Revised Method for Measuring Compliance with Consent Decree Load-Reduction Requirements

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TOC Meeting

June 19, 2007

Topics

- Settlement Agreement Requirements
- Alternative Yardsticks:
  - STA/Bypass Outflow Conc (1996 Method)
  - Loads Removed by BMP's/STA's (Goforth 2007)
  - Loads to Marsh vs. Historical (Proposed Here)
- Targets Based on 1994 Conceptual Plan
- Recent Data & Forecasts
- Rain-Dependent Yearly Limits
- Summary

1995 Amended Consent Decree Section 8A

"Phosphorus loads discharged from the EAA will be reduced by approximately 80% to the EVPA by October 1, 2003 and will be reduced by approximately 85% to the Refuge by February 1, 1999, as compared with mean levels measured from 1979 to 1988."

Assumed here to mean that loads to EVPA must be <=20% of historical & loads to Refuge must be <=15% of historical from sources treated under 1992 Settlement Agreement

The Arithmetic

		Refuge	EVPA
1979-1988 Load to Marsh	Mt/yr	105	205
Required Reduction	%	~ 85%	~ 80%
Load Removed	Mt/yr	89	164
Load to Marsh	Mt/Yr	16	41

1992 STA Design		Refuge	EVPA
Outflow Volume	Kac-ft/yr	211	680
Outflow Conc	ppb	50	50
Outflow Load	Mt/Yr	13	42

Alternative Compliance Methodologies - Refuge

	Included Sources	Excluded Sources	Source mt/yr	BMP/STA Removal mt/yr	Discharge to Marsh		
					Flow kac-ft/yr	Conc ppb	Load mt/yr
Design Basis	1992 SA	C139	105	89	259	50	**16 ***
Walker 1996	1992 SA	C139	-	-	Assume <= 259	< = 50	Infer <=16
Goforth 2007	EAA	Lake, C51W, L8, 298 Dist	X	> = 89	-	-	<= X - 89
Walker 2007 a	1992 SA	Sources Added by 1994 CP	-	-	-	-	< = 16
Walker 2007 b	1994 CP	None	-	-	-	-	< = 24

* Target Load = 15% of Historical Discharge to Marsh from 1992 SA Sources

Compliance Criterion

- No Constraint

Alternative Compliance Methodologies - EVPA

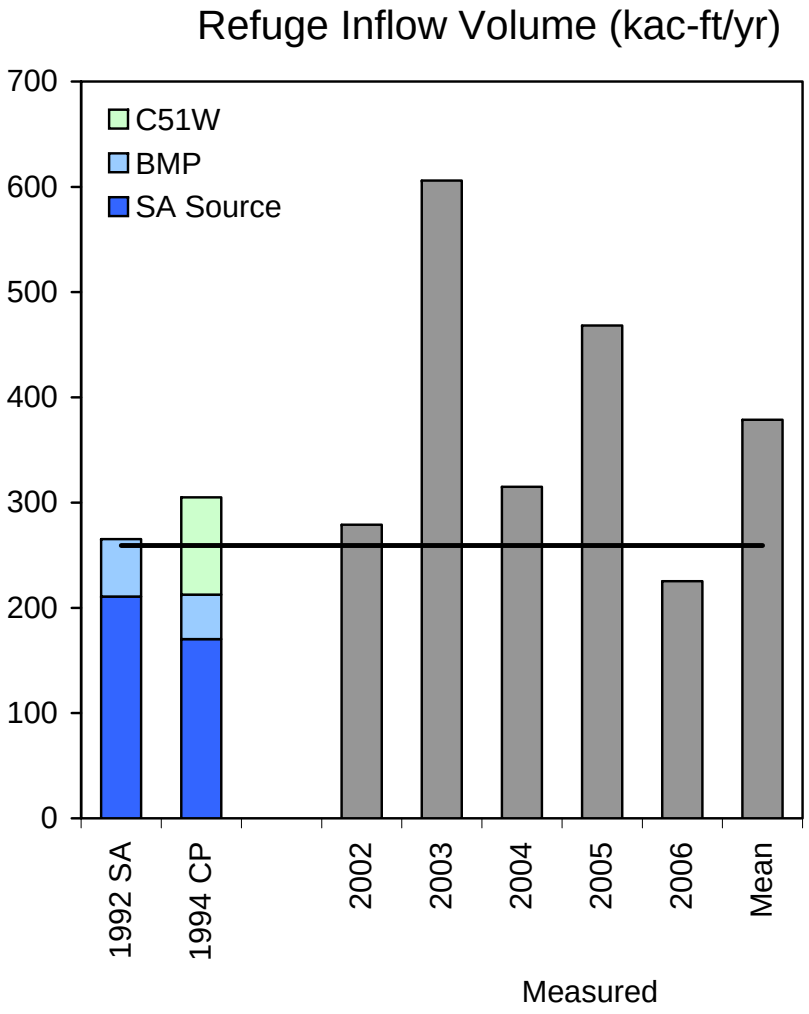
	Included Sources	Excluded Sources	Source mt/yr	BMP / STA Removal mt/yr	Discharge to Marsh		
					Flow kac-ft/yr	Conc ppb	Load mt/yr
Design Basis	1992 SA	C139	205	164	664	50	**41 ***
Walker 1996	1992 SA	C139	-	-	Assume <= 664	< = 50	Infer <=41
Goforth 2007	EAA	Lake, C51W, L8 C139, 298 Dist	X	> = 164	-	-	<= X - 164
Walker 2007 a	1992 SA	Sources Added by 1994 CP	-	-	-	-	< = 41
Walker 2007 b	1994 CP	None	-	-	-	-	< = 84

