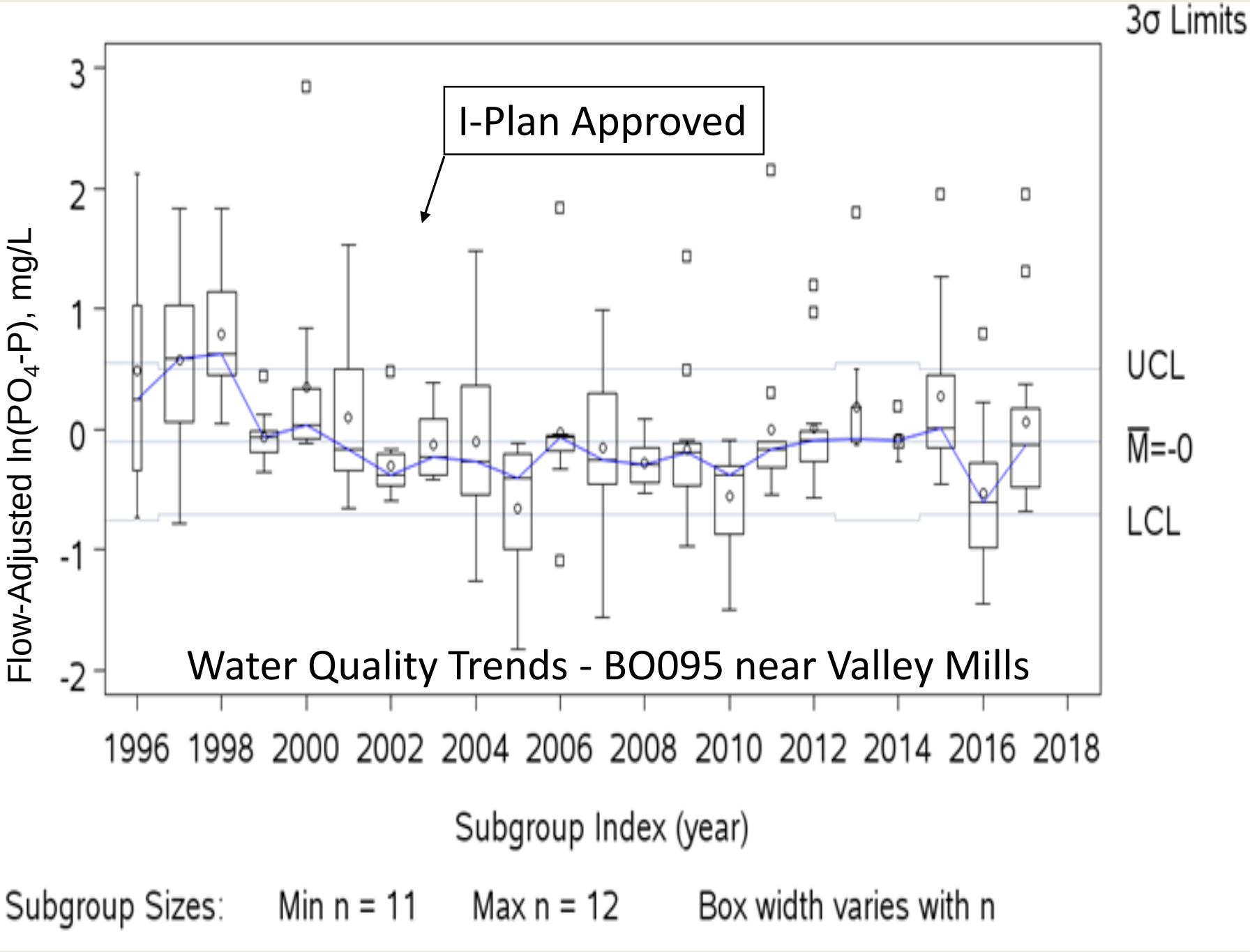
North Bosque River Index Stations (+1)

TIAER	TCEQ	Location	Period	SRP	Total P
BO020	17226	Above Stephenville	1997-2017		
BO040	11963	Below Stephenville	1994-2017		
BO070	11963*	Near Hico	1993-2017		
BO083	18003**	Near Iredell	2003-2017		
BO090	11956	Near Clifton	1996-2017		
BO095	11954	Near Valley Mills	1996-2017		

