Discussion on Lake Minimum Level Compliance Evaluation

Presentation 3 of 3

Presented to NTB II (LTPRG)

April 9, 2008

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Hydrologic Evaluation Section
SWFWMD

Today's Discussion

- Review of Last Two Presentations
  - Presentation 1: Analysis of Long-term = 60 years
  - Presentation 2: Introduction to Line of Organic Correlation (LOC) to Produce a 60 Year Historic Record
- Presentation 3: Evaluation of Lake Level Compliance

MFL Terminology Review

1. Historic
2. Current
3. Structural Alteration
4. Long-Term
5. P10
6. P50
7. P90
8. Minimum Lake Level
9. High Minimum Lake Level
10. High Guidance Level

Structural Alteration:

- Change to the conveyance system of the lake that changes the lake stage fluctuation in a measurable manner.
- Usually, but not always, it involves a change to the outlet of the lake.
- Can include downstream alterations that result in tail water effects.
- Can include up stream changes that either increase or decrease flow to the lake.
- We recognize sinkholes during compliance evaluation, but usually don’t set the level based on them.

Historic

1. Period with no measurable groundwater or withdrawal impacts

2. Structural conditions same as now

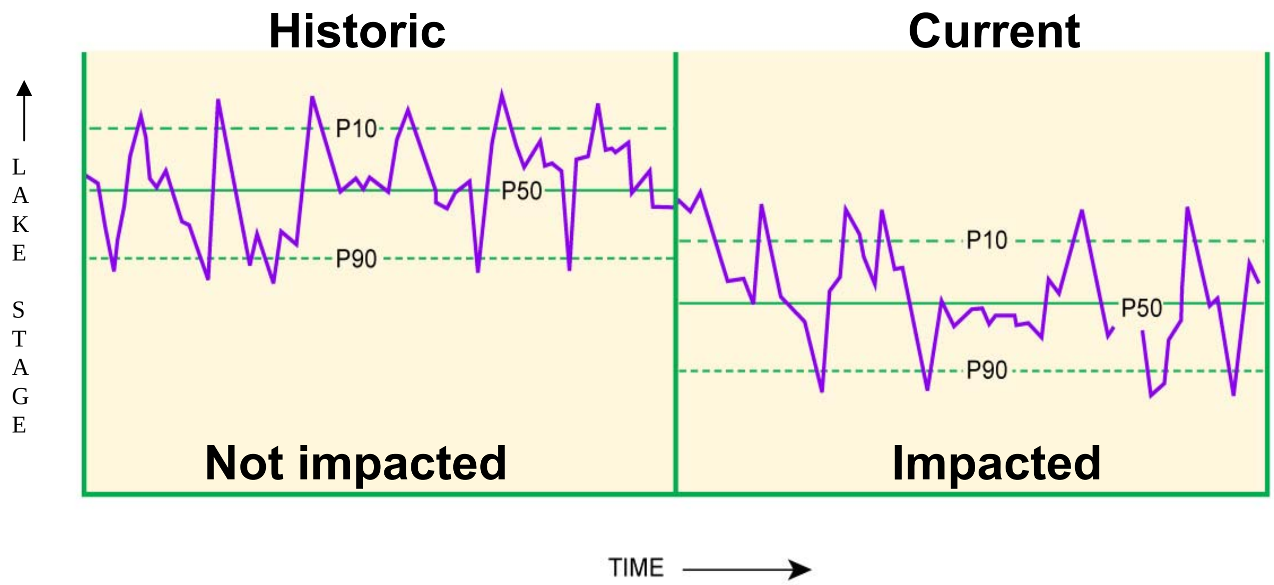
4. No Augmentation

Current

1. ~~No~~ Groundwater or withdrawal impacts

2. Structural conditions same as now

3. No Augmentation



P10 = Elevation the lake stage is equal to or above 10% of the time

P50 = Elevation the lake stage is equal to or above 50% of the time

P90 = Elevation the lake stage is equal to or above 90% of the time

Minimum Lake Levels are Long-Term Percentiles

- Minimum Lake level is the Historic P50 minus some offset.

  MLL represents a new P50 value

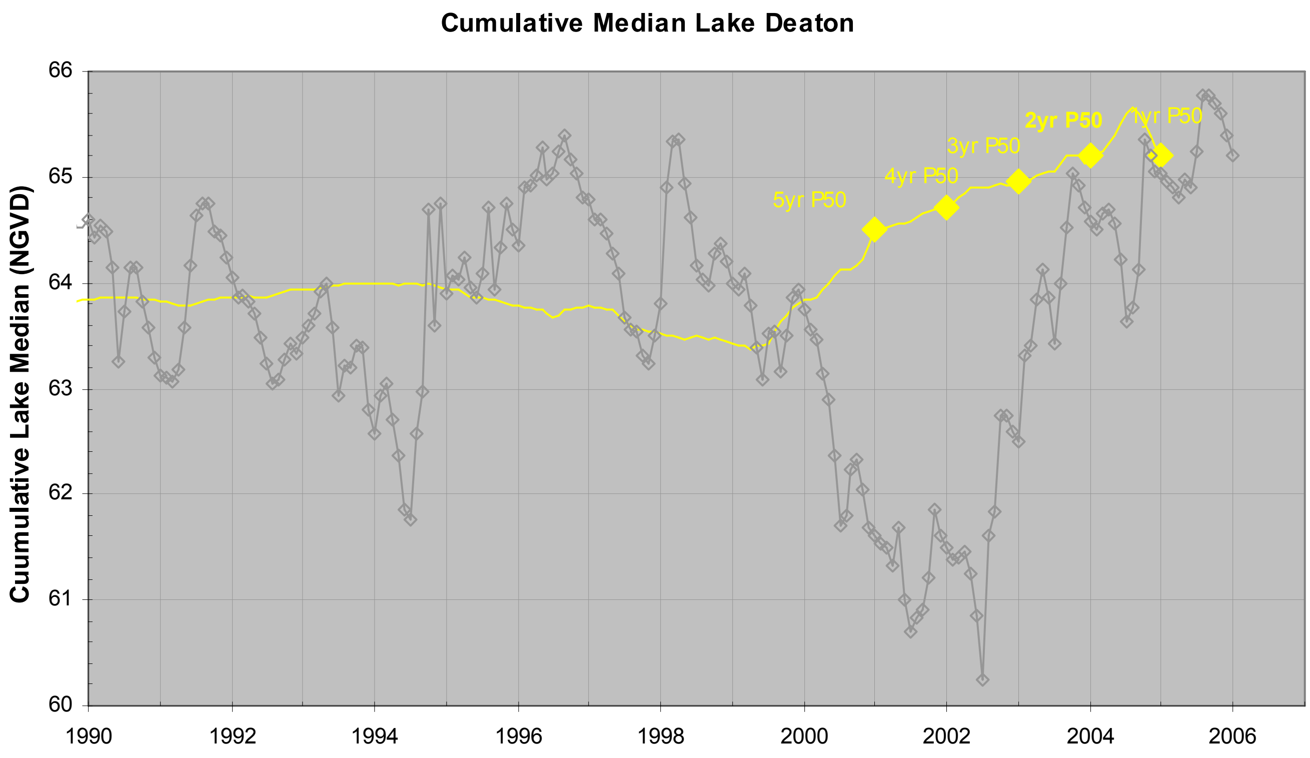
- High Minimum Lake Level is the Historic P10 minus some offset.

  HMLL represents a new P10 value

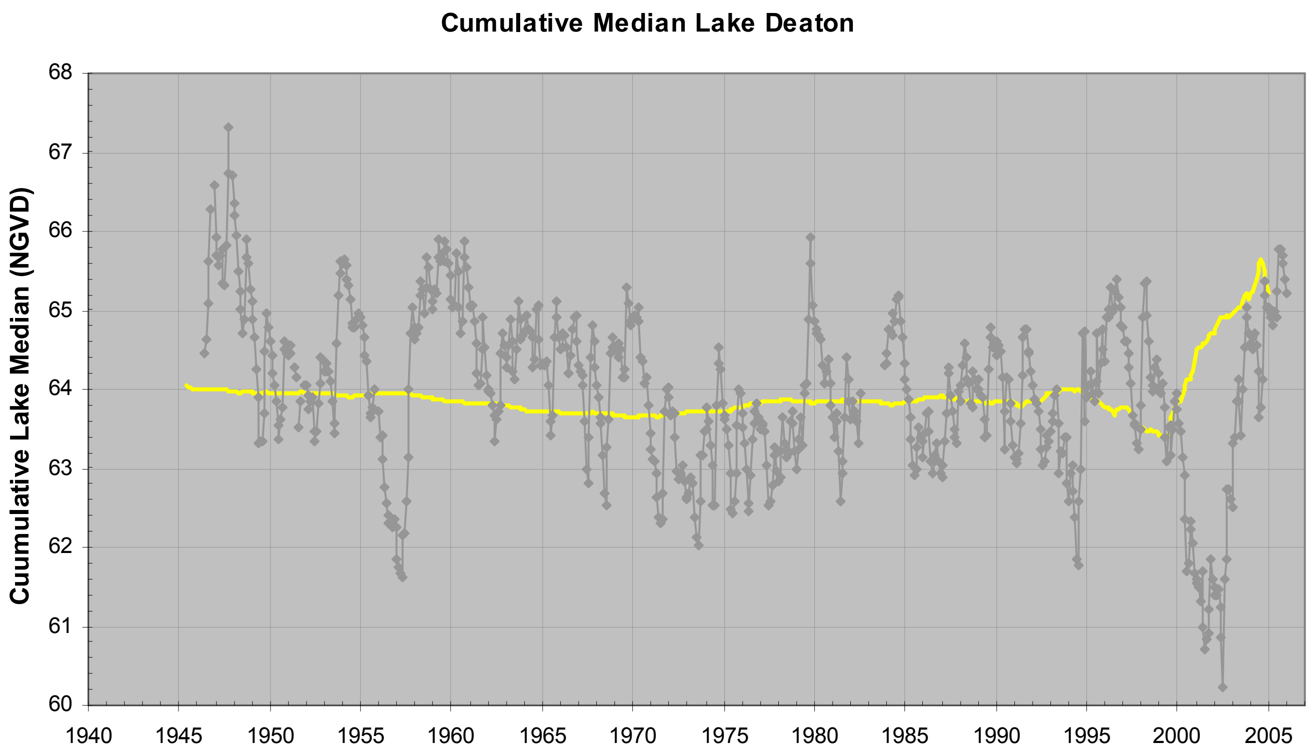
- High Guidance Level is the Historic P10 (i.e. no offset)

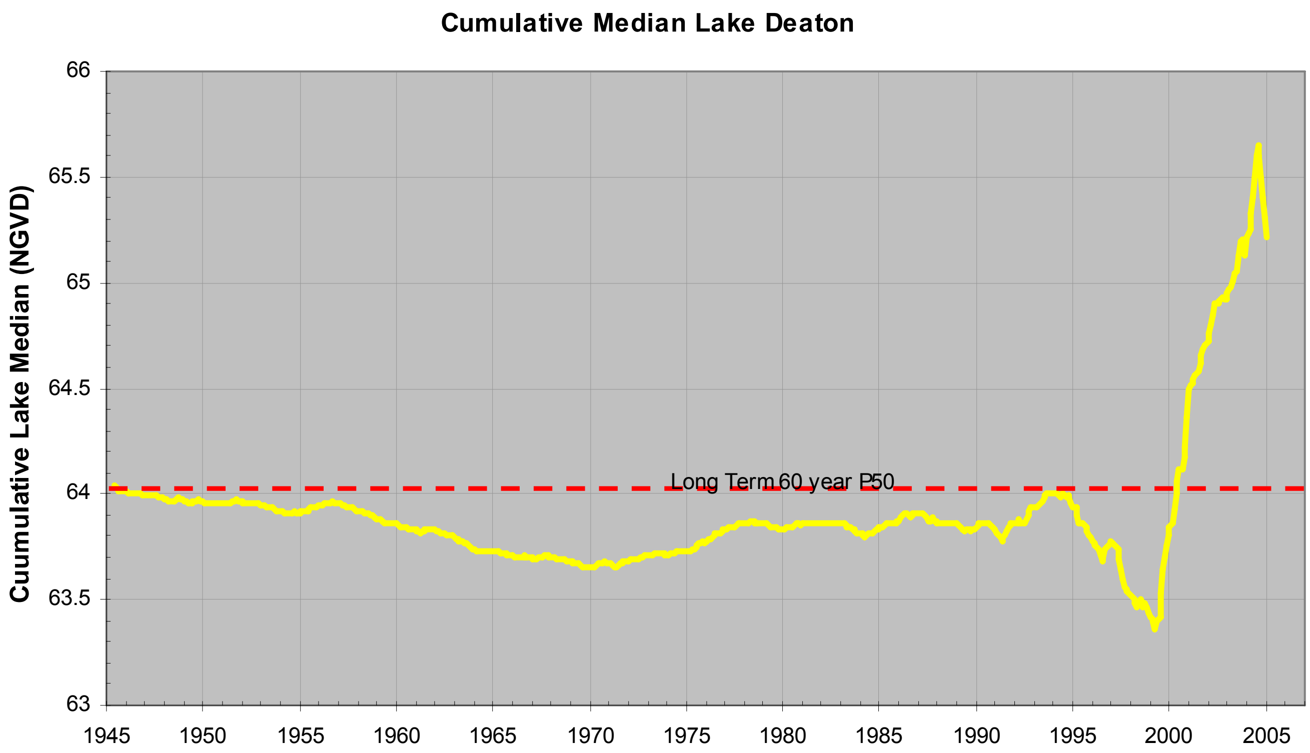
  HGL = Historic P10

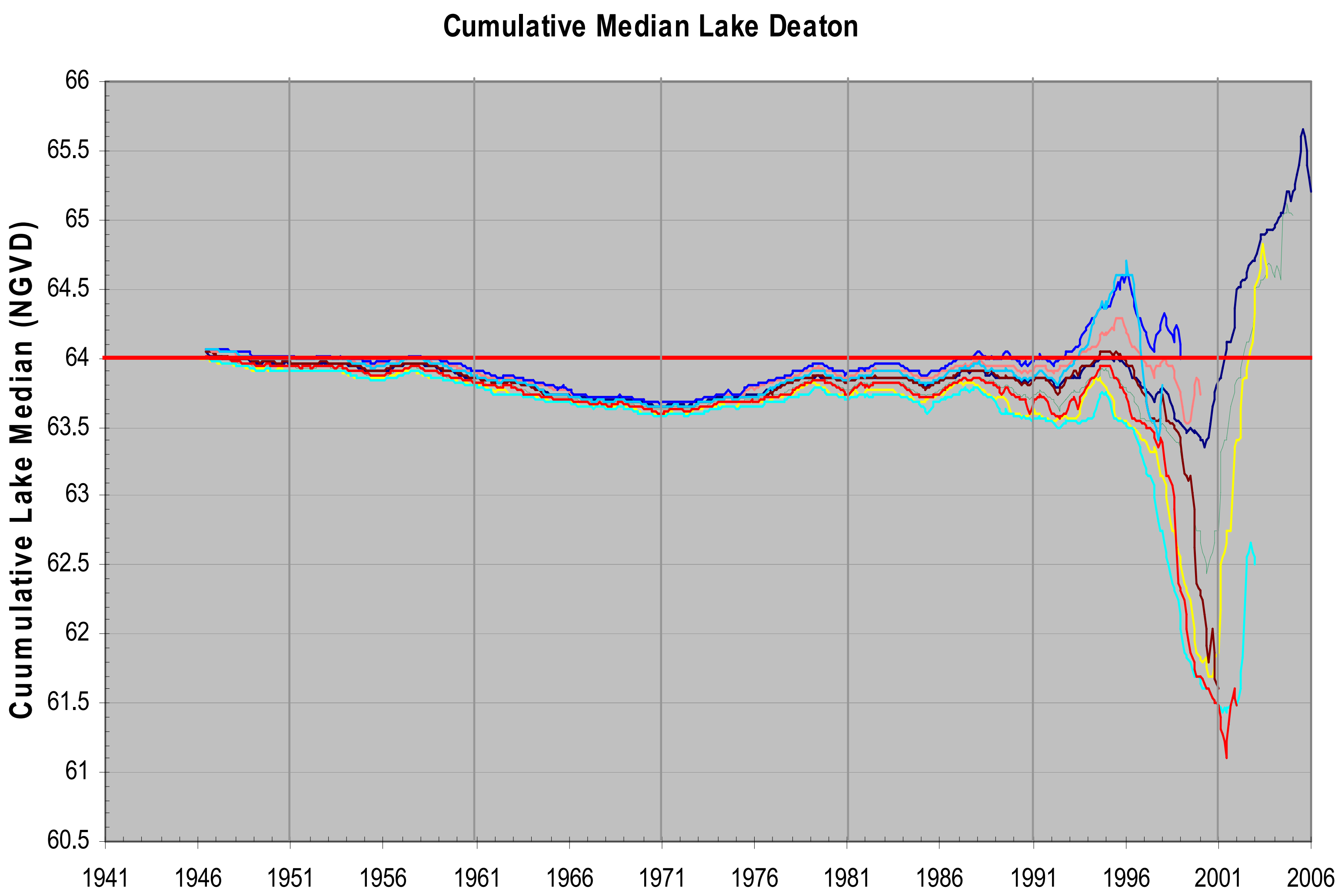
Analysis
Of
“Long Term”