* Target Load = 20% of Historical Discharge to Marsh from 1992 SA Sources

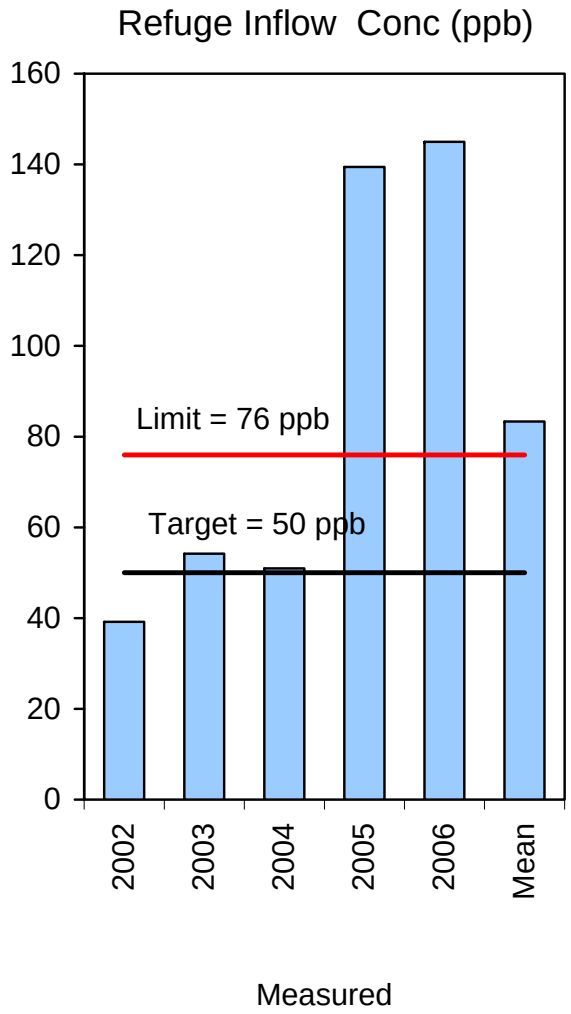
Compliance Criterion

- No Constraint

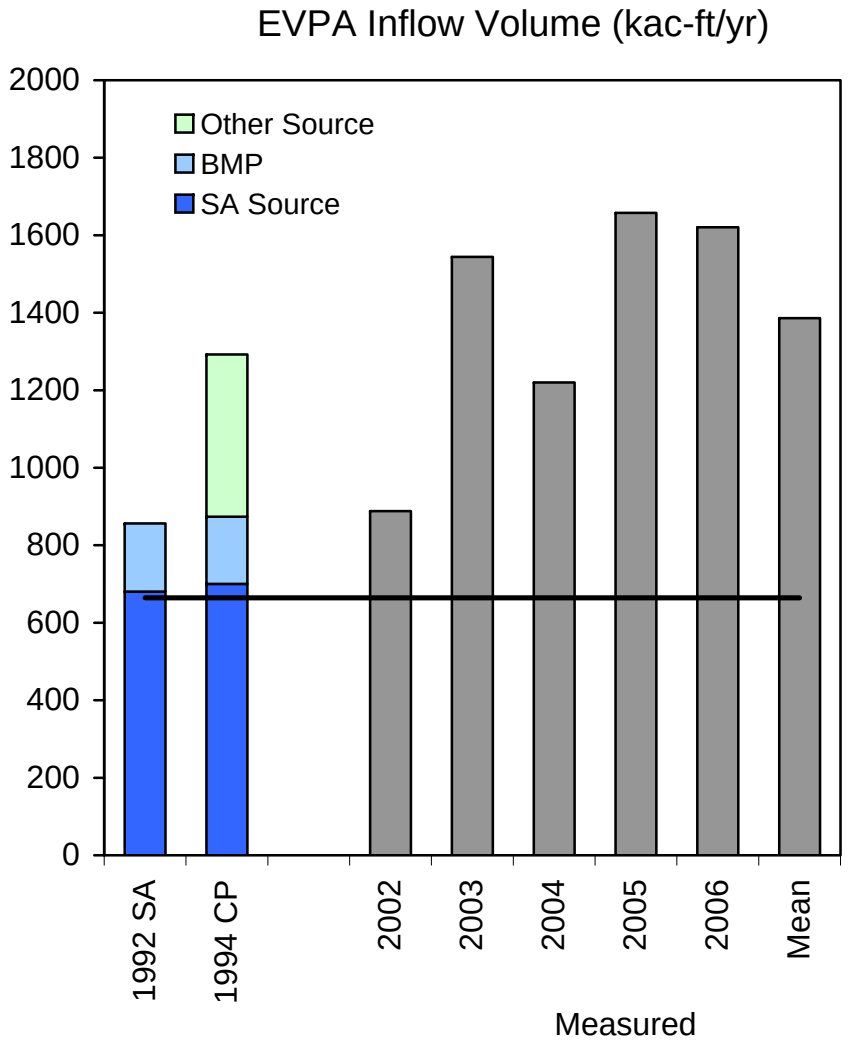
Application of 1996 Methodology to Refuge Inflows