*Not a designated Index Station

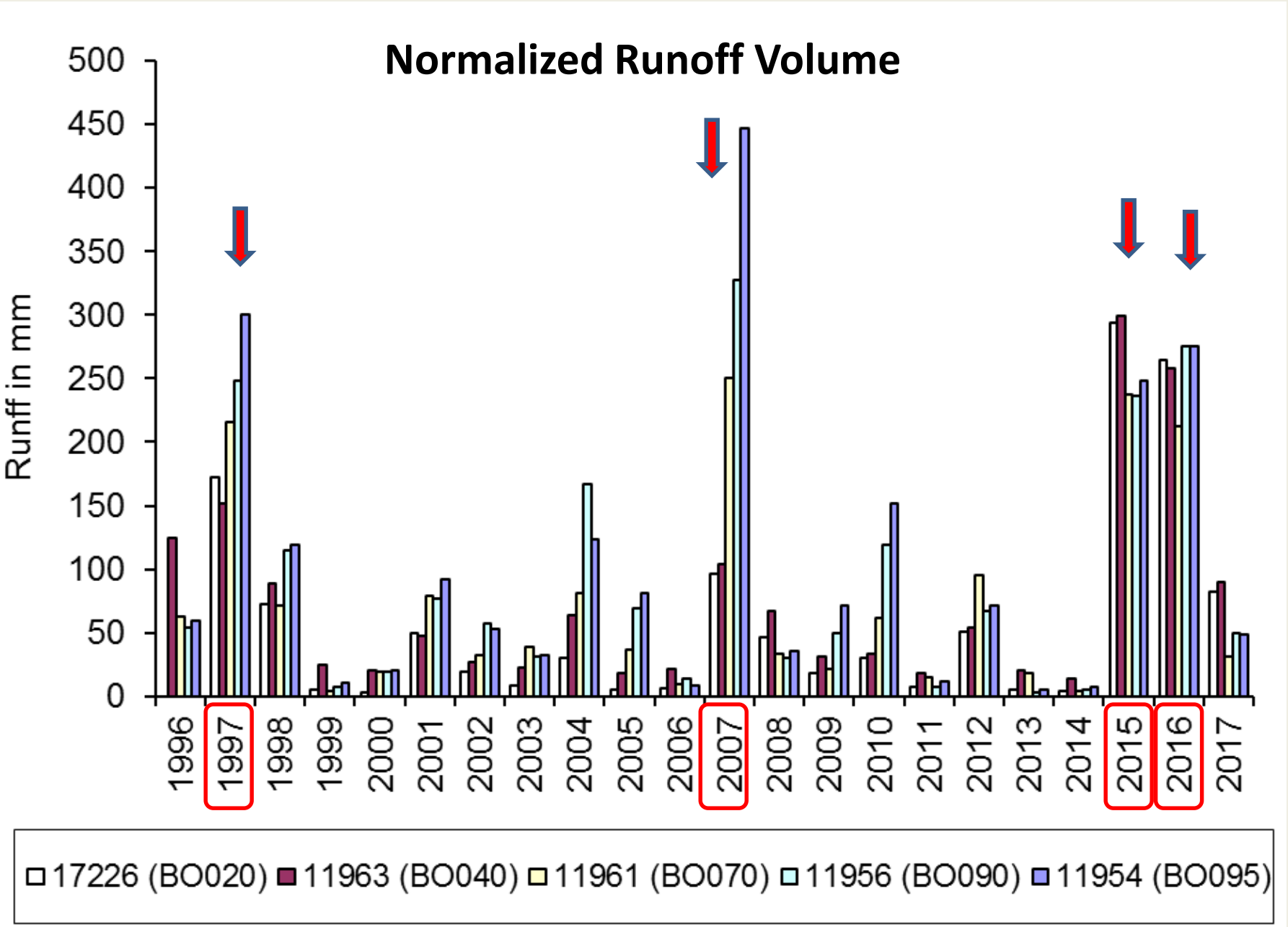
** Limited flow data at station 18003


WWTF P removal implemented
3σ Limits
UCL
M=-0
LCL
Flow-Adjusted ln(PO4-P), mg/L
2
1
0
-1
-2
-3
-4
1994
1998
2002
2006
2010
2014
2018
Subgroup Index (year)
Water Quality Trends - BO040 below Stephenville
Subgroup Sizes: Min n = 11 Max n = 12 Box width varies with n