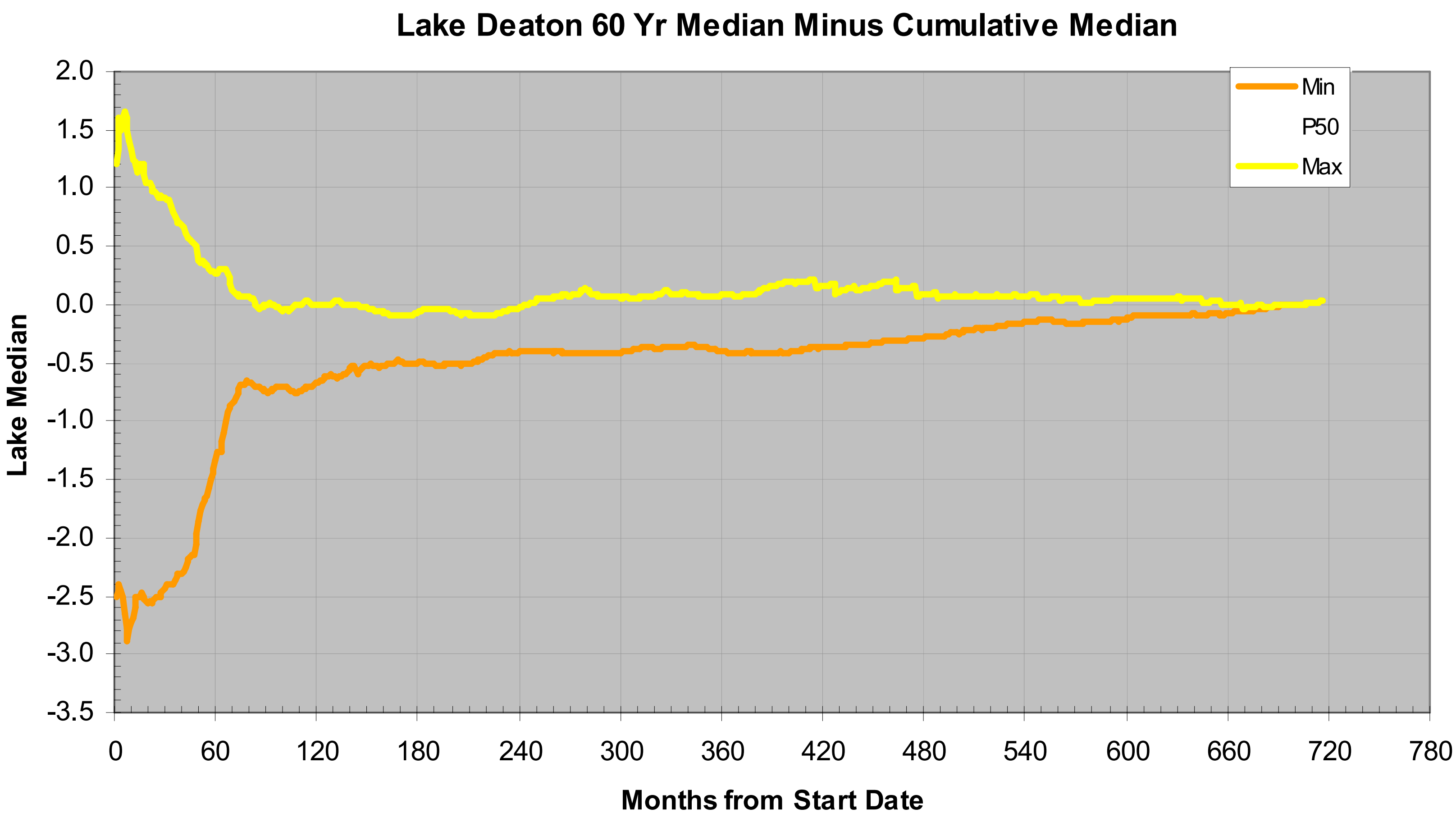


Cumulative Median Lake Deaton
Cuumulative Lake Median (NGVD)
66
65
64
63
62
61
60
1990
1992
1994
1996
1998
2000
2002
2004
2006
5yr P50
4yr P50
3yr P50
2yr P50
1yr P50


Cumulative Median Lake Deaton
Cuumulative Lake Median (NGVD)
68
67
66
65
64
63
62
61
60
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005


Cumulative Median Lake Deaton
Cuumulative Lake Median (NGVD)
66
65.5
65
64.5
64
63.5
63
Long Term 60 year P50
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005


Cumulative Median Lake Deaton
Cuumulative Lake Median (NGVD)
66
65.5
65
64.5
64
63.5
63
62.5
62
61.5
61
60.5
1941
1946
1951
1956
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006


Lake Deaton 60 Yr Median Minus Cumulative Median
Min
P50
Max
Lake Median
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
0
60
120
180
240
300
360
420
480
540
600
660
720
780
Months from Start Date

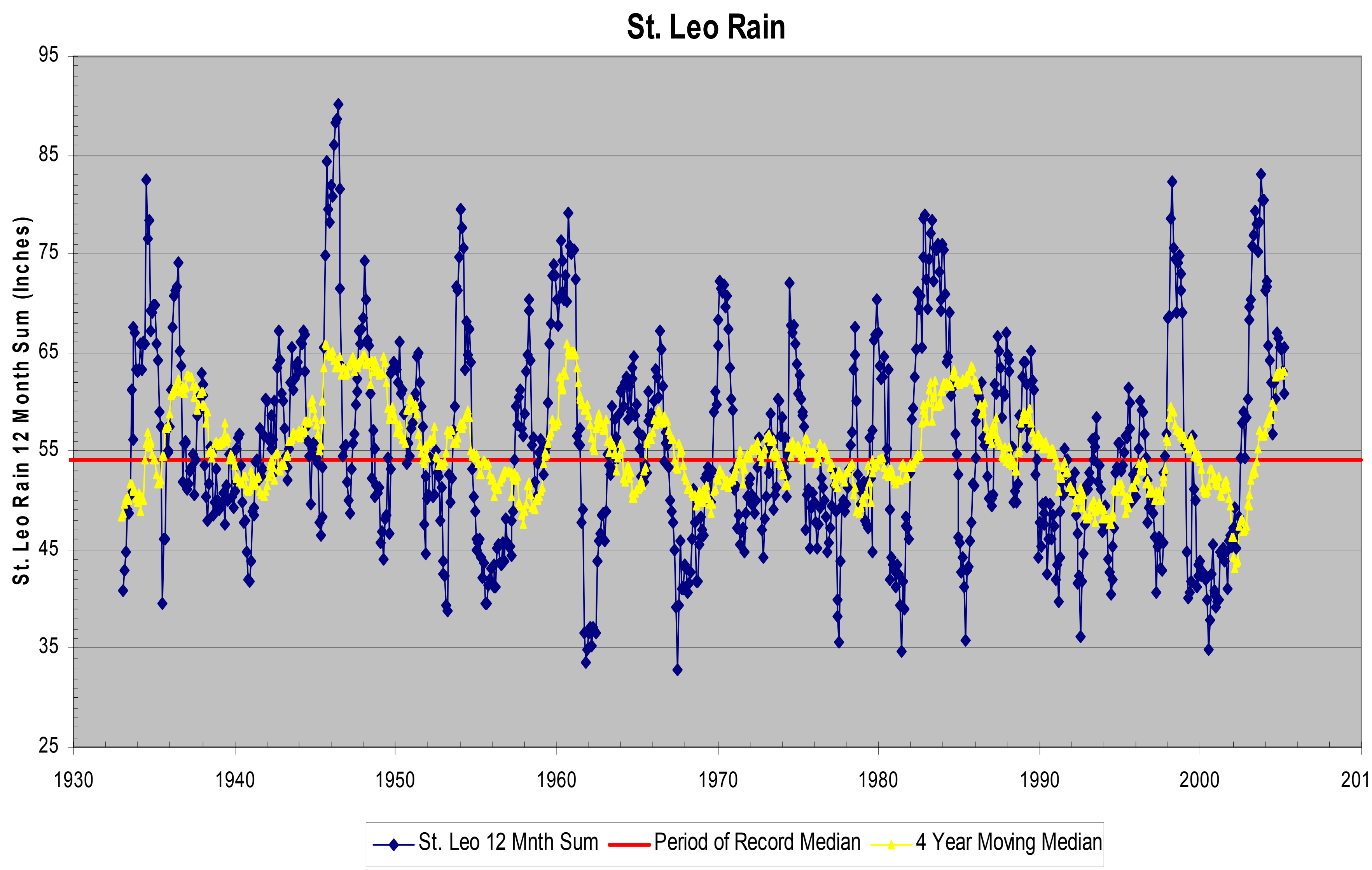
Long-Term is at Least 60 + Years

(Actually there are cycles in cycles, that will keep producing new values but we are setting a limit at 60 to 100 years)

Fact:

1. Percentiles calculated with shorter windows of time will cycle above and below the longer term percentile.

2. The shorter the window of time the larger the variation around the long-term.

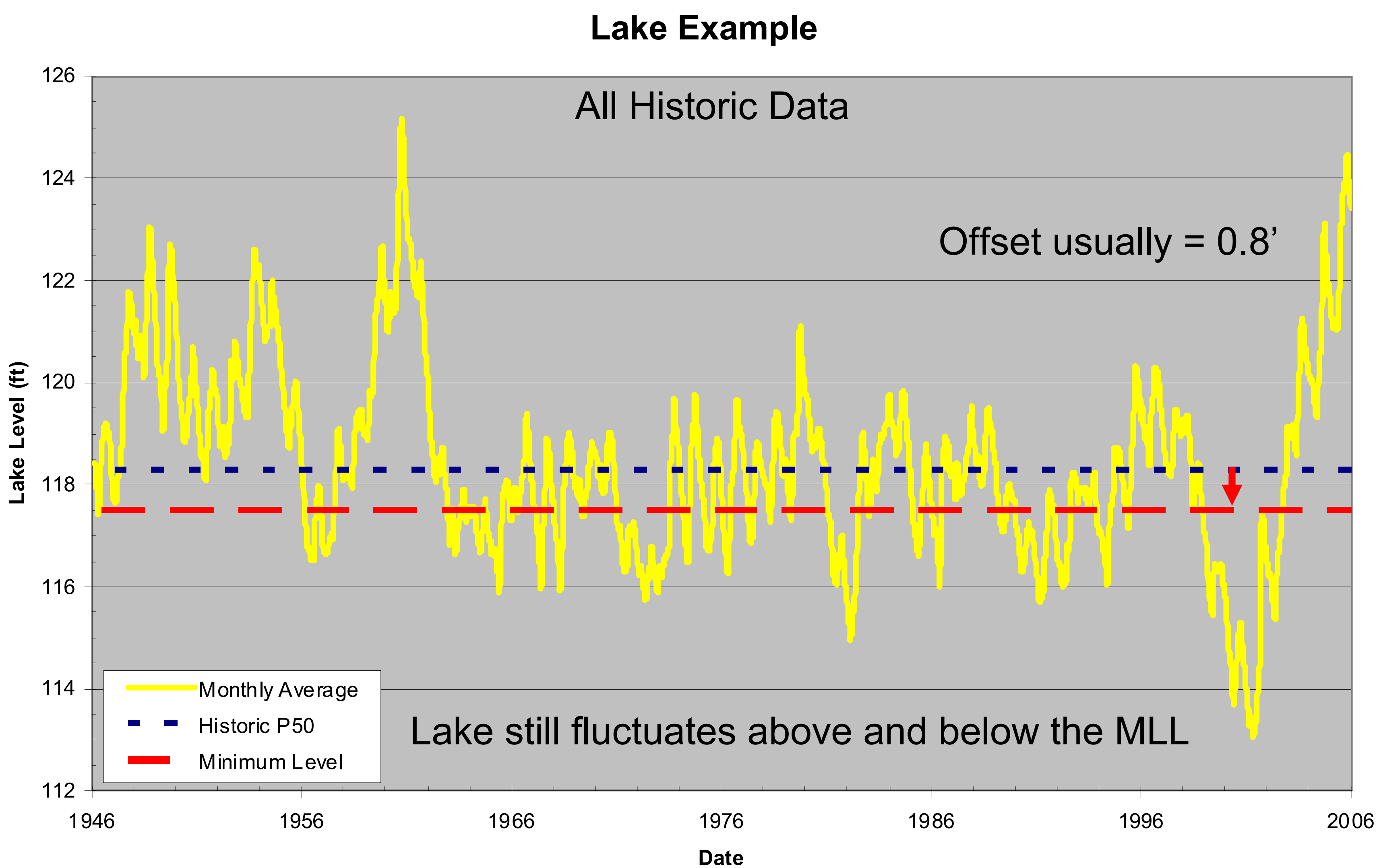


D.L.E. August 21, 2006

Calculating
Lake Stage Fluctuation Statistics Used
to Set Lake Minimum Levels

In a perfect world you have long-term historic data and it’s very easy!

Calculate the Historic P50 using the data and apply the appropriate offset.