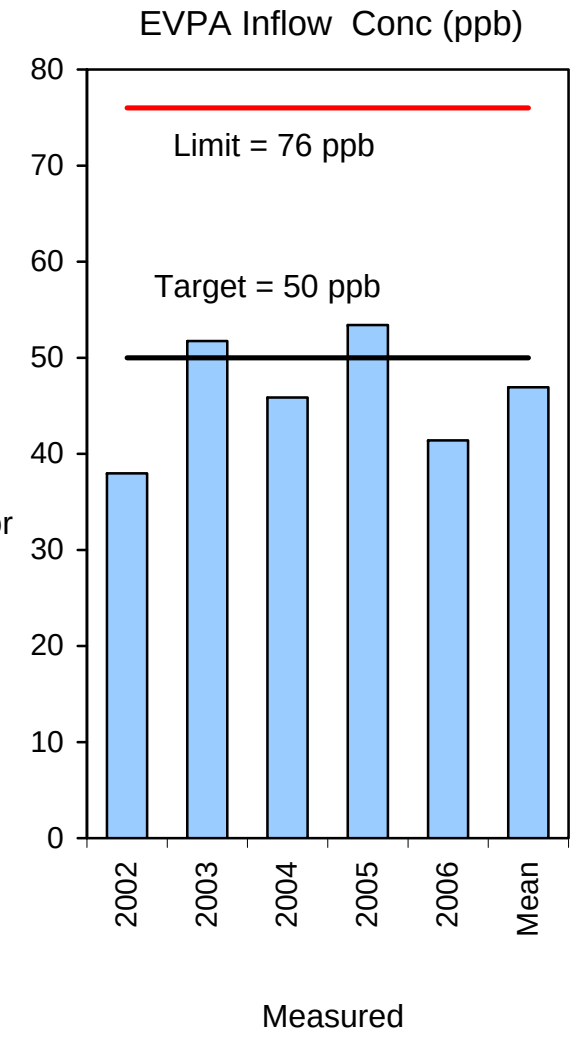
Assumed for 85% Load Reduc



Application of 1996 Methodology to EVPA Inflows



Assumed for 80% Load Reduc



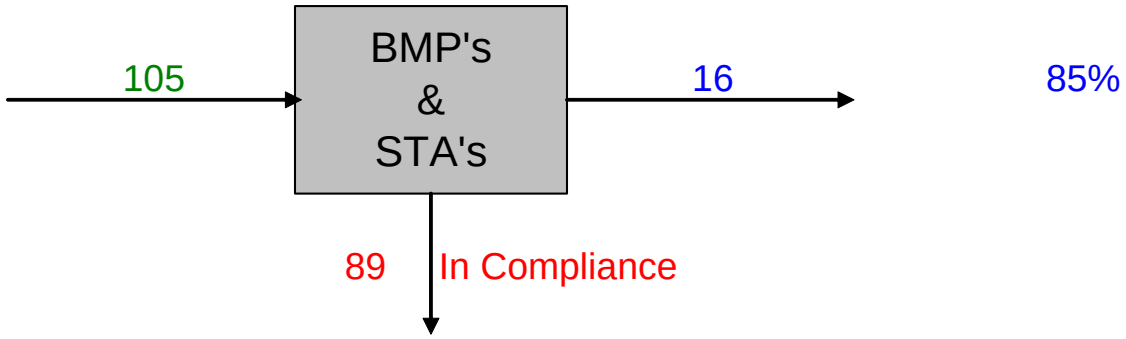
Measured Values Exclude ACME Basin B & C139/STA5 Inflows

Demonstration of Goforth 2007 Alternative Methodology

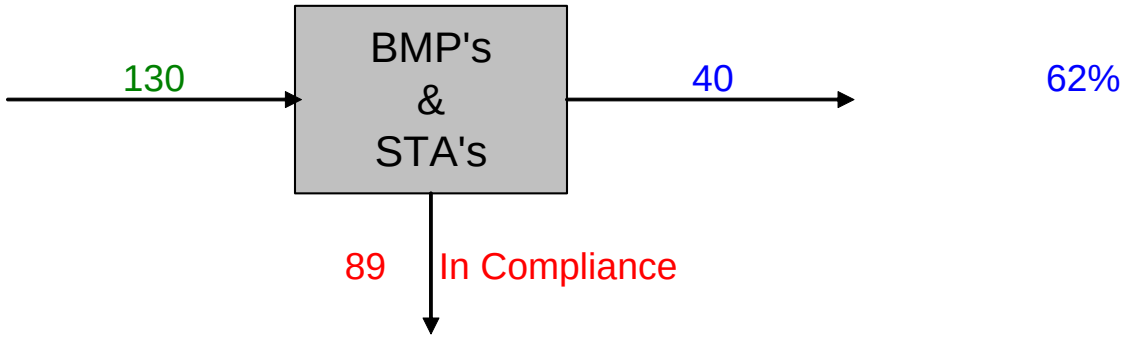
Requirement for Refuge: Load Removed >= 89 mt/yr

Source Load | Load to Marsh | Percent Reduction of 1978-1988 Load

Historical Scenario (1979-1988)

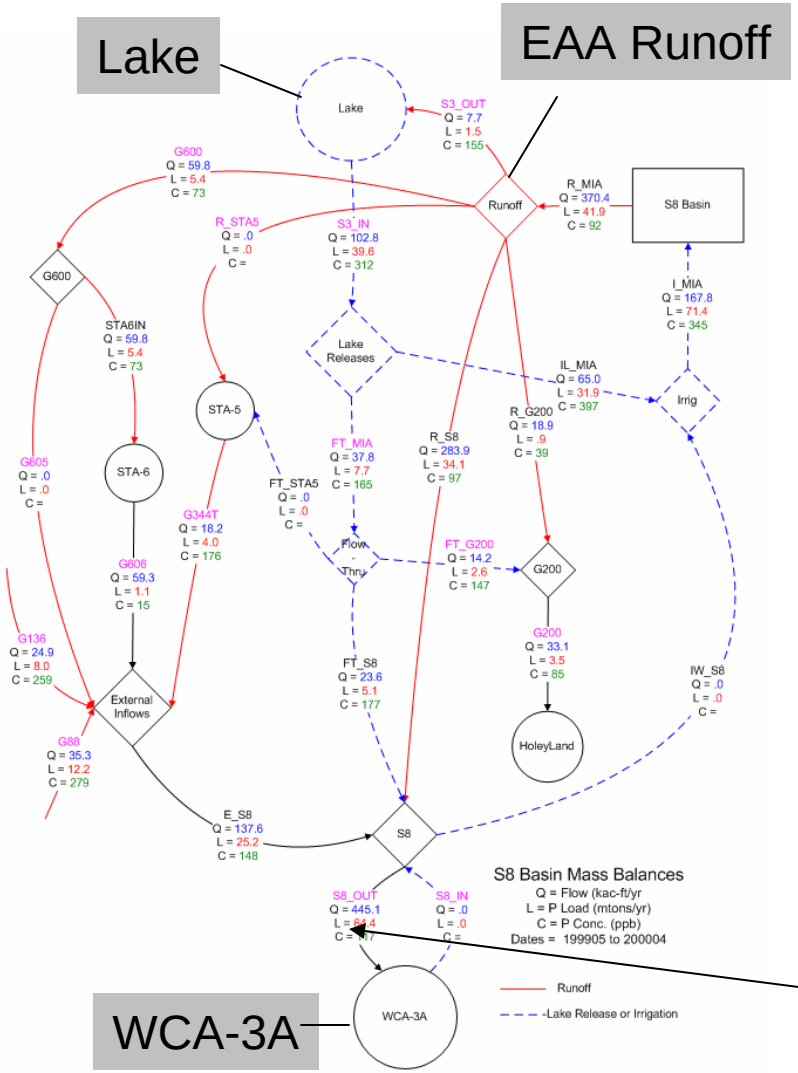


Hypothetical Scenario



- Load removals are estimated, not directly measured.
- Model used to estimate BMP reduction not calibrated to S5A basin.
- Does not constrain loads to the marsh.
- Does not ensure future load to marsh <= 15 % of historical load.