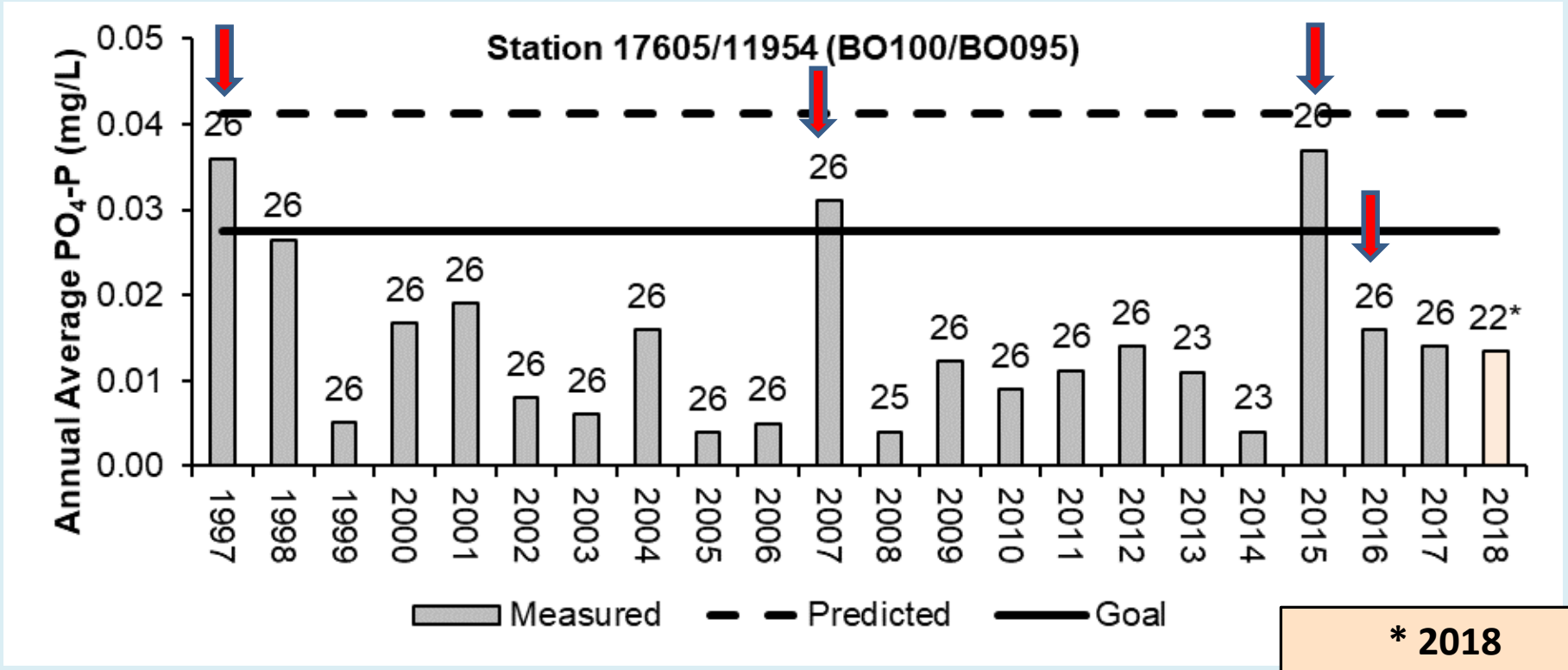

3σ Limits
I-Plan Approved
Flow-Adjusted ln(PO4-P), mg/L
3
2
1
0
-1
-2
UCL
M=-0
LCL
Water Quality Trends - BO095 near Valley Mills
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018
Subgroup Index (year)
Subgroup Sizes: Min n = 11 Max n = 12 Box width varies with n

Have we met target goals?

Not entirely but getting close


Normalized Runoff Volume
Runff in mm
500
450
400
350
300
250
200
150
100
50
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
17226 (BO020)
11963 (BO040)
11961 (BO070)
11956 (BO090)
11954 (BO095)


Erath County
Somervell County
Bosque County
Hamilton County
McLennan County
Coryell County
BO020 (17226)
BO040 (11963)
Stephenville
Dublin
GC100 (13486)
BO070 (11961)
Hico
Iredell
BO083 (18003)
Meridian
BO090 (11956)
NC060 (11826)
Clifton
Cranfills Gap
BO095 (11954)
Valley Mills
Waco
Crawford
McGregor
N
Sampling Sites
0 5 10 20 30
Kilometers