Lake Example
All Historic Data
Offset usually = 0.8’
Lake still fluctuates above and below the MLL
Lake Level (ft)
126
124
122
120
118
116
114
112
1946
1956
1966
1976
1986
1996
2006
Date
Monthly Average
Historic P50
Minimum Level

We never have a perfect world situation.

- **Need method to calculate Long-Term Historic P50.**

- **Need a method to estimate what the natural stage of the lake should be at any moment based on preceding climatic conditions**

Typical lake has less than 20 years and very frequently has no historic data.

How are we handling this?

1. Old Way - Reference Lake Water Regime concept

2. New Way – Climate Based Models

Goal: Estimate Lake Stage Given Climatic Conditions

Brief Introduction to Line of Organic Correlation (regression)

- Fully discussed in Helsel and Hirsch (1992)

  Studies in Environmental Science 49

  Statistical Methods in Water Resources

  USGS,Water Resources Division

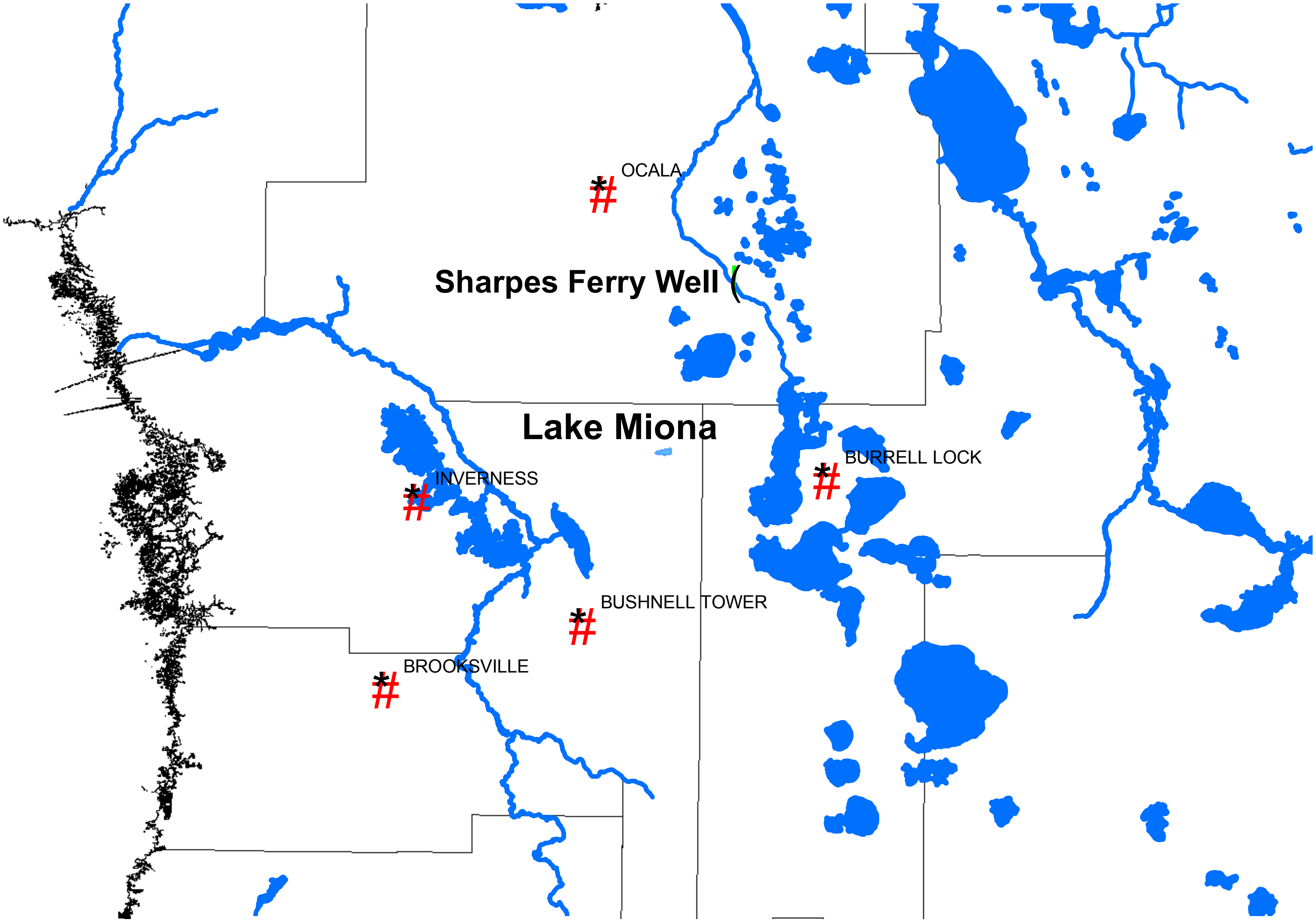
- Minimizes Error in Both x and y direction

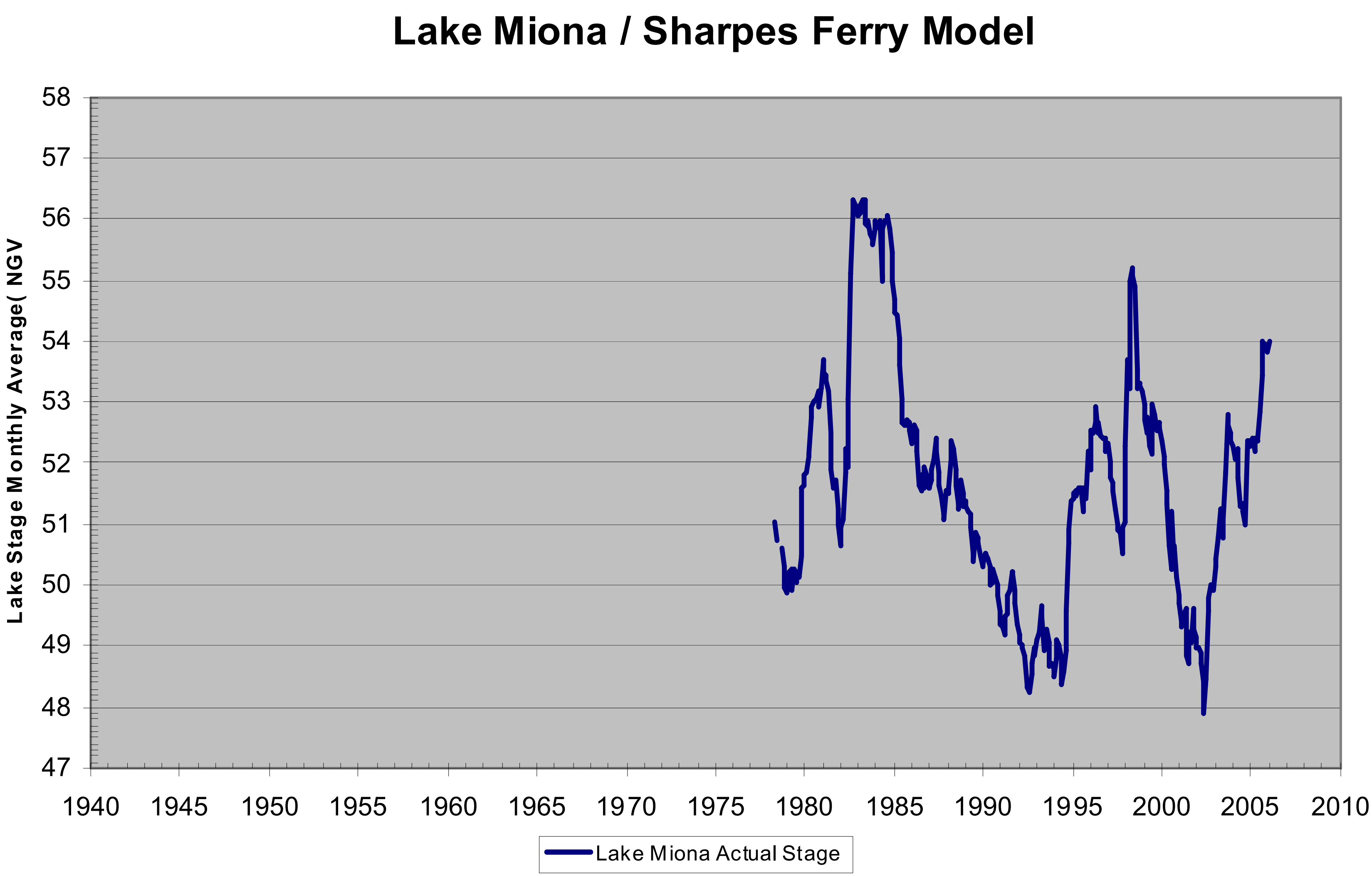
- Slightly different form of regression

- Good to fill in missing data using overlapping records two stations

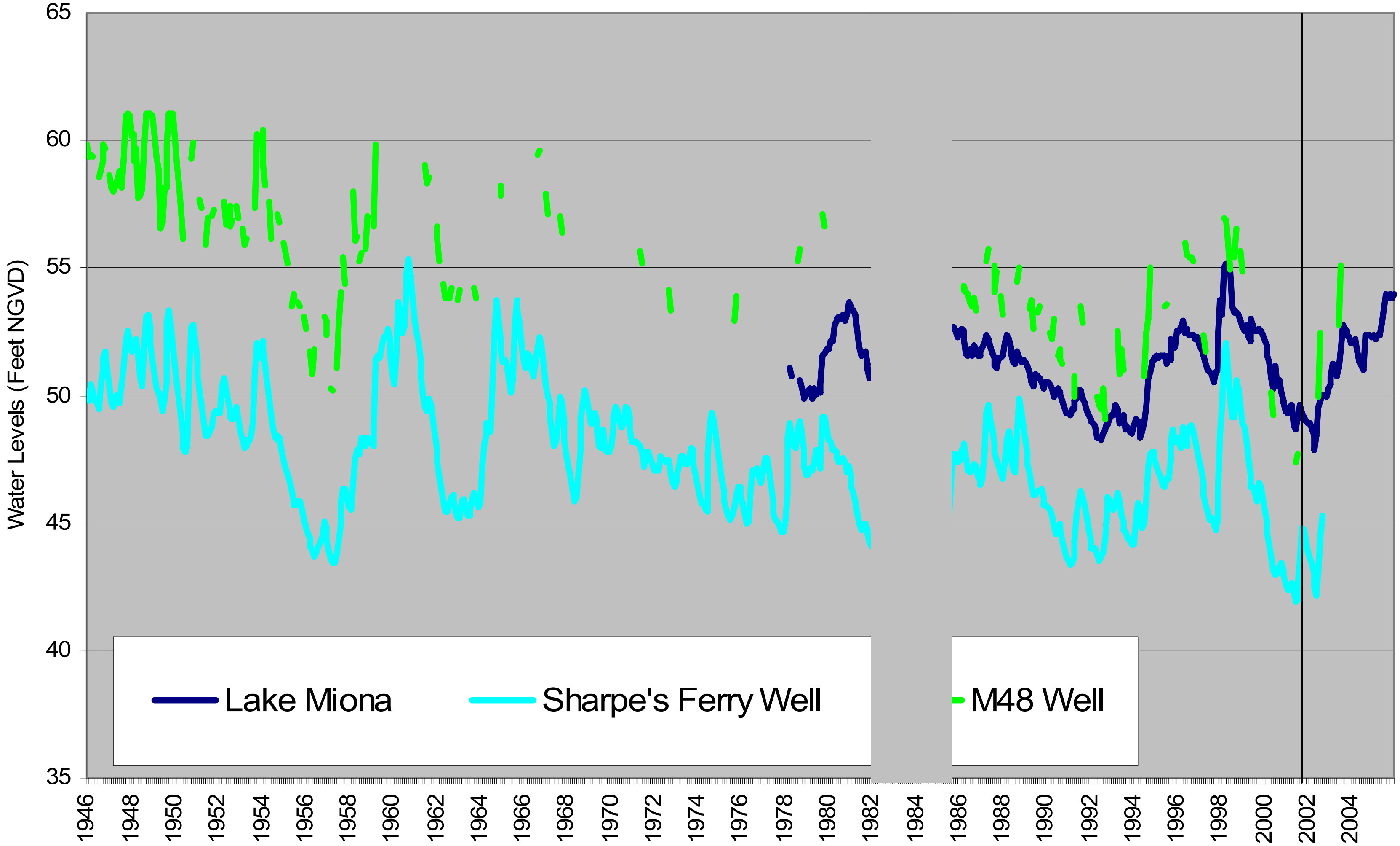
First Application of LOC - Lake Miona Model Based on Sharpes Ferry Well

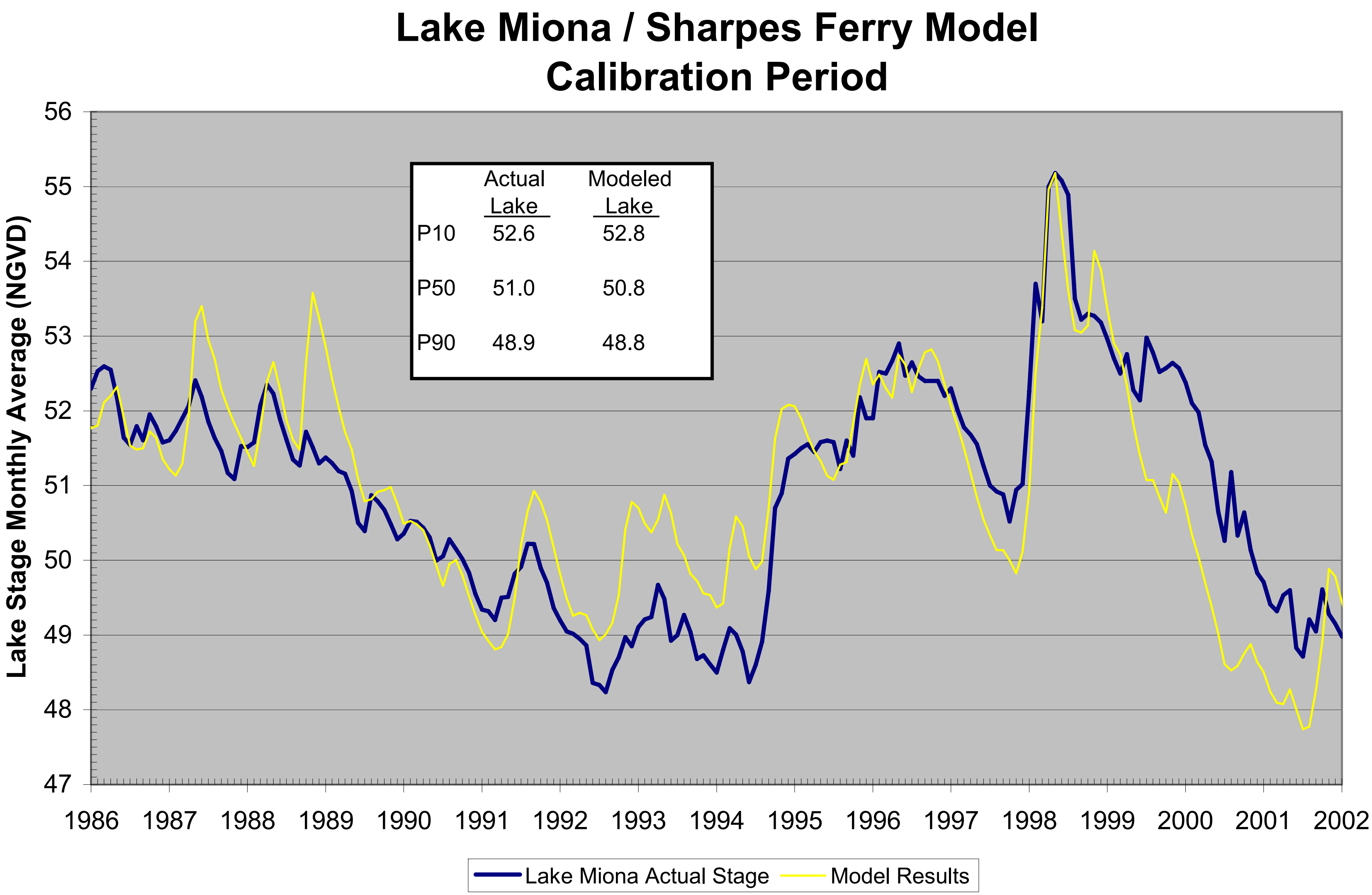
(Hancock 2007)