Pasta Recipe for Estimating EAA Runoff based upon Monitoring Data



Goforth's alternative method requires yearly estimates of EAA runoff load reduction.

EAA runoff is not measured, but estimated.

Loads measured at structures reflect variety of sources.

Parsing loads to individual sources (EAA, Lake, C139, 298, etc) based upon monitoring data requires numerous assumptions.

Example for S8 Basin (Walker, 1999). computations more complex with STA's operating

Yearly load reductions are estimated from estimated runoff and rainfall model

Simpler & more reliable to base compliance on measured loads to marsh.

Parsing of WCA-1 & WCA-3 Loads – SFER 2007

WCA-1

Real Data, i.e. Measured Loads

WCA-3A

Into WCA1

Structure	Flow	Phosphorus	
	1000 ac-ft	Load (kg)	FWMC (ppb)
G300 & G301	46.808	14007	243
from EAA	*36.828*	*10009*	
from East Beach	*2.981*	*1962*	
from Lake	*3.928*	*1065*	
from L8 Basin	*0.337*	*81*	
From WCA1	*0.030*	*6*	
from G311	*2.821*	*914*	
Mass Balance Adjustment	*-0.117*	*-30*	
S362 (from STA-1E)	40.540	7292	146
from EAA	*31.896*	*5211*	
from East Beach	*2.582*	*1022*	
from Lake	*3.402*	*554*	
from L8 Basin	*0.292*	*42*	
From WCA1	*0.026*	*3*	
from G311	*2.443*	*476*	
Mass Balance Adjustment	*-0.102*	*-16*	
G251 (from STA-1W)	34.187	4533	107
from EAA	*26.898*	*3239*	
from East Beach	*2.177*	*635*	
from Lake	*2.869*	*345*	
from L8 Basin	*0.246*	*26*	
From WCA1	*0.022*	*2*	
from G311	*2.060*	*296*	
Mass Balance Adjustment	*-0.086*	*-10*	
G310 (from STA-1W)	103.703	14732	115
from EAA	*81.592*	*10527*	
from East Beach	*6.604*	*2064*	
from Lake	*8.703*	*1120*	
from L8 Basin	*0.748*	*85*	
From WCA1	*0.066*	*7*	
from G311	*6.250*	*961*	
Mass Balance Adjustment	*-0.260*	*-31*	
ACME1 (from Basin B)	14.161	1403	80
ACME2 (from Basin B)	12.767	1832	116
Total	**252.167**	**43.799**	**141**

Into WCA3

Structure	Flow	Phosphorus	
	1000 ac-ft	Load (kg)	FWMC (ppb)
S140 (from L28 Canal)	203.575	12507	50
S190 (from Feeder Canal)	150.359	28717	155
L3 Borrow Canal (from C139-G409)	78.545	43306	447
STA6	26.312	848	26
S8	447.46	16964	31
From STA3/4	*298.577*	*45158*	
From Lake O	*23.433*	*7599*	
From EAA	*229.987*	*28923*	
From C-139	*11.744*	*3710*	
From STA-5	*20.472*	*2546*	
From SFCD	*7.249*	*1425*	
From SSDD	*5.692*	*955*	
From diversion (G373)	*57.337*	*6519* [3]	
From Lake O	*6.968*	*1285*	
From EAA	*11.529*	*927*	
From C-139	*1.648*	*531*	
From STA-5	*36.462*	*3676*	
From SFCD	*0.004*	*1*	
From SSDD	*0.725*	*100*	
From Rotenberger	*0.922*	*48*	
From Lake O	*0.373*	*14*	
From EAA	*0.080*	*1*	
From C-139	*0.000*	*0*	
From STA-5	*0.462*	*33*	
From SFCD	*0.000*	*0*	
From SSDD	*0.006*	*0*	
G204/G205/G206 (from Holey Land)	*1.726*	*41*	
STA5	90.710	10218	
STA3/4 reduction		*-45655*	
Mass Balance Adjustment	*-1.811*	*634*	
S150	38.35	749	16
from STA 3/4	*25.590*	*3870*	
From Lake O	*2.008*	*651*	
From EAA	*19.711*	*2479*	
From C-139	*1.007*	*318*	
From STA-5	*1.755*	*218*	
From SFCD	*0.621*	*122*	
From SSDD	*0.488*	*82*	
From diversion (G371)	*0.340*	*27*	
from Lake O	*0.340*	*27*	
from EAA	*0.000*	*0*	
STA3/4 reduction		*-1778*	
Mass Balance Adjustment	*12.419*	*-1370*	
G404 & G357	104.022	4598	36
From STA3/4	*69.411*	*10498*	
From Lake O to G409	*5.448*	*1766*	
From EAA	*53.466*	*6724*	
From C-139	*2.730*	*863*	
From STA-5	*4.759*	*592*	
From SFCD	*1.685*	*331*	
From SSDD	*1.323*	*222*	
From diversion (G373)	13.329	1767 [3]	
From Lake O	*1.620*	*348*	
From EAA	*2.680*	*251*	
From C-139	*0.383*	*144*	
From STA-5	*8.477*	*996*	
From SFCD	*0.001*	*0*	
From SSDD	*0.169*	*27*	
From Rotenberger	*0.214*	*13*	
From Lake O	*0.087*	*4*	
From EAA	*0.019*	*0*	
From C-139	*0.000*	*0*	
From STA-5	*0.107*	*9*	
From SFCD	*0.000*	*0*	
From SSDD	*0.002*	*0*	
STA5	21.088	2770	
STA3/4 reduction		*-9736*	
Mass Balance Adjustment	*-0.020*	*-714*	