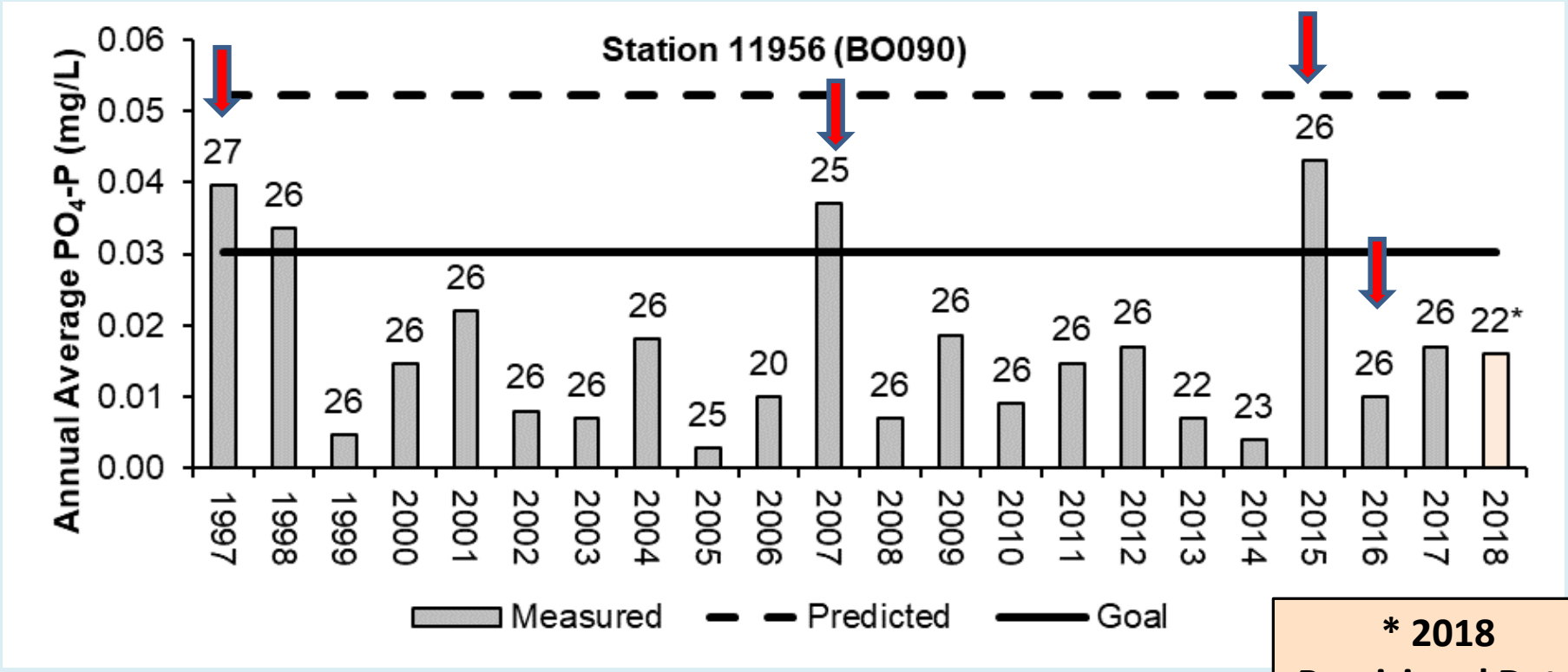


*** 2018 Provisional Data**

North Bosque May 29, 2015

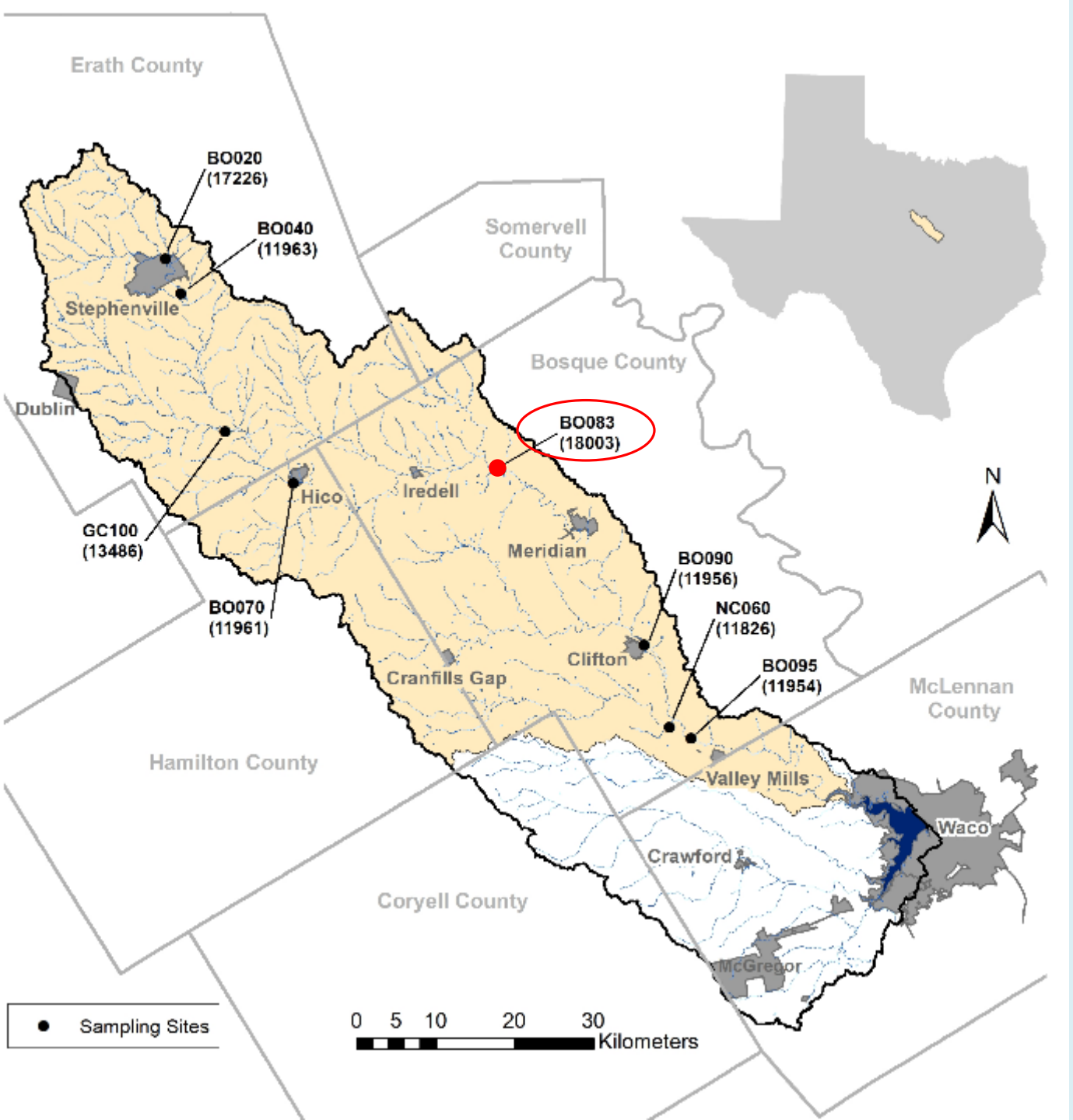
Station 17605/11954 located near Valley Mills