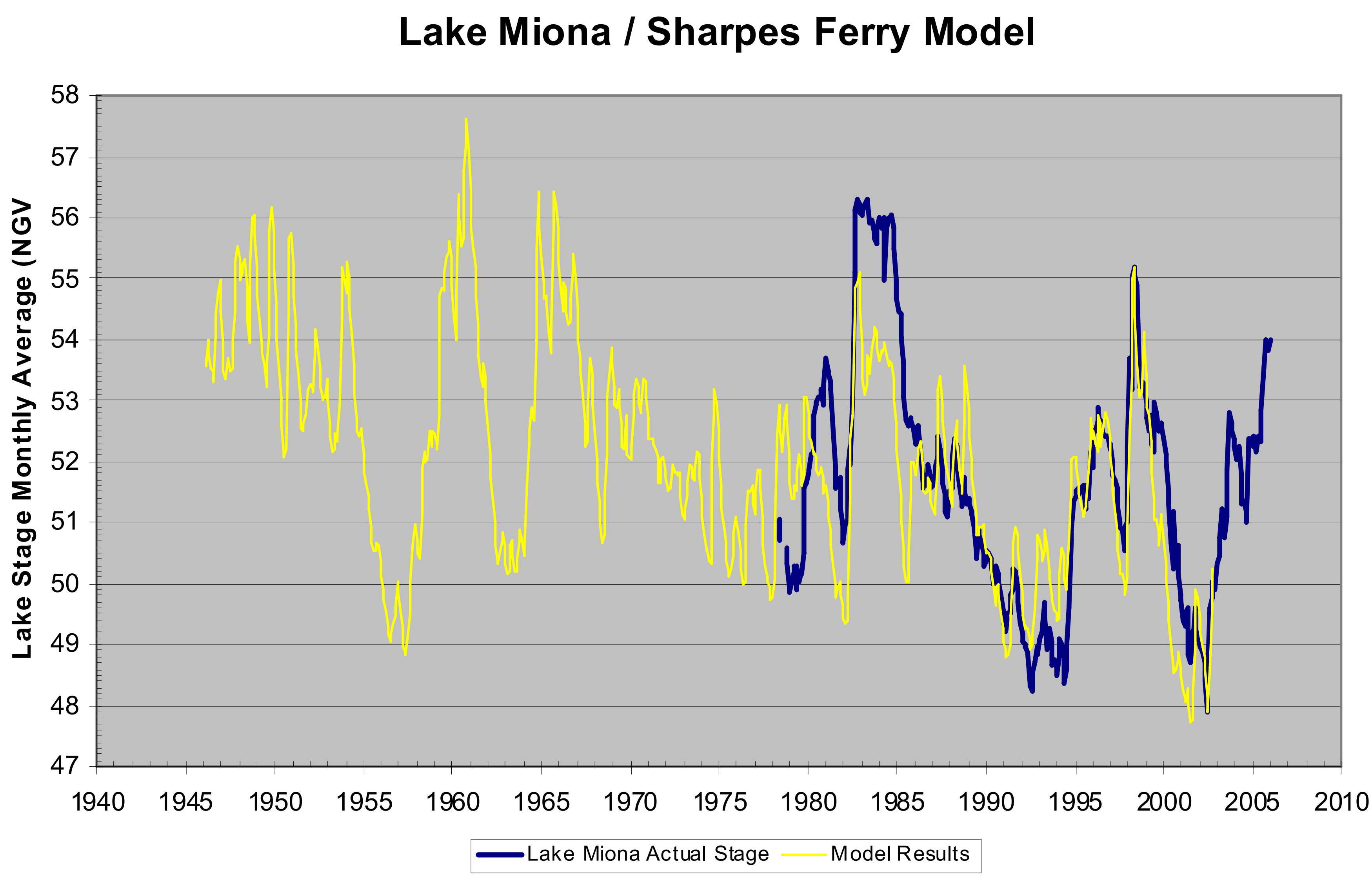

OCALA
Sharpes Ferry Well
Lake Miona
BURRELL LOCK
INVERNESS
BUSHNELL TOWER
BROOKSVILLE


Lake Miona / Sharpes Ferry Model
Lake Stage Monthly Average(NGV
58
57
56
55
54
53
52
51
50
49
48
47
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Lake Miona Actual Stage

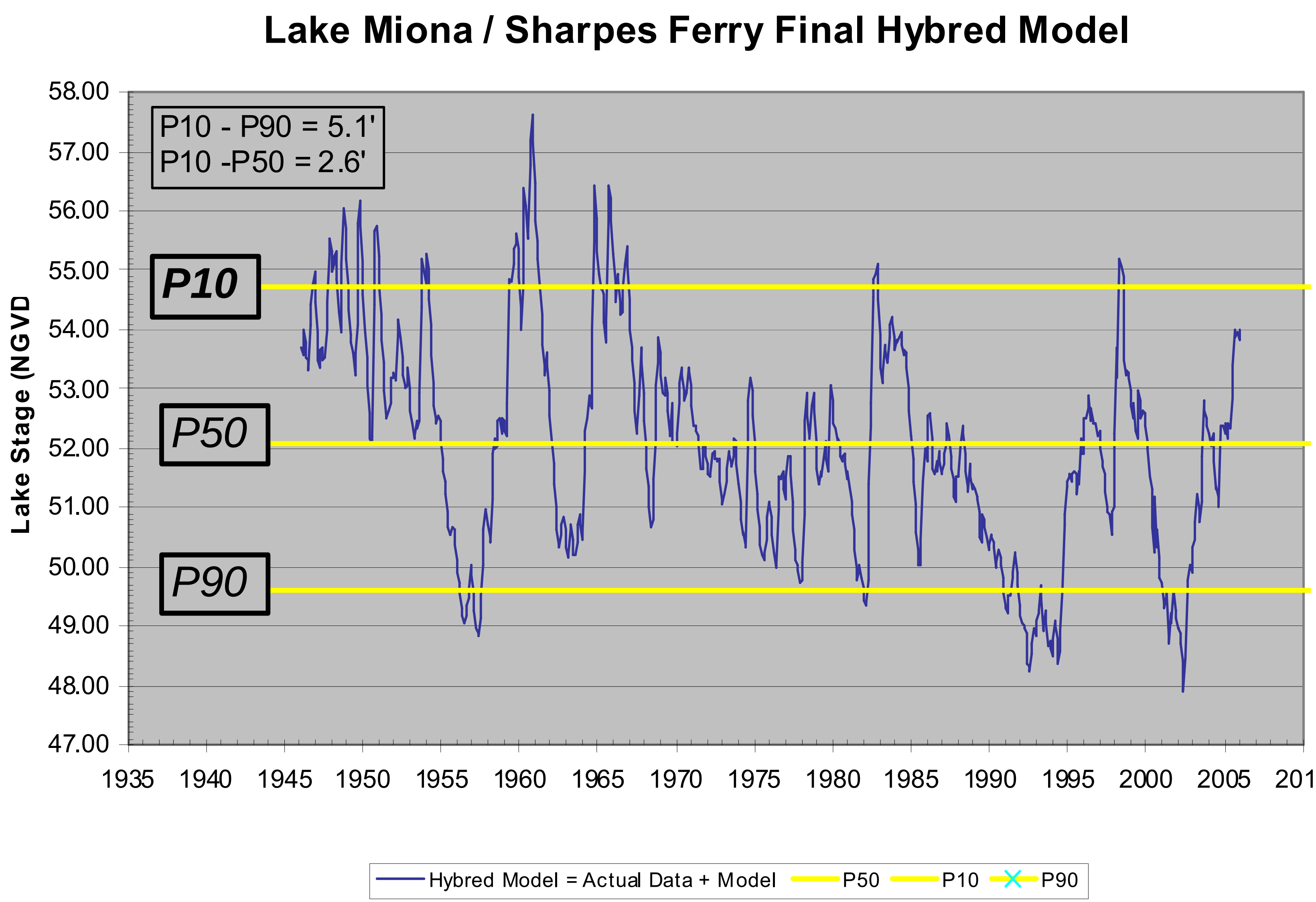
Lake Miona / Sharpes Ferry Water Level Based Model




Lake Miona / Sharpes Ferry Model
Calibration Period
Lake Stage Monthly Average (NGVD)
56
55
54
53
52
51
50
49
48
47
Actual Lake
Modeled Lake
P10 52.6 52.8
P50 51.0 50.8
P90 48.9 48.8
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Lake Miona Actual Stage
Model Results

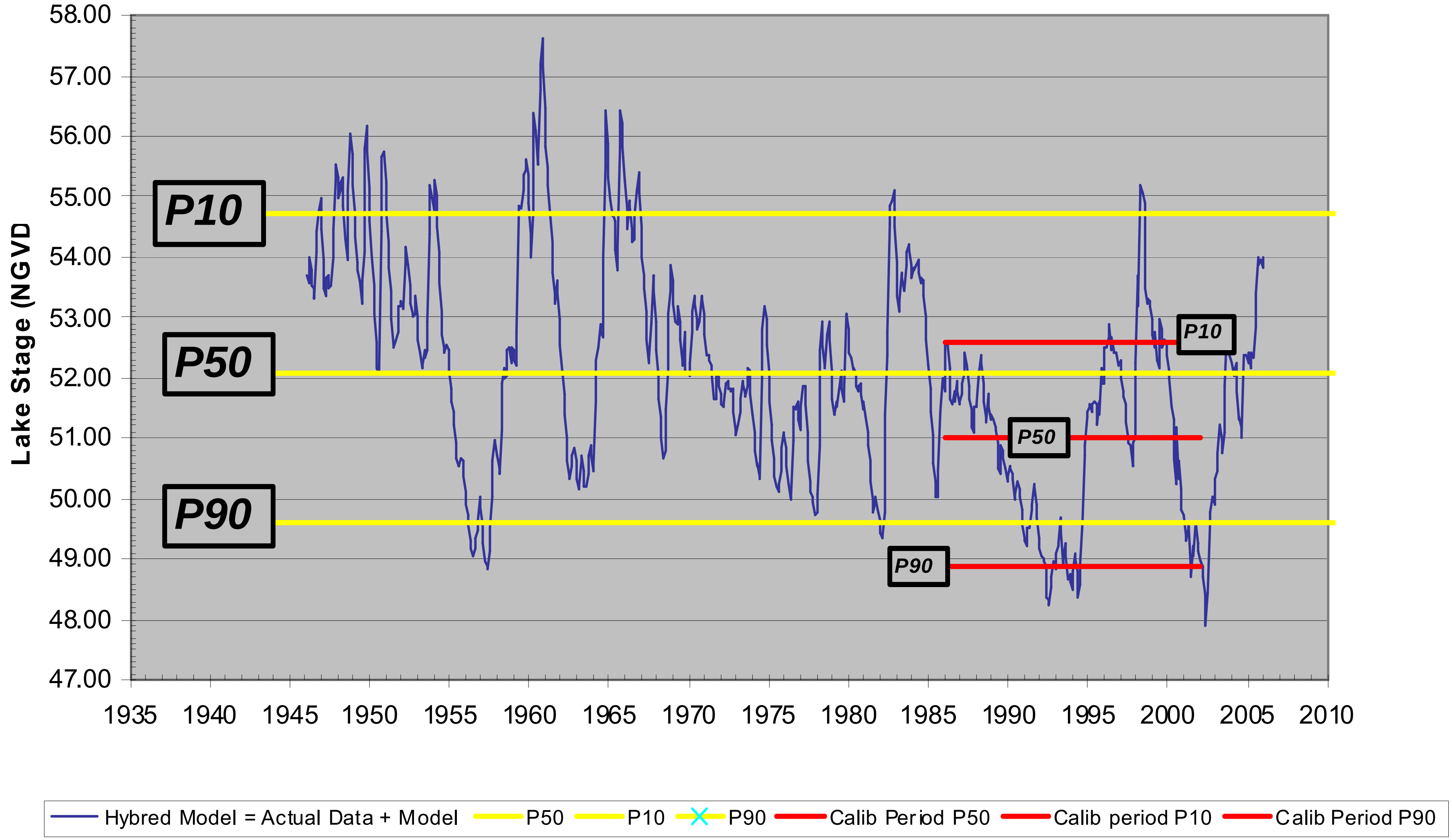


Lake Miona / Sharpes Ferry Model
Lake Stage Monthly Average (NGV
58
57
56
55
54
53
52
51
50
49
48
47
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Lake Miona Actual Stage
Model Results



Lake Miona / Sharpes Ferry Final Hybred Model
P10 - P90 = 5.1'
P10 -P50 = 2.6'
P10
P50
P90
Lake Stage (NGVD
58.00
57.00
56.00
55.00
54.00
53.00
52.00
51.00
50.00
49.00
48.00
47.00
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Hybred Model = Actual Data + Model
P50
P10
P90

Lake Miona / Sharpes Ferry Final Hybred Model



Lake Miona Model
Using the Ocala Rain Gauge
Instead of Sharpes Ferry
(Example of a Rainfall Model)

- Goal is a Climate Based Model to Predict Un-impacted Monthly Average Lake Level

- Eliminates Anthropogenic Changes in the Model

- Numerous Rain Gauges throughout the District to Use, Minimizing Location and Distance Issues

- Rain Gauges Still Exist, Haven’t Been Abandoned

Lake Stage Models Based on Rainfall

- Rainfall is summed to relate to lake fluctuation
- Monthly sums are the starting data
- Method of summing is critical
  - Lake Stage is dependent on prior months of rainfall
  - Previous rainfall's influence diminishes as time passes
  - Linear Inverse Weighted Sum or a Decay series addresses the fading memory issue

Rainfall Decay Series

- Lake stage is a result of current rain and past rain
- Lakes have a fading memory of past rainfall
- This months rain is more influential than rain that occurred 3 months ago, and the rain three months ago is more influential than 6 months ago. and so on…….