1994 Conceptual Plan

- Adopted under 1995 Amended Consent Decree as plan to accomplish interim treatment goals (50 ppb)
- Expanded STA's Treating Additional Flows
  - 1979-1988 flows to EVPA treated in 1992 SA (thru S5A, S6, S7, S8, S150)
  - 1979-1988 flows to EVPA from L3 Canal/ C139 basin
  - New diversions to EVPA from EAA 298's, C51W, & additional Lake regulatory releases
- Burns & McDonnell report provides detailed accounting of flow sources & expected outflows from each STA
- Provides context for measuring compliance with load reduction requirements

1994 Conceptual Plan - Projected Loads to Marsh from Sources Treated under 1992 Settlement Agreement

Estimate	Refuge	EVPA	Notes
1994 Conceptual Plan	10.5	43.2	from data in B&M (1994) report
1994 Conceptual Plan	12.4	43.2	adjusted for S5A diversion to STA2
Target for 85/80% Reduc	15.8	41.0	15/20% of Historical Load to Marsh
1992 STA Design	13.0	42.0	from 1992 SWIM Plan, Appendix F

Average loads (mt/yr) under 1979-1988 hydrologic conditions

SA sources = historical flows thru S5A, S6, S7, S150, S8 treated to 50 ppb

Assumption:
SA load-reduction requirements will be met if measured loads to Refuge/EVPA from all sources are similar to forecasts.

Load Allocations Based Upon 1994 Conceptual Plan

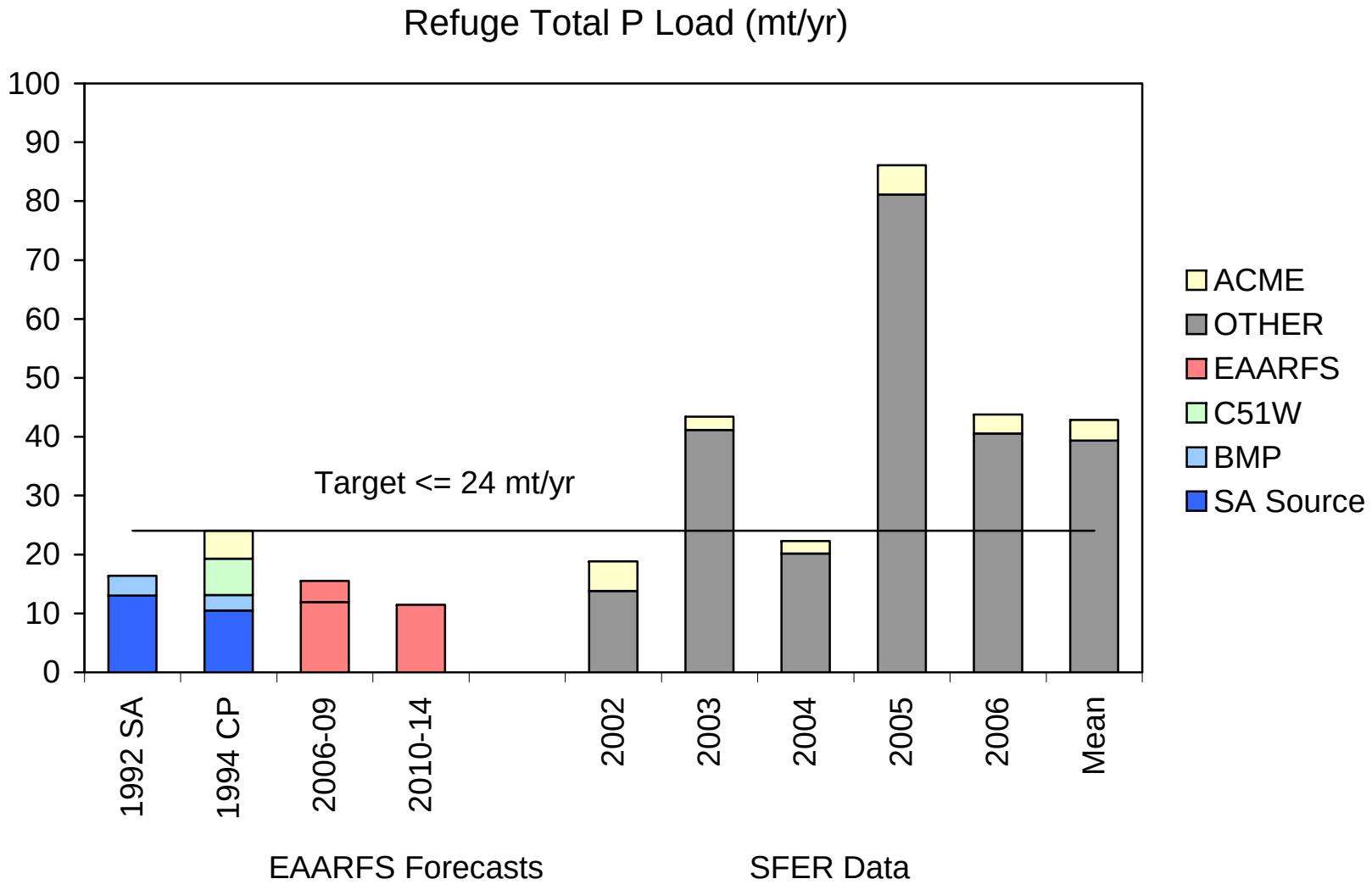
Component	Refuge	EVPA	Notes
Total STA Outflows to EVPA	16.7	68.9	Treated to 50 ppb*
From1992 SA Sources	12.4	43.2	1979-1988 thru S5A, S6, S7, S150, S8
From Other Sources	4.3	25.7	Sources not Treated in 1992 SA
Bypass/Untreated Flows	0.0	0.0	All Flows Treated, 1978-1979 Cond.
BMP Replacement	2.6	10.7	20% of Historical EAA Runoff @ 50 ppb
ACME B	4.7	4.7	Historical Mean @ 113 ppb
Total Target Load to Marsh	24.0	84.4	For Compliance Determination