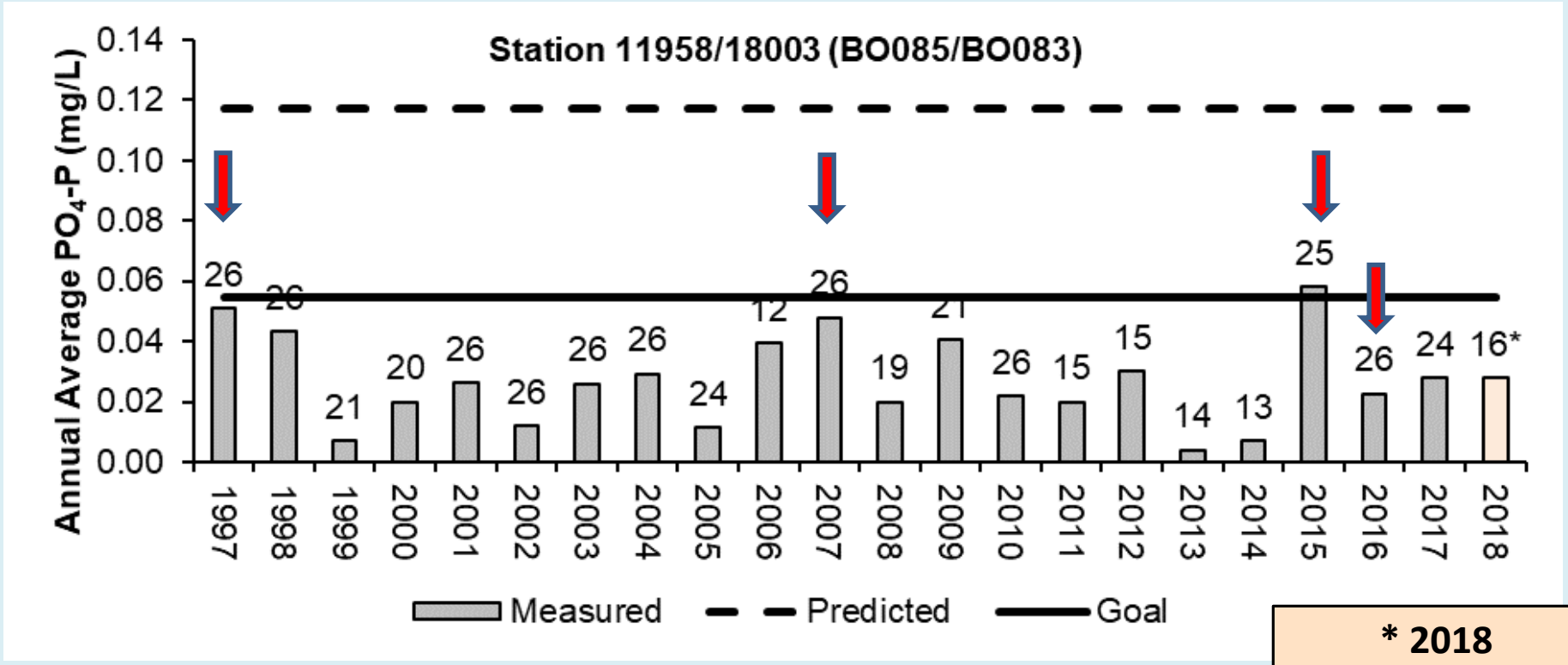

Erath County
Somervell County
Bosque County
Hamilton County
McLennan County
Coryell County
BO020 (17226)
BO040 (11963)
Stephenville
Dublin
GC100 (13486)
BO070 (11961)
Hico
Iredell
BO083 (18003)
Meridian
BO090 (11956)
NC060 (11826)
Clifton
Cranfills Gap
BO095 (11954)
Valley Mills
Waco
Crawford
McGregor
N
Sampling Sites
0 5 10 20 30
Kilometers