Rainfall Decay Series

- To capture this concept each month of rainfall is weighted
- With the highest weight assigned to the current month and decreasing weights are assigned to each month back in time
- A simple linear decreasing weighting system is used

Example - Calculation of 12 Month Rainfall Decay Series Sum

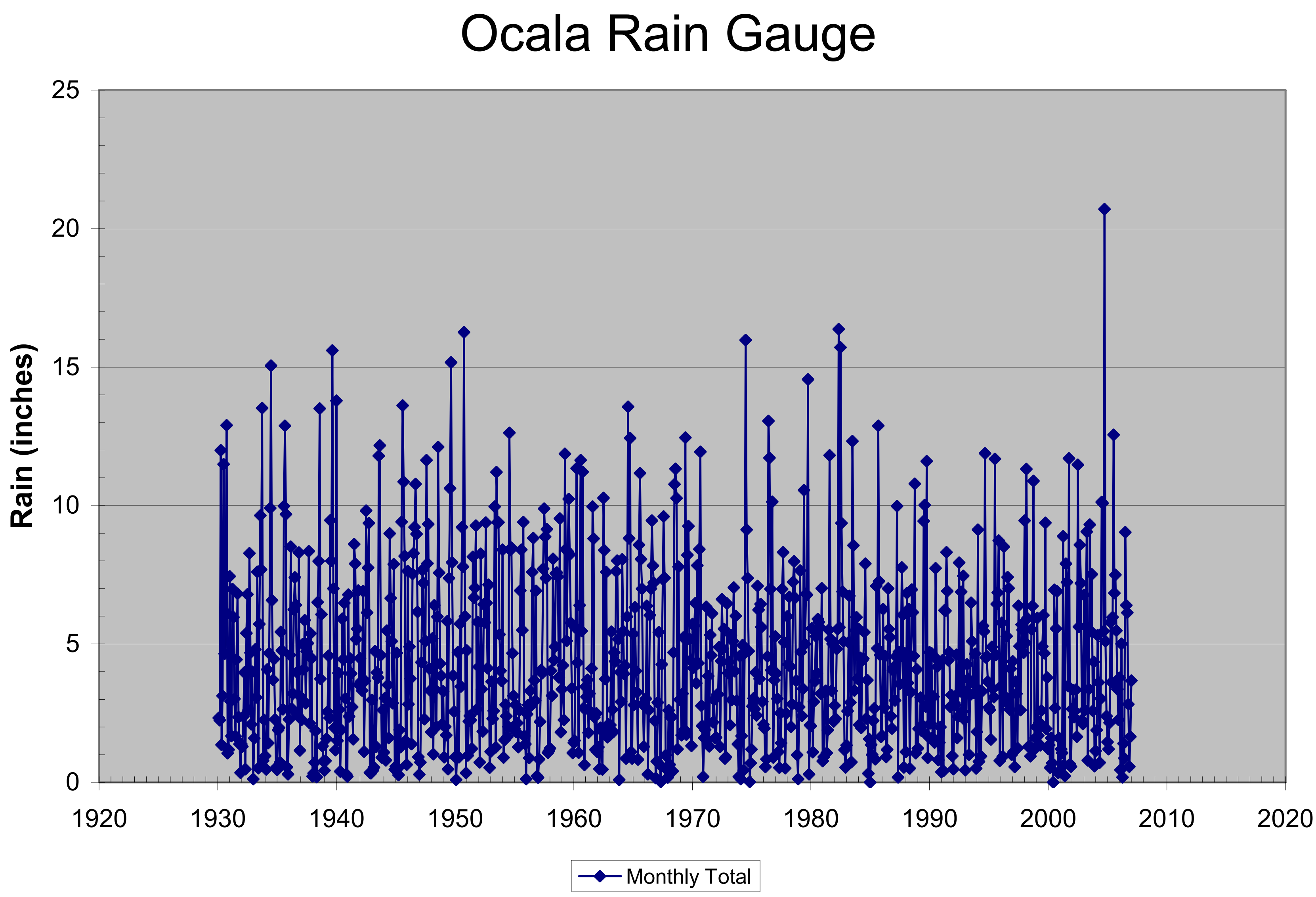
Rain Monthly Total (inches)	Sum of Rain Decay Series (inches)	
R_1	D_1	$= R_1 (12/12) + R_2 (11/12) \ldots + R_{12} (1/12)$
R_2	D_2	$= R_2 (12/12) + R_3 (11/12) \ldots + R_{13} (1/12)$
R_3	D_3	$= R_3 (12/12) + R_4 (11/12) \ldots + R_{14} (1/12)$
.	.	
.	.	
.	.	
R_x	D_x	$= R_x (12/12) + R_{(x+1)} (11/12) \ldots + R_{(x+11)} (1/12)$
$R_{(x+1)}$		
$R_{(x+2)}$		
.		
.		
.		
$R_{(x+11)}$		

Decay Series Expression

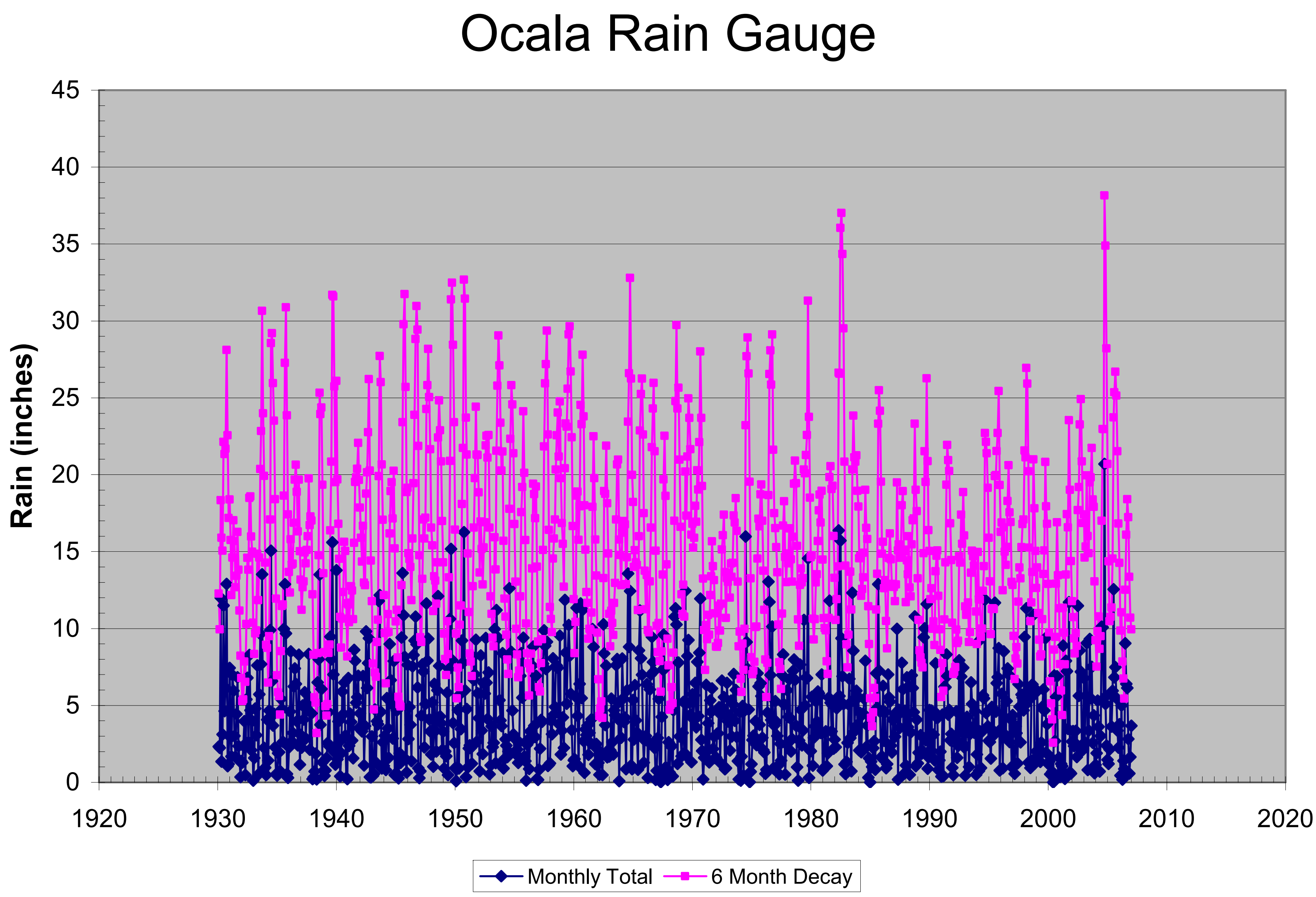
The general form of the decay series expression is:

$$Dx = Rx\ (L/L) + R(x+1)\ ((L-1)/L) + \ldots + R(x+L)\ ((L-L)/L)$$

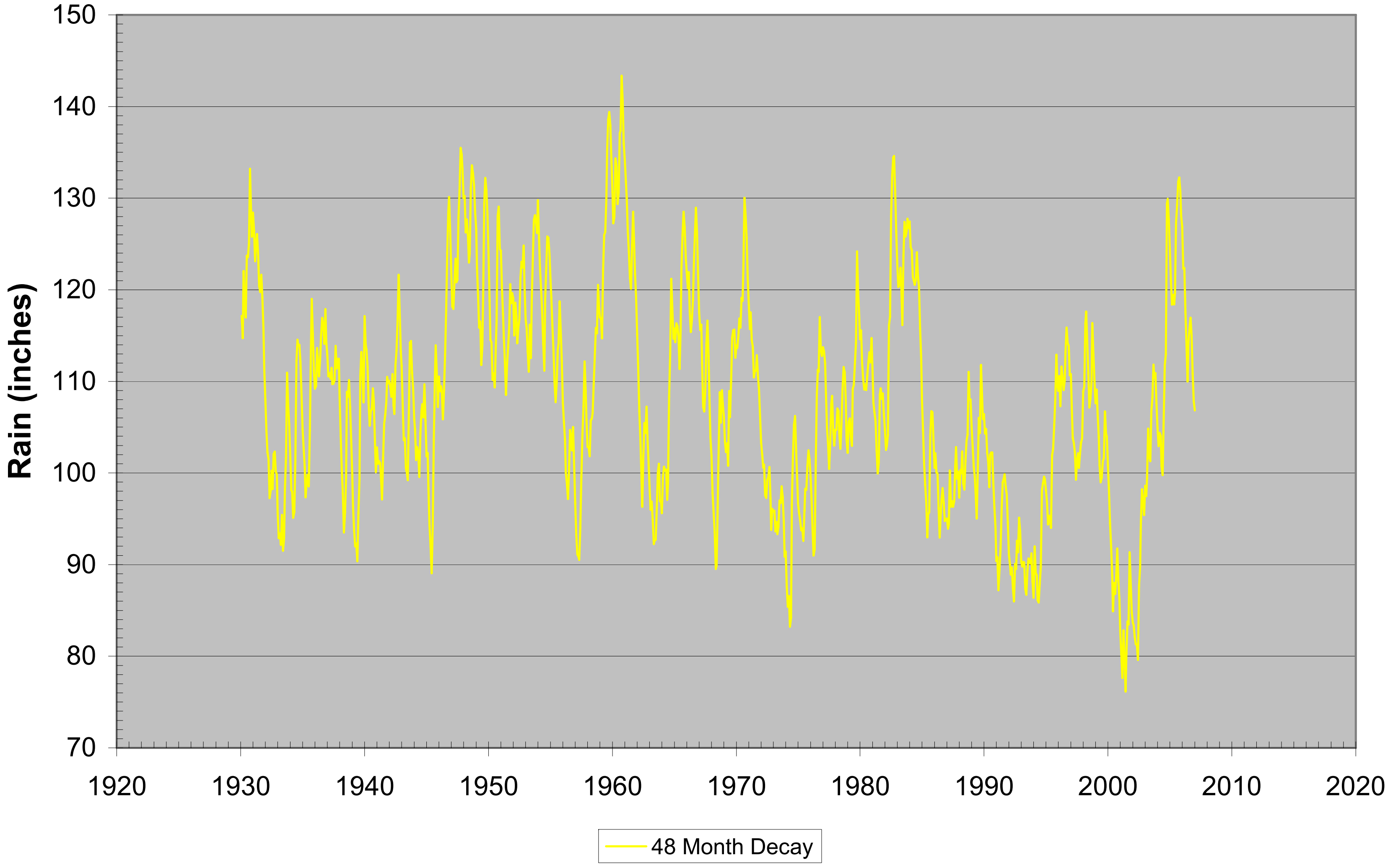
Where: L = number of months in the decay period
Dx is the sum of the rain decay series



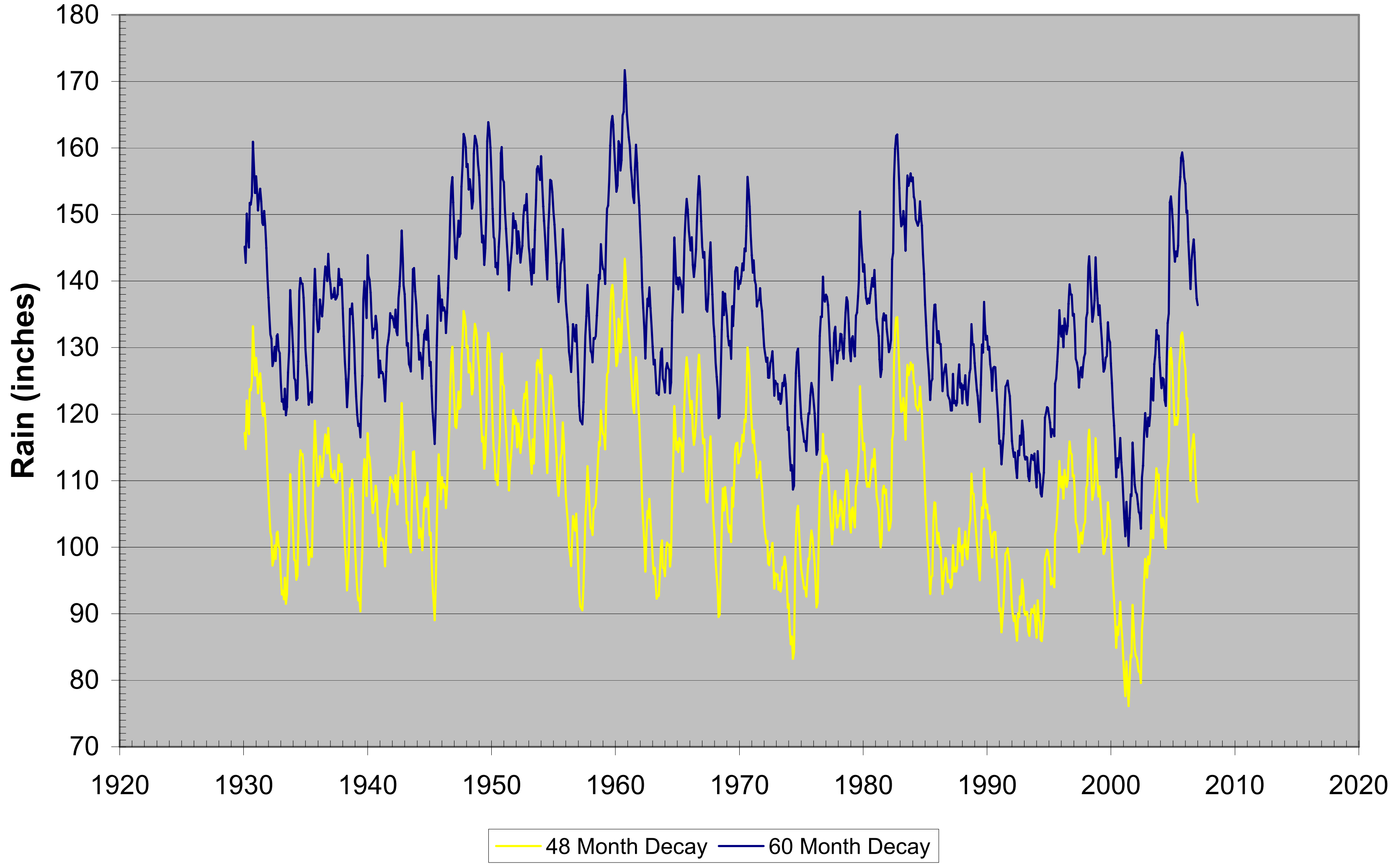
Ocala Rain Gauge
Rain (inches)
25
20
15
10
5
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Monthly Total