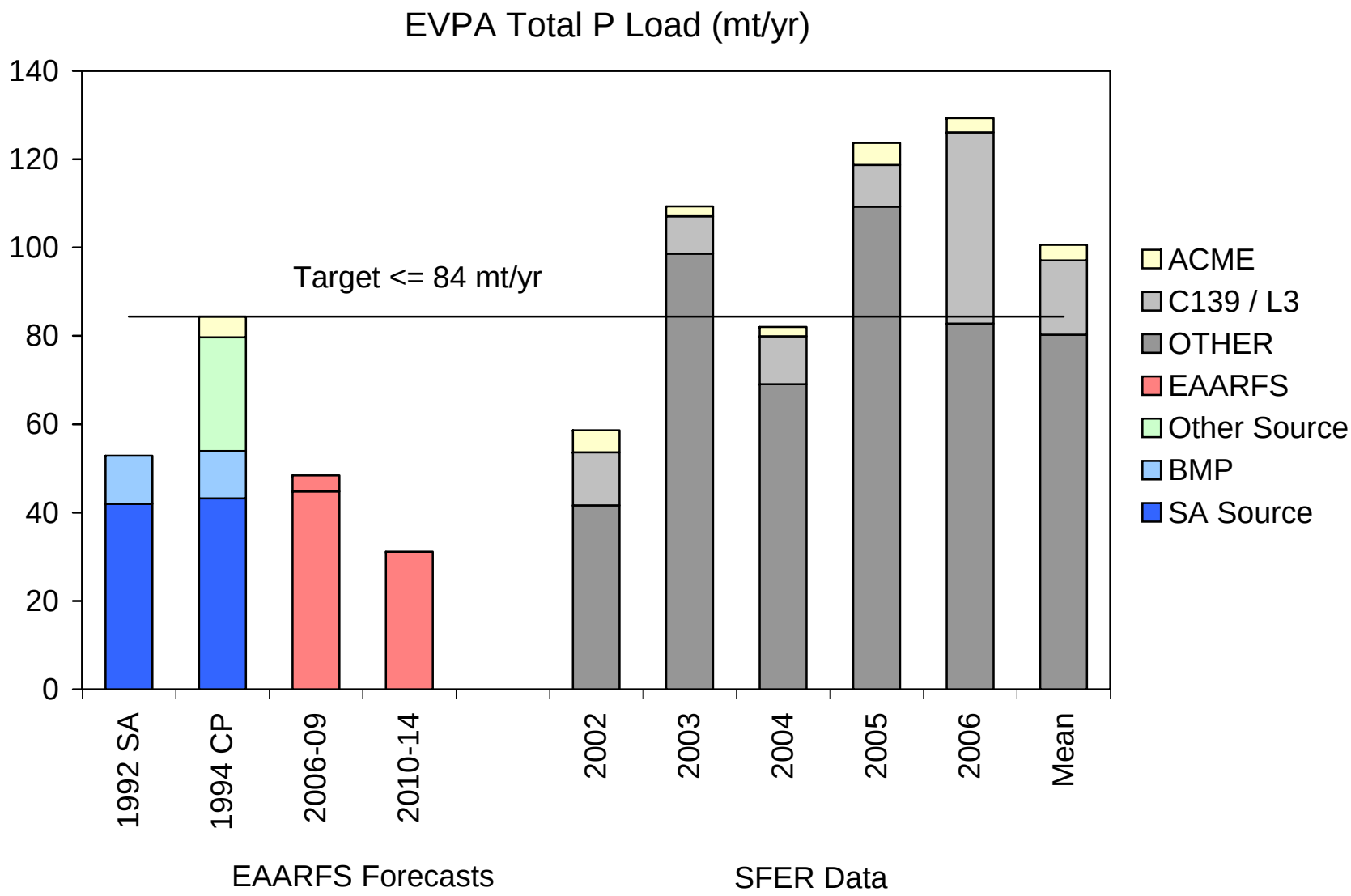
* Table A-5, Burns & McDonnell (1994), adopted under 1995 Consent Decree

Design basis for current operating STA's 1W, 1E, 2, 34, 5, 6.

Assumes 50% of STA-5 discharge to Rotenberger (2.7 mt/yr)

All values are long-term average loads (mt/yr) for 1979-1988 hydrologic conditions

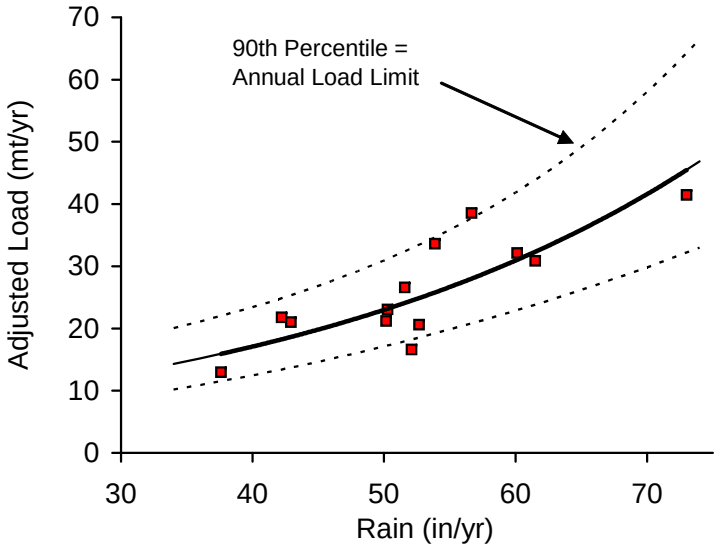

Refuge Total P Load (mt/yr)
100
90
80
70
60
50
40
30
20
10
0
Target <= 24 mt/yr
1992 SA
1994 CP
2006-09
2010-14
2002
2003
2004
2005
2006
Mean
EAARFS Forecasts
SFER Data
ACME
OTHER
EAARFS
C51W
BMP
SA Source


EVPA Total P Load (mt/yr)
140
120
100
80
60
40
20
0
Target <= 84 mt/yr
1992 SA
1994 CP
2006-09
2010-14
2002
2003
2004
2005
2006
Mean
EAARFS Forecasts
SFER Data
ACME
C139 / L3
OTHER
EAARFS
Other Source
BMP
SA Source