*** 2018 Provisional Data**

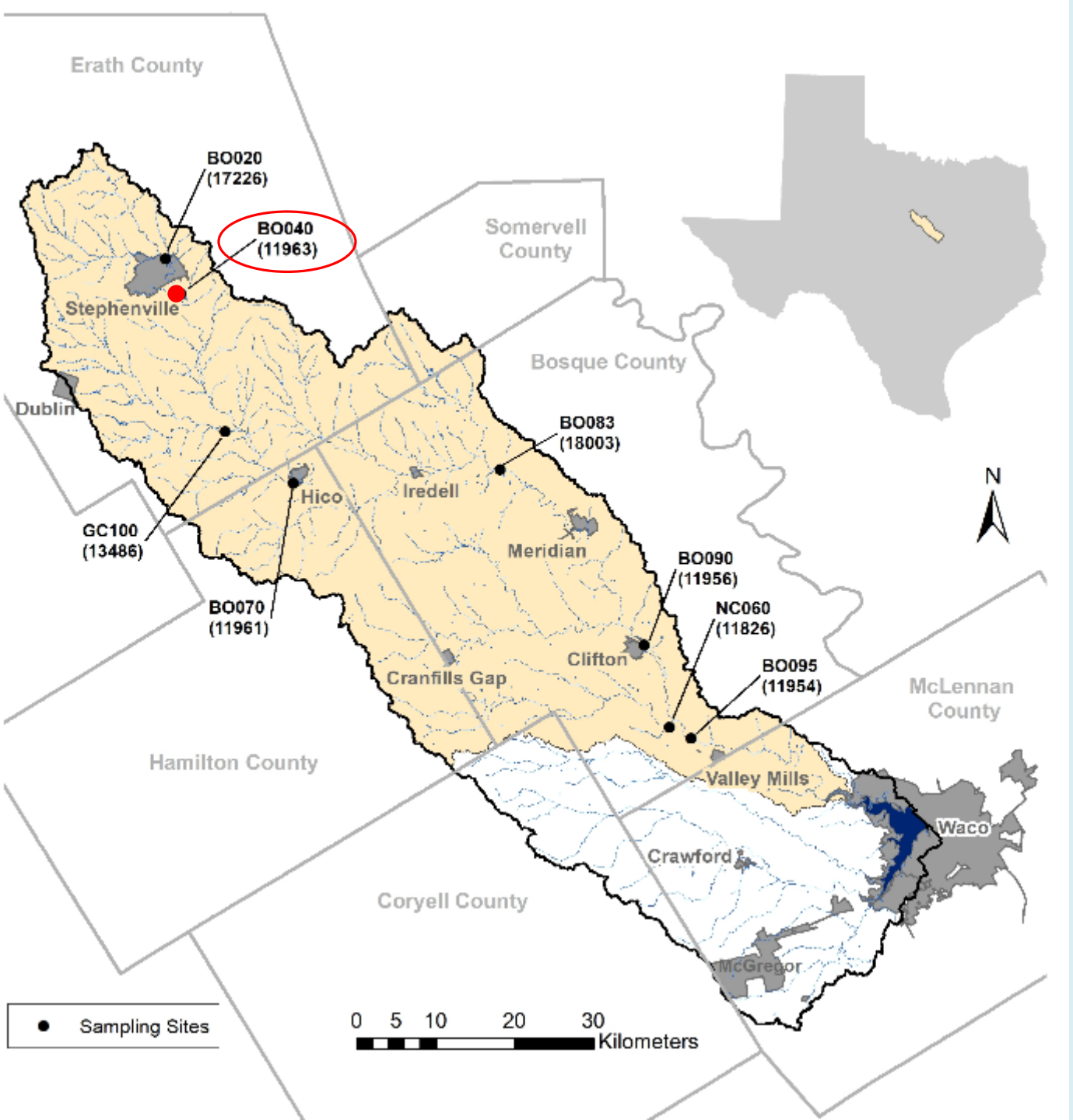
Station 11956 located near Clifton

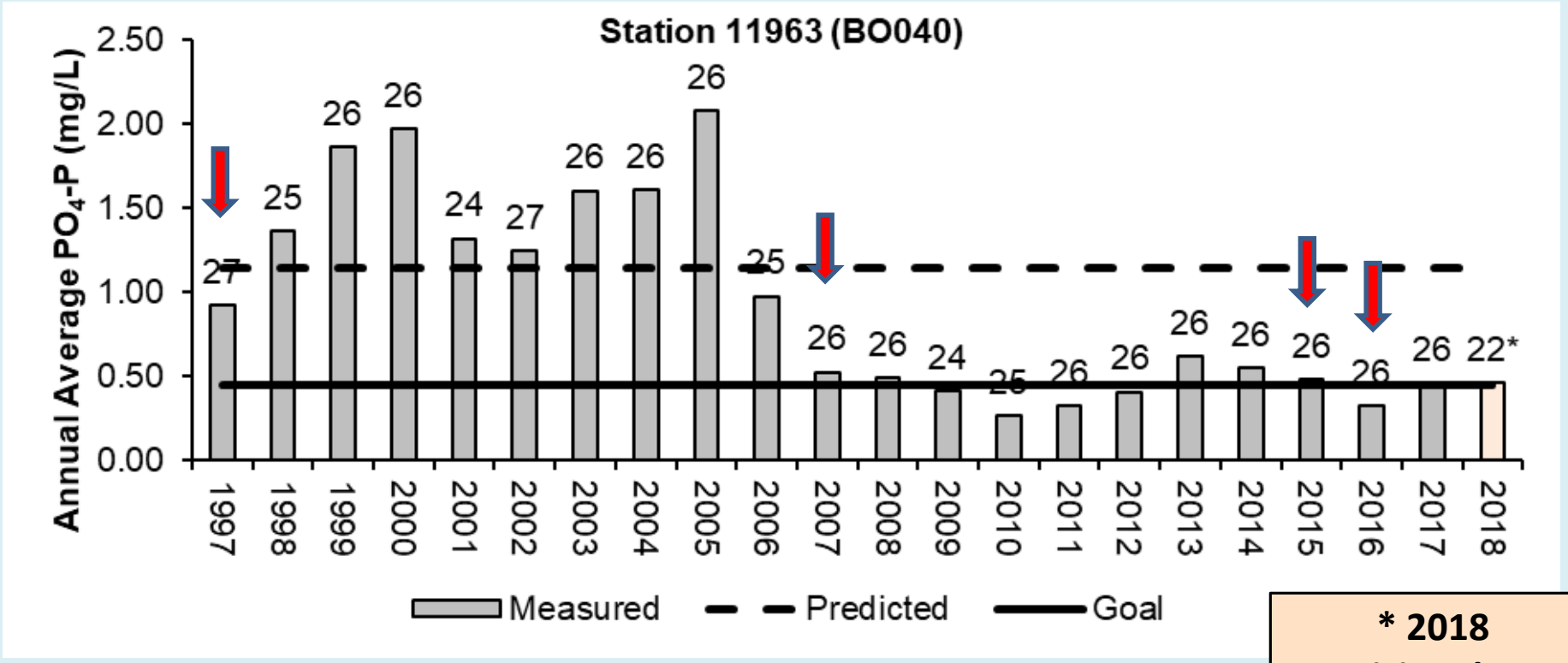

Erath County
Somervell County
Bosque County
Hamilton County
Coryell County
McLennan County
BO020 (17226)
BO040 (11963)
Stephenville
Dublin
GC100 (13486)
BO070 (11961)
Hico
Iredell
BO083 (18003)
Meridian
BO090 (11956)
NC060 (11826)
Clifton
BO095 (11954)
Cranfills Gap
Valley Mills
Waco
Crawford
McGregor
N
Sampling Sites
0 5 10 20 30
Kilometers