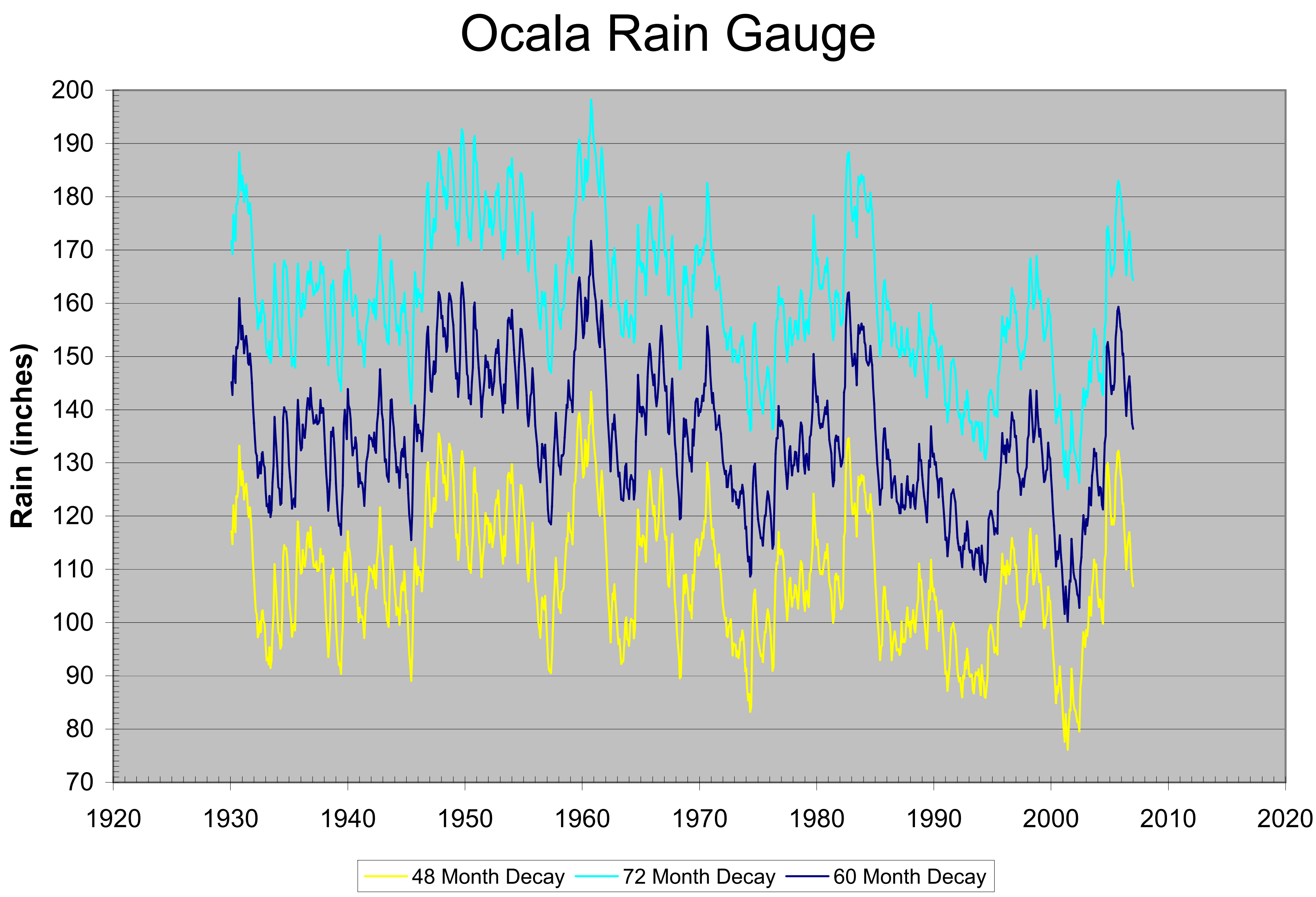

Ocala Rain Gauge
Rain (inches)
0
5
10
15
20
25
30
35
40
45
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Monthly Total
6 Month Decay

Ocala Rain Gauge

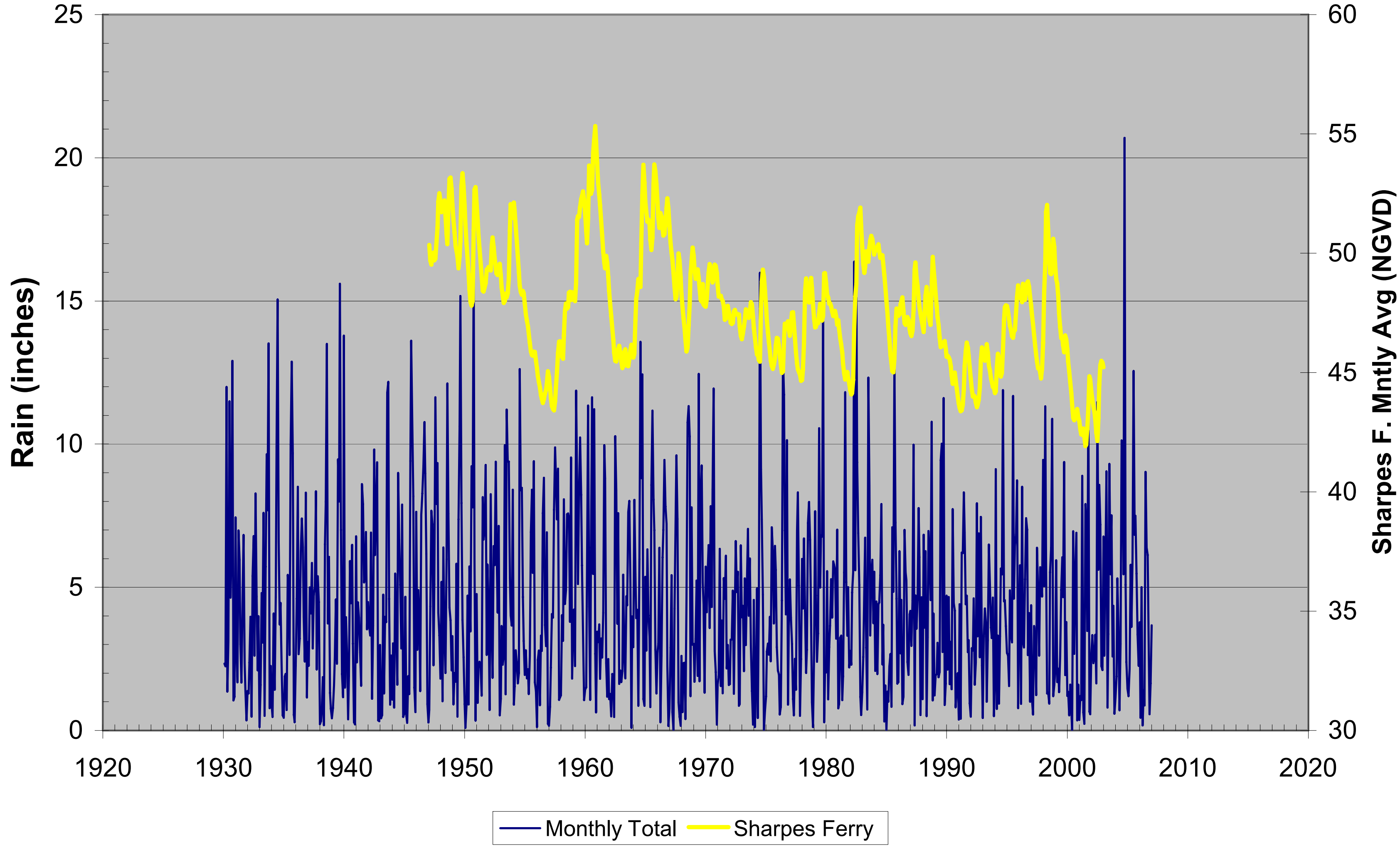


Ocala Rain Gauge

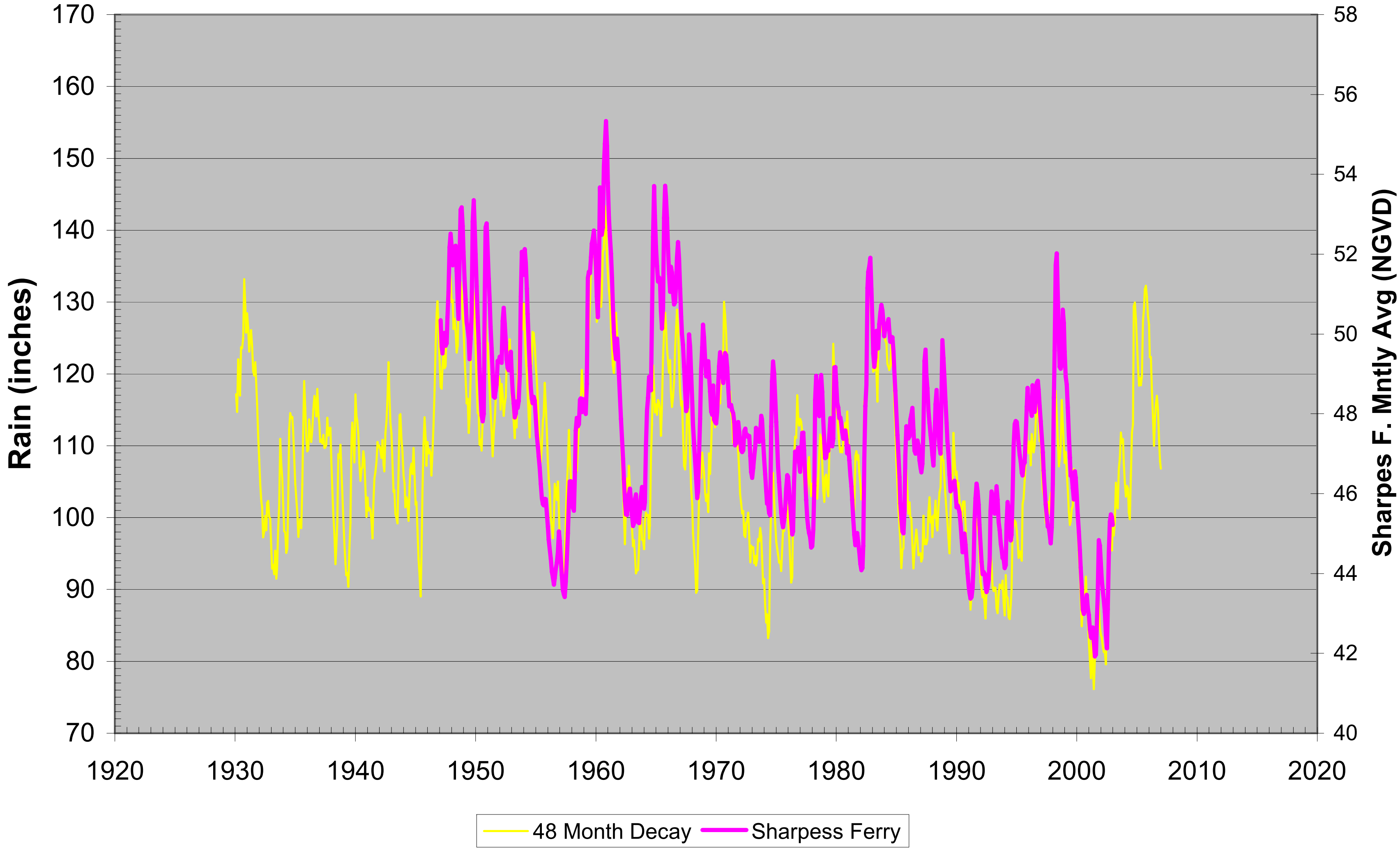



Ocala Rain Gauge
Rain (inches)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
48 Month Decay
72 Month Decay
60 Month Decay

Ocala Rain Gauge with Sharpes Ferry Well



Ocala Rain Gauge



Lake Models Based on Rainfall

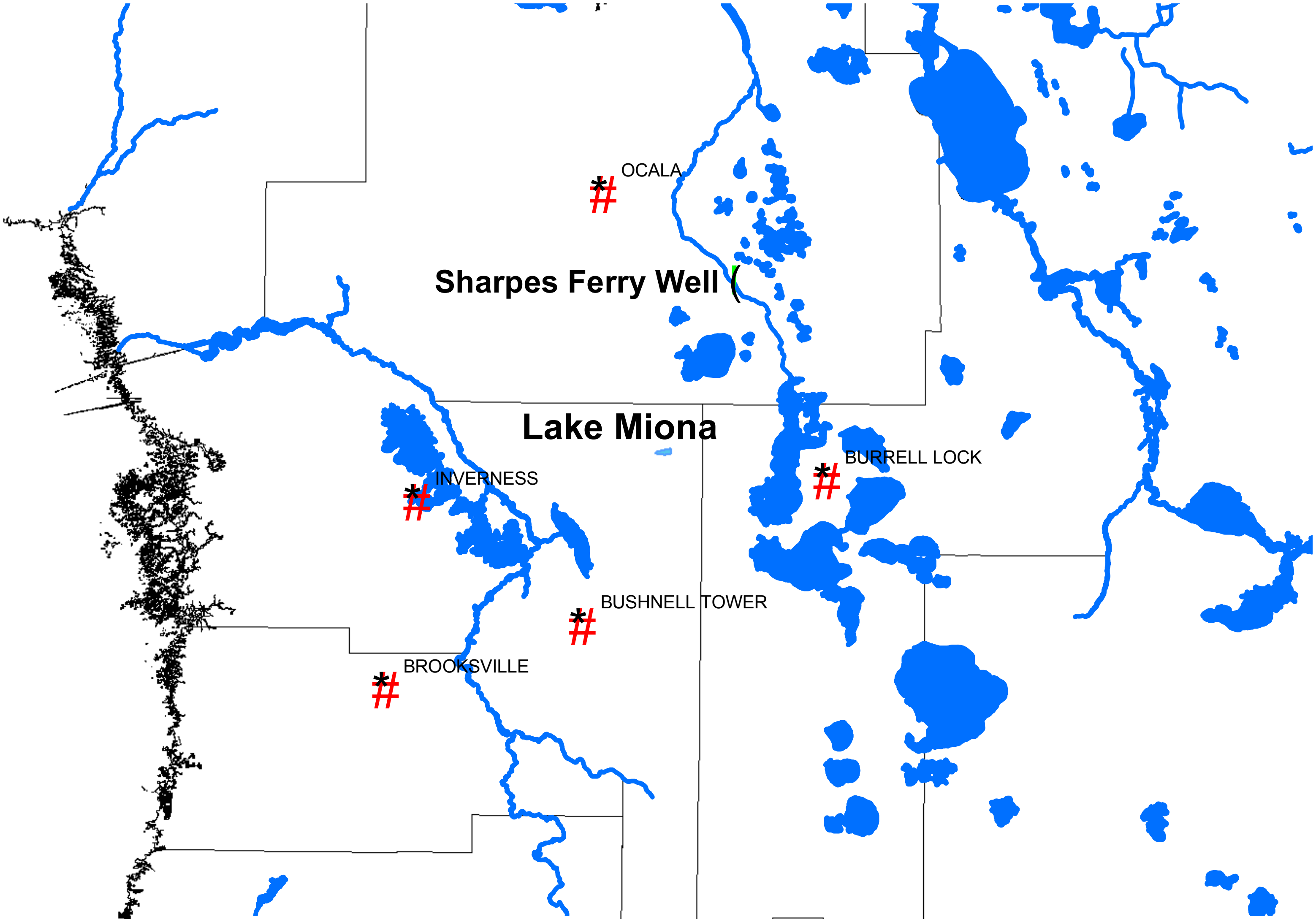
- The new decay series monthly totals are substituted for Sharpes Ferry water levels and the LOC model is ran in the same manner, with the following additional steps