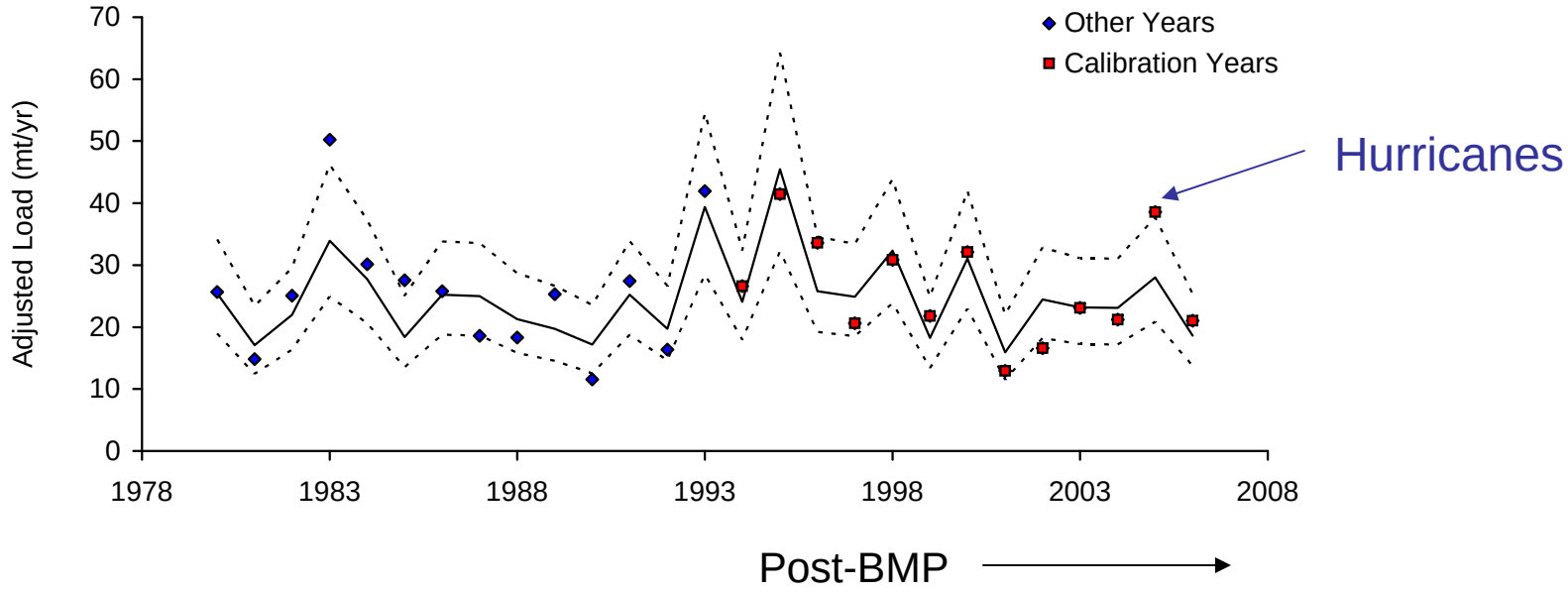
Recipe for Developing Yearly Load Limits

- Compile Data from STA Inflow Sources
  - Historical Measurements, 1980 - 2006
  - EAARFS Model Inflows for C51W & ACME
- Correlate Loads to Rainfall
  - Calibrate to 1994-2006 data (post-BMP)
  - Test against 1980-1993 data
- Rescale predicted loads to equal target loads in WY 1980-1988 (24 mt/yr for Refuge, 84 mt/yr for EVPA)
- Set yearly limit at upper 90^{th} percentile of predicted loads at a given rainfall
- Similar to models use for tracking BMP performance in EAA & C139 basin

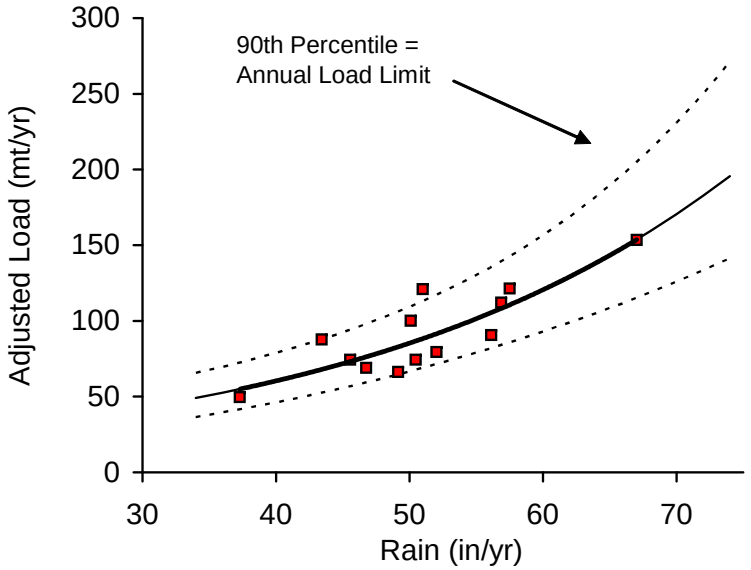
Derivation of Yearly Limits for Refuge Inflow Loads