*** 2018 Provisional Data**

Station 11958/18003 located near Iredell

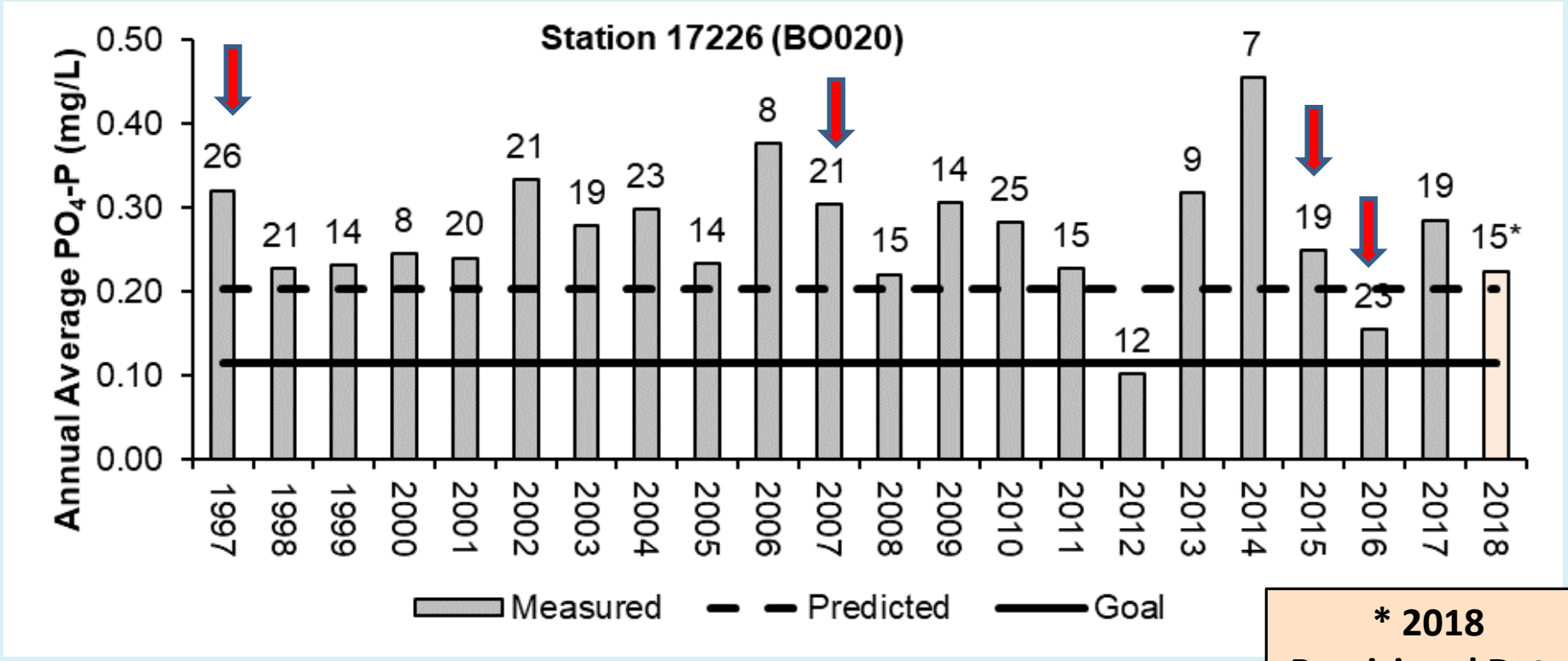

Erath County
BO020
(17226)
BO040
(11963)
Somervell
County
Stephenville
Bosque County
Dublin
BO083
(18003)
N
Hico
Iredell
GC100
(13486)
Meridian
BO090
(11956)
NC060
(11826)
BO070
(11961)
Clifton
Cranfills Gap
BO095
(11954)
McLennan
County
Hamilton County
Valley Mills
Waco
Crawford
Coryell County
McGregor
Sampling Sites
0 5 10 20 30
Kilometers



*** 2018 Provisional Data**

Station 11963 located below Stephenville


Erath County
BO020
(17226)
BO040
(11963)
Stephenville
Somervell
County
Bosque County
Dublin
BO083
(18003)
Hico
Iredell
GC100
(13486)
Meridian
BO090
(11956)
NC060
(11826)
BO070
(11961)
Clifton
Cranfills Gap
BO095
(11954)
McLennan
County
Hamilton County
Valley Mills
Waco
Crawford
Coryell County
McGregor
N
Sampling Sites
0 5 10 20 30
Kilometers



*** 2018 Provisional Data**

Station 17226 located above Stephenville

Is Water Quality Improving?

Yes!

Changes in treatment by WWTFs & land management are having an impact

Why is it taking so long?

Changes in land management impacted by variations in

- Timing and location of practices
- Residual impacts (soil & sediments)
- Long-term weather patterns

Acknowledgements

Funding for Monitoring -

- **TCEQ - Texas Commission on Environmental Quality**
- **TSSWCB - Texas State Soil & Water Conservation Board**
- **USDA-NRCS - Natural Resources Conservation Service**
- **EPA - Environmental Protection Agency**
- **BRA - Brazos River Authority**
- **TIAER – Texas Institute for Applied Environmental Research**