Additional Steps

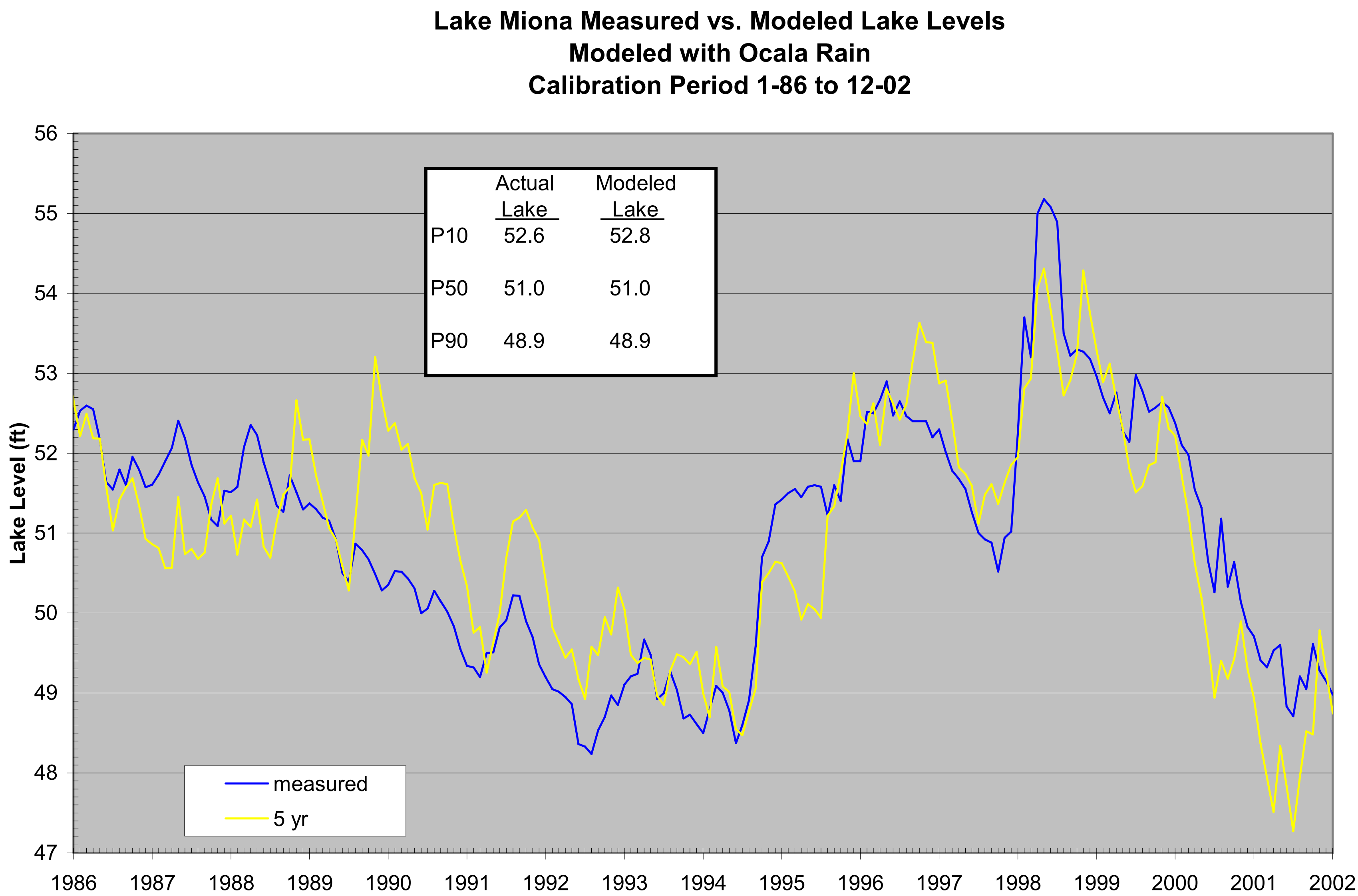
- Test Different Time Lengths for the Decay Series (12 month, 24 month, 36 month D…..)
- Compare each model and make selection using:
  – Lowest Absolute Sum of Percentile Differences
  – Highest r^2

Additional Steps

- Repeat for other nearby rain gauges approximately equal distance away from the lake
- Use same decision process on selection of best rain gauge and decay series time length
  - Lowest Absolute Sum of Percentile Differences
  - Highest r^2

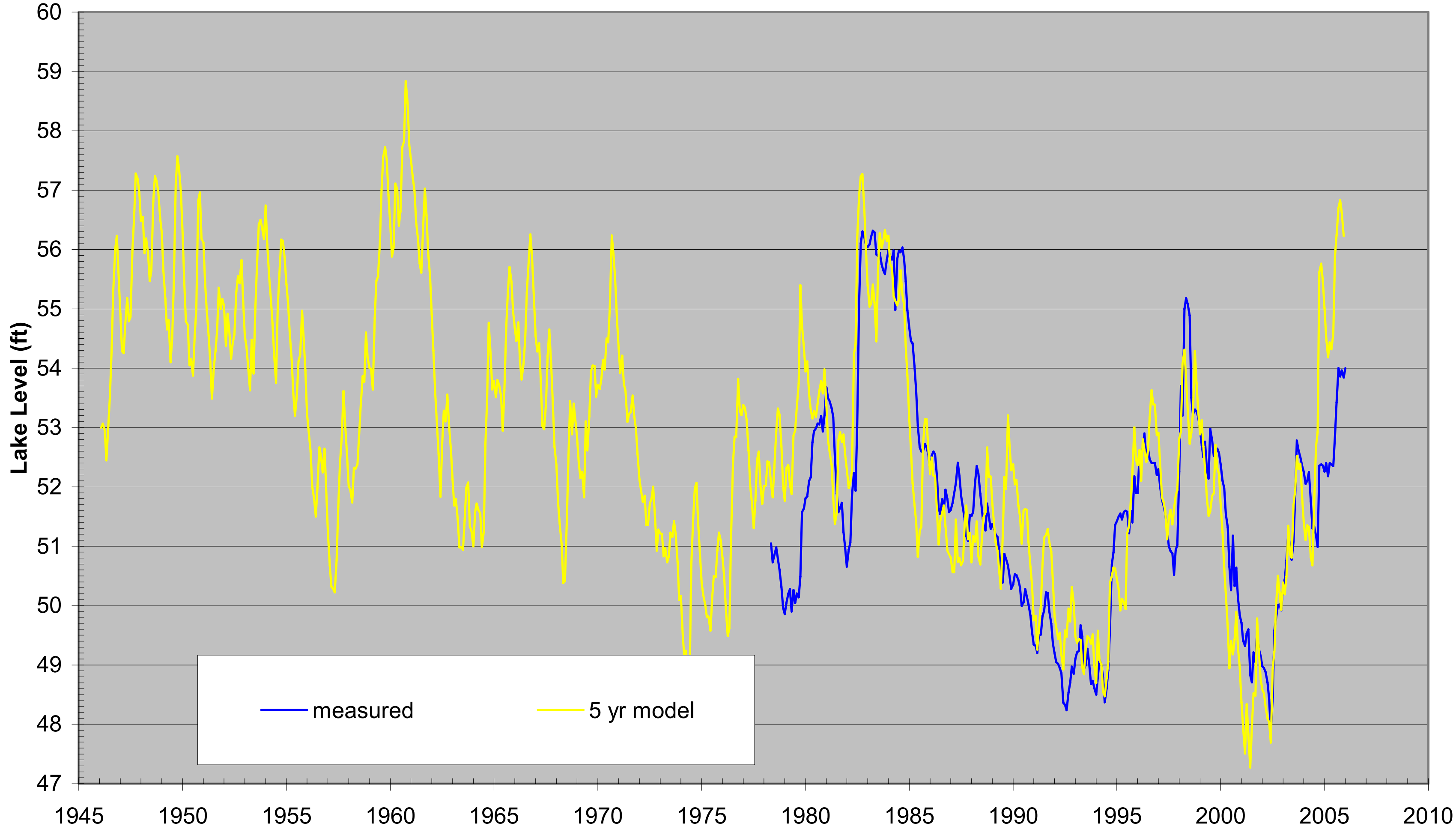

OCALA
Sharpes Ferry Well
Lake Miona
BURRELL LOCK
INVERNESS
BUSHNELL TOWER
BROOKSVILLE

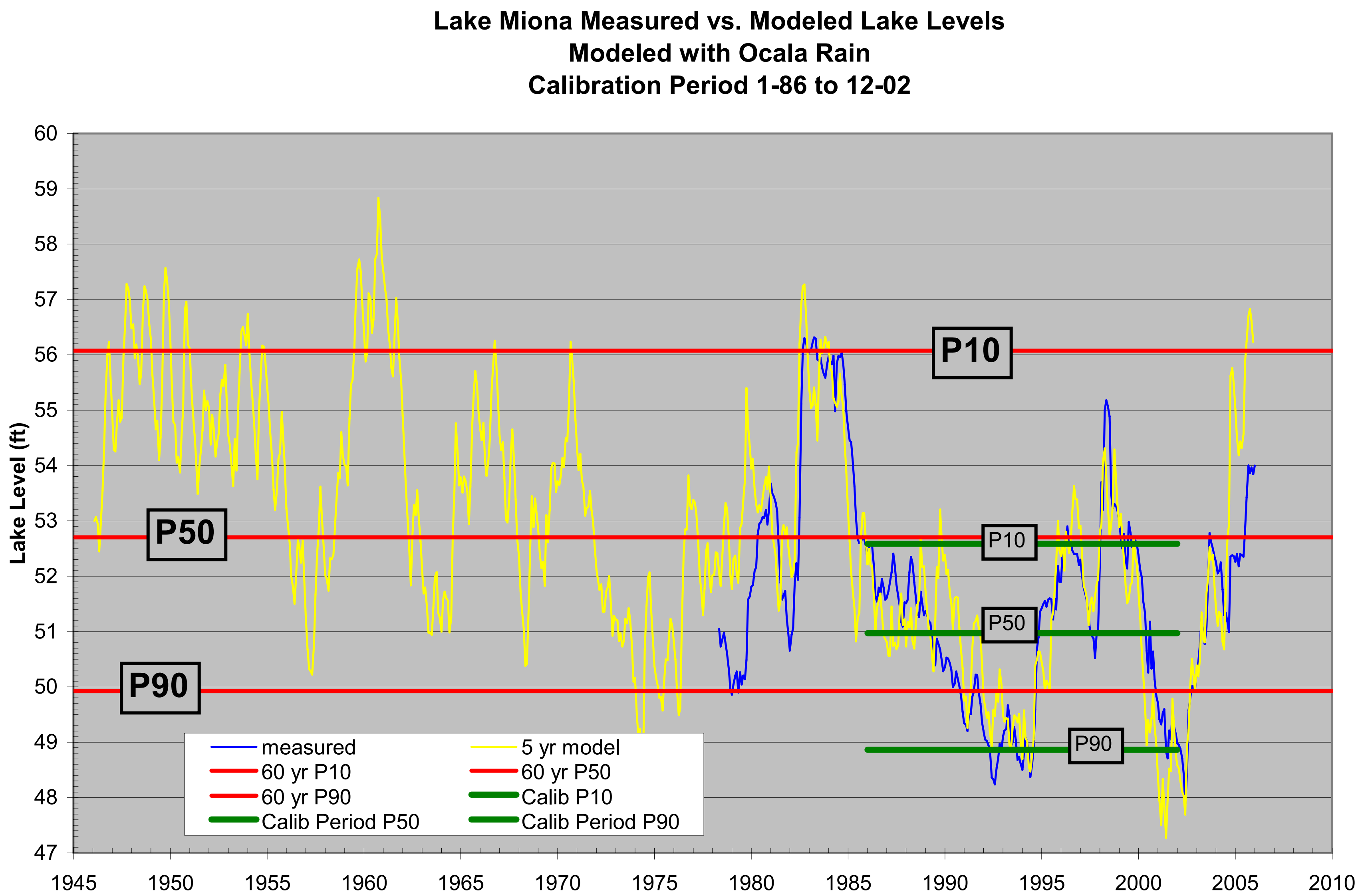
Decay Period	R^2	ppt Lake Model minus Measured/Lake Level Model Calib Per P50	ppt Lake Model minus Measured/Lake Level Model Calib Per P10	ppt Lake Model minus Measured/Lake Level Model Calib Per P90	ABS P50	ABS P10	ABS P90	Sum ABS
6 months	0.06	-0.22	0.45	0.12	0.22	0.45	0.12	0.80
1 year	0.21	-0.22	0.22	0.07	0.22	0.22	0.07	0.51
2 years	0.39	-0.12	0.24	0.11	0.12	0.24	0.11	0.48
3 years	0.52	-0.01	0.41	-0.01	0.01	0.41	0.01	0.43
4 years	0.61	-0.03	0.33	0.02	0.03	0.33	0.02	0.37
5 years	0.68	0.01	0.22	0.01	0.01	0.22	0.01	**0.24**
6 years	0.73	0.16	0.11	-0.09	0.16	0.11	0.09	0.36
7 years	0.74	0.13	0.08	-0.12	0.13	0.08	0.12	0.34
8 years	0.69	-0.05	0.18	-0.02	0.05	0.18	0.02	0.25
9 years	0.61	-0.10	0.12	-0.04	0.10	0.12	0.04	0.25
10 years	0.52	-0.09	0.21	0.03	0.09	0.21	0.03	0.33
Minimum	0.06							0.235
Maximum	0.74							0.799