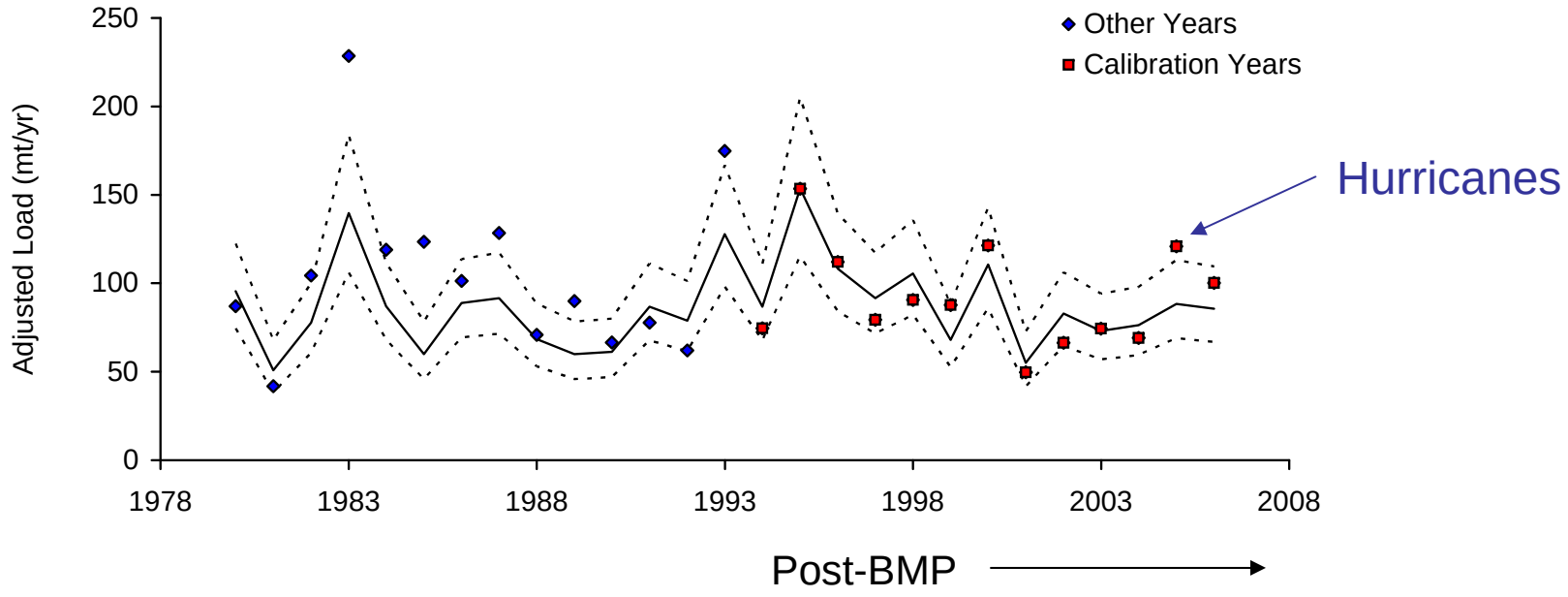
Regression model:	y = Exp (a + b X)	
Target Mean Load =	24.0	mt/yr
Regression R^2 =	0.65	
Std Error of Estimate	0.208	base e log
Intercept (a)	1.6532	
Slope (b)	0.0296	
Std Error of Slope	0.0065	
Number of Years	13	
Calibration years	1994	2006
Rainfall Statistics (in)	1980-1988	1994-2006
Mean Rain	50.8	52.7
Min Rain	40.0	37.6
Max Rain	63.1	73.0
Predicted Load mt/yr	24.0	25.8



Derivation of Yearly Limits for EVPA Inflow Loads



Regression model:	y = Exp (a + b X)	
Target Mean Load =	84.4	mt/yr
Regression R^2 =	0.70	
Std Error of Estimate	0.174	base e log
Intercept (a)	2.7184	
Slope (b)	0.0346	
Std Error of Slope	0.0068	
Number of Years	13	
Calibration years	1994	2006
Rainfall Statistics (in)	1980-1988	1994-2006
Mean Rain	48.6	51.0
Min Rain	35.0	37.3
Max Rain	64.2	67.0
Predicted Load mt/yr	84.4	91.2



Revised Compliance Test Summary

- Similarities to 1996 Method
- Differences from 1996 Method
- Limitations
- Potential Refinements

Revised Compliance Test Similarities to 1996 Method

- Tracks all discharges from & bypasses around STAs 1E, 1W, 2, & 34, as designed in 1994 CP
- Assumes compliance with 80/85% load reduction if data at inflows to the marsh (conc or load) are consistent with 1994 CP design.
- Does not attempt to parse out individual basin sources
- Simple to implement based directly upon SFER data
- Calibrated to historical data from STA sources
- One- & three-yr tests based on 90th & 50th percentiles
- Special provisions for hydrologic conditions outside of 1979-1988 design period and for low-flow water-supply deliveries

Revised Compliance Test Differences from 1996 Method

- Based upon load instead of concentration
- No assumptions regarding future source loads or flows; addresses major problem with 1996 method
- Provides greater assurance that future inflow loads to the Refuge from 1992 SA sources will be <=15% of 1979-1988 loads
- Provides greater assurance that future inflow loads to the EVPA from 1992 SA sources will be <=20% of 1979-1988 loads
- Includes loads from C139 & ACME-B basins, so that all external inflows to the Refuge, WCA-2A, and northern WCA3A are tracked.
- Target & limit loads adjusted for rainfall
- Yearly limits calibrated to post BMP (1994-2006) vs. pre-BMP (1979-1988) periods

Revised Compliance Test Limitations

- Accept performance vs. 1994 CP as surrogate for measuring reductions in historical load to marsh from 1992 SA sources
- Slightly different base period (May 1980-April 1988) vs. 1994 CP (Oct 1979-Sept 1988); reflecting change in Water Year definition.
- Rainfall adjustments calibrated to STA inflow sources; can be refined when sufficient STA outflow data are available.
- Potentially impacted by unusual spatial variations in rainfall (C51W/ACME/C139 vs. EAA) not experienced in 1994-2006 calibration period; can be evaluated in compliance determination.
- Seepage losses from STA's (~8% for STA1E, 7% for STA5, 36% for STA6) are ignored but may impact marsh. Allocations for measured surface outflow loads would be lower if seepage were considered.

Revised Compliance Test
Potential Refinements

- Add loads from C139-Annex (<1 mt/yr) to EVPA allocation
- Assumed 50% of STA-5 outflow goes to Rotenberger vs. EVPA
- Rainfall spatial averaging & regressions
- Review allocations for BMP replacement water.
- Include or exclude hurricane year (2005) in calibration
- Parallel set of rainfall regressions for tracking inflow volumes.
- Methodology can be rescaled to track inflow loads relative to EAARFS / Long-Term-Plan forecasts
- Provisions for wet/dry years, water-supply, extreme events.