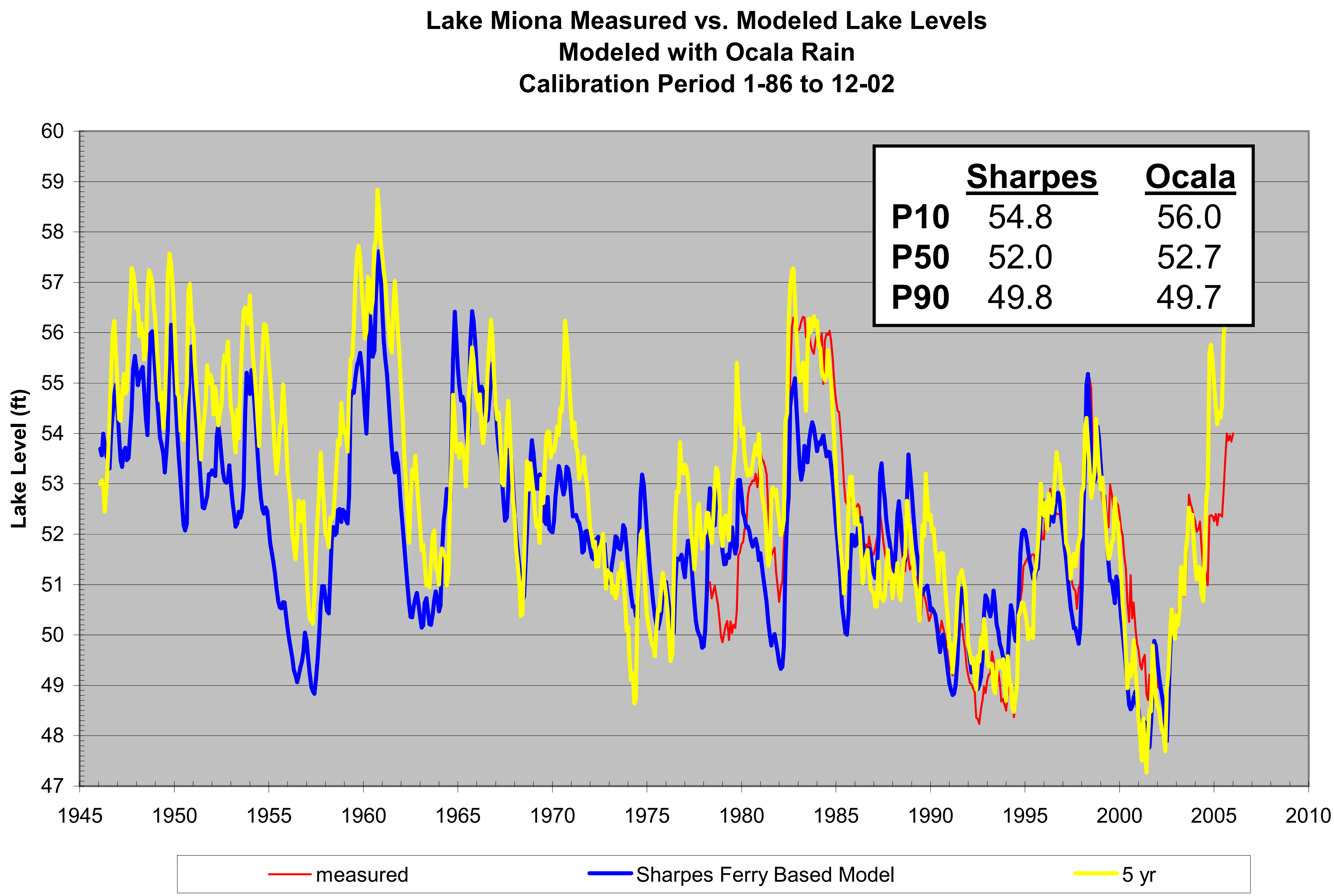


Lake Miona Measured vs. Modeled Lake Levels
Modeled with Ocala Rain
Calibration Period 1-86 to 12-02
Lake Level (ft)
56
55
54
53
52
51
50
49
48
47
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Actual Lake
Modeled Lake
P10 52.6 52.8
P50 51.0 51.0
P90 48.9 48.9
measured
5 yr

Lake Miona Measured vs. Modeled Lake Levels
Modeled with Ocala Rain
Calibration Period 1-86 to 12-02




Lake Miona Measured vs. Modeled Lake Levels
Modeled with Ocala Rain
Calibration Period 1-86 to 12-02
Lake Level (ft)
60
59
58
57
56
55
54
53
52
51
50
49
48
47
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
P10
P50
P90
P10
P50
P90
measured
5 yr model
60 yr P10
60 yr P50
60 yr P90
Calib P10
Calib Period P50
Calib Period P90

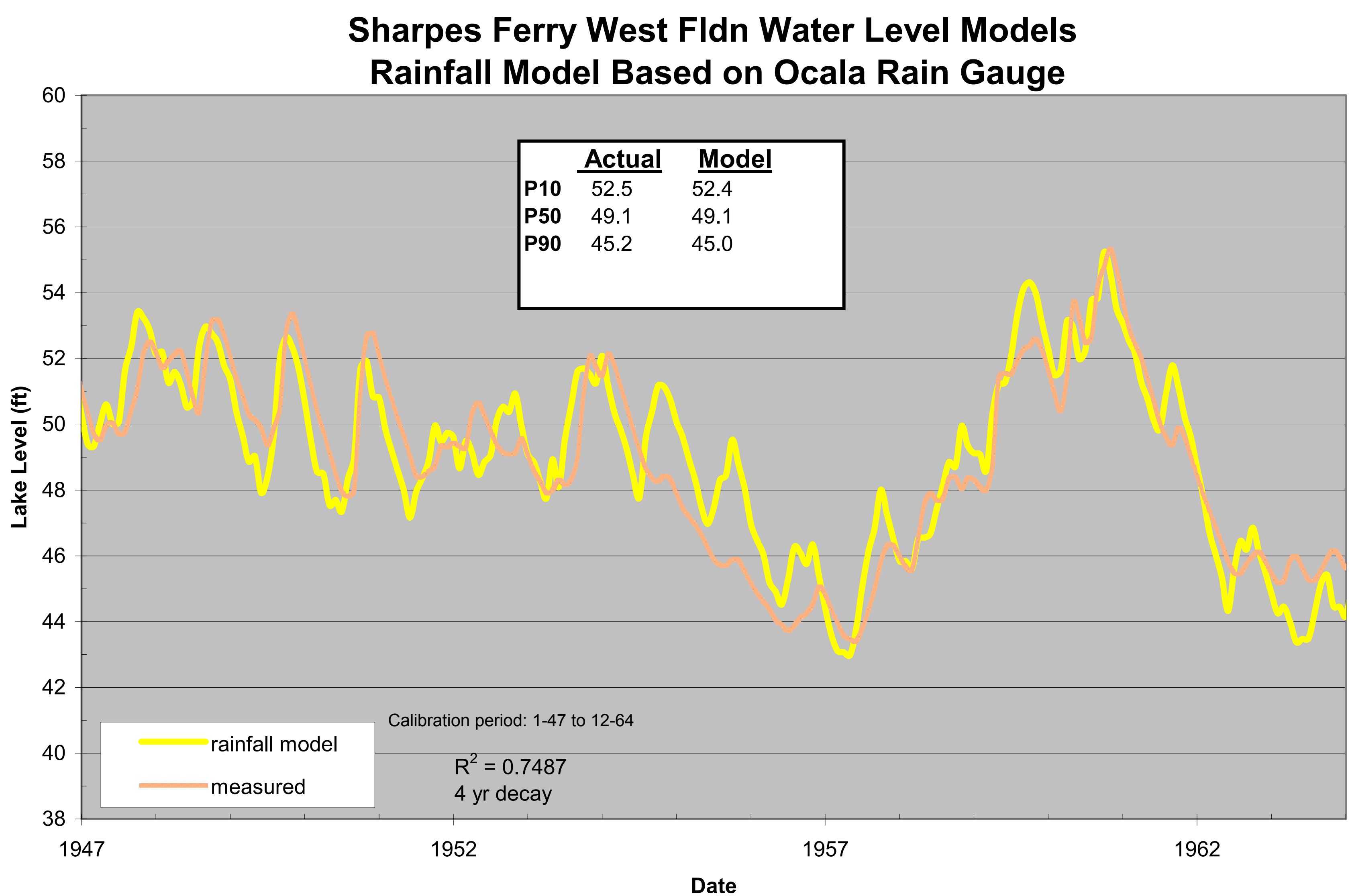

Lake Miona Measured vs. Modeled Lake Levels
Modeled with Ocala Rain
Calibration Period 1-86 to 12-02
Sharpes
Ocala
P10
54.8
56.0
P50
52.0
52.7
P90
49.8
49.7
Lake Level (ft)
60
59
58
57
56
55
54
53
52
51
50
49
48
47
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
measured
Sharpes Ferry Based Model
5 yr

Rainfall Model 60 yr Test

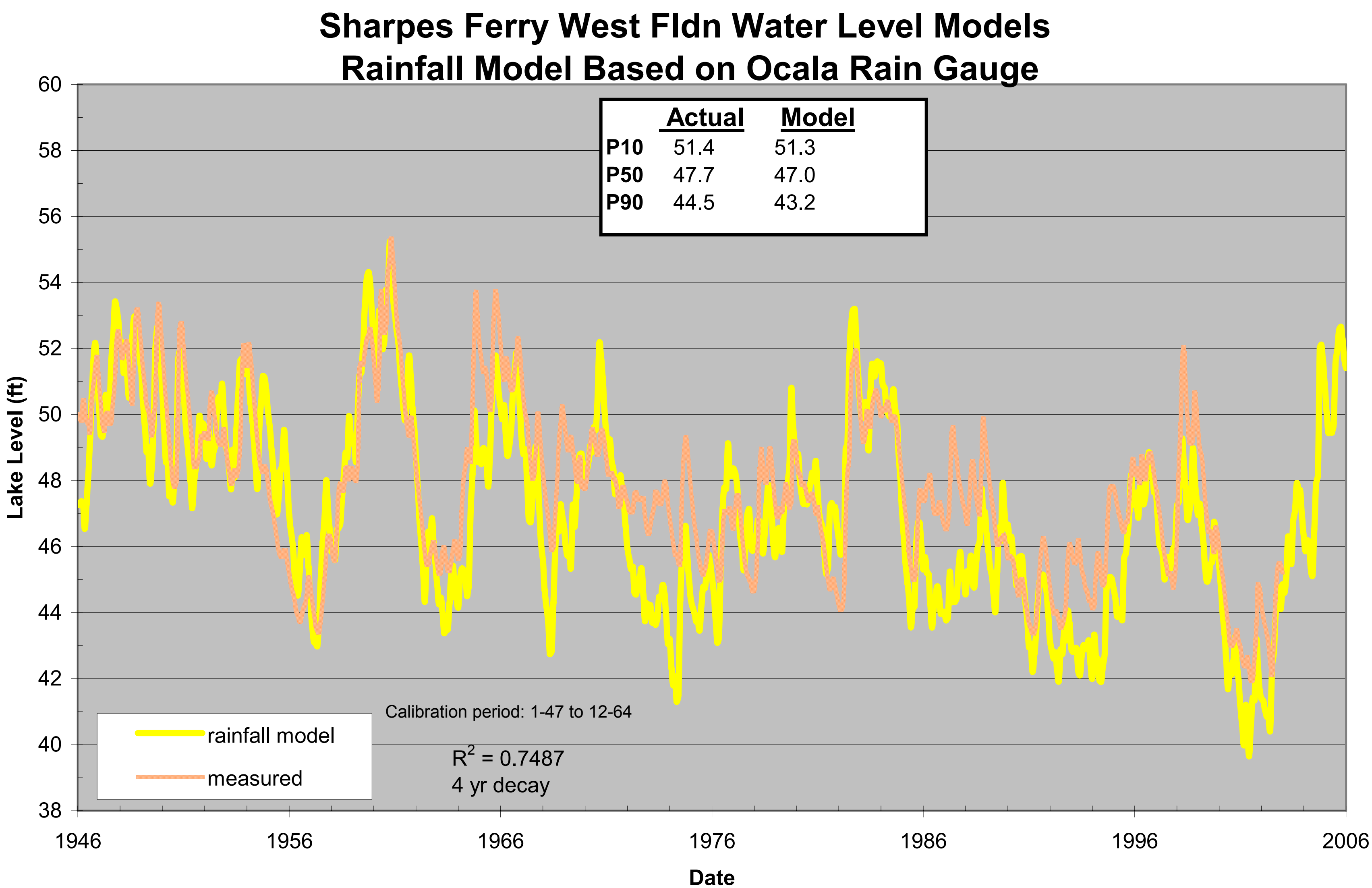
- Model Sharpes Ferry Using Ocala Rainfall
- Use a Portion of Sharpes Ferry Well Data for Calibration
- Run Model and Project Out the Full 60 Years of Available Data
- Keep in Mind Some Changes to Ocklawaha River thus Possibly Some Changes to Sharpes Ferry

Model of Sharpes Ferry Well Using Ocala Rain
Calibration Period 1947 - 1964

Decay Period	R^2	ppt Lake Model minus Measured/Lake Level Model Calib Per P50	ppt Lake Model minus Measured/Lake Level Model Calib Per P10	ppt Lake Model minus Measured/Lake Level Model Calib Per P90	ABS P50	ABS P10	ABS P90	Sum ABS
6 months	0.10	-0.20	0.17	0.19	0.20	0.17	0.19	0.56
1 year	0.34	-0.33	0.36	0.25	0.33	0.36	0.25	0.94
2 years	0.59	-0.14	0.00	-0.23	0.14	0.00	0.23	0.37
3 years	0.72	0.01	-0.19	-0.32	0.01	0.19	0.32	0.52
4 years	0.75	0.00	-0.10	-0.22	0.00	0.10	0.22	**0.32**
5 years	0.73	0.03	0.07	-0.33	0.03	0.07	0.33	0.43
6 years	0.70	0.07	-0.03	-0.35	0.07	0.03	0.35	0.45
7 years	0.68	0.36	-0.06	-0.20	0.36	0.06	0.20	0.62
8 years	0.66	0.31	-0.10	-0.22	0.31	0.10	0.22	0.64
9 years	0.61	0.31	-0.05	-0.26	0.31	0.05	0.26	0.61
10 years	0.55	0.26	-0.01	-0.27	0.26	0.01	0.27	0.53
Minimum	0.10							0.32
Maximum	0.75							0.94



Sharpes Ferry West Fldn Water Level Models
Rainfall Model Based on Ocala Rain Gauge
Actual
Model
P10 52.5 52.4
P50 49.1 49.1
P90 45.2 45.0
60
58
56
54
52
50
48
46
44
42
40
38
Lake Level (ft)
rainfall model
measured
Calibration period: 1-47 to 12-64
R2 = 0.7487
4 yr decay
1947
1952
1957
1962
Date


Sharpes Ferry West Fldn Water Level Models
Rainfall Model Based on Ocala Rain Gauge
Actual
Model
P10 51.4 51.3
P50 47.7 47.0
P90 44.5 43.2
Lake Level (ft)
60
58
56
54
52
50
48
46
44
42
40
38
1946
1956
1966
1976
1986
1996
2006
Date
rainfall model
measured
Calibration period: 1-47 to 12-64
R2 = 0.7487
4 yr decay

Evaluation of Compliance Based on Climatic Conditions

Lake Minimum Level Compliance Evaluation

1. Evaluate using LOC Model – Compare Predicted based on rain versus measured lake level.

2. Review other lakes in the area.

3. Look for changes in water use to explain trends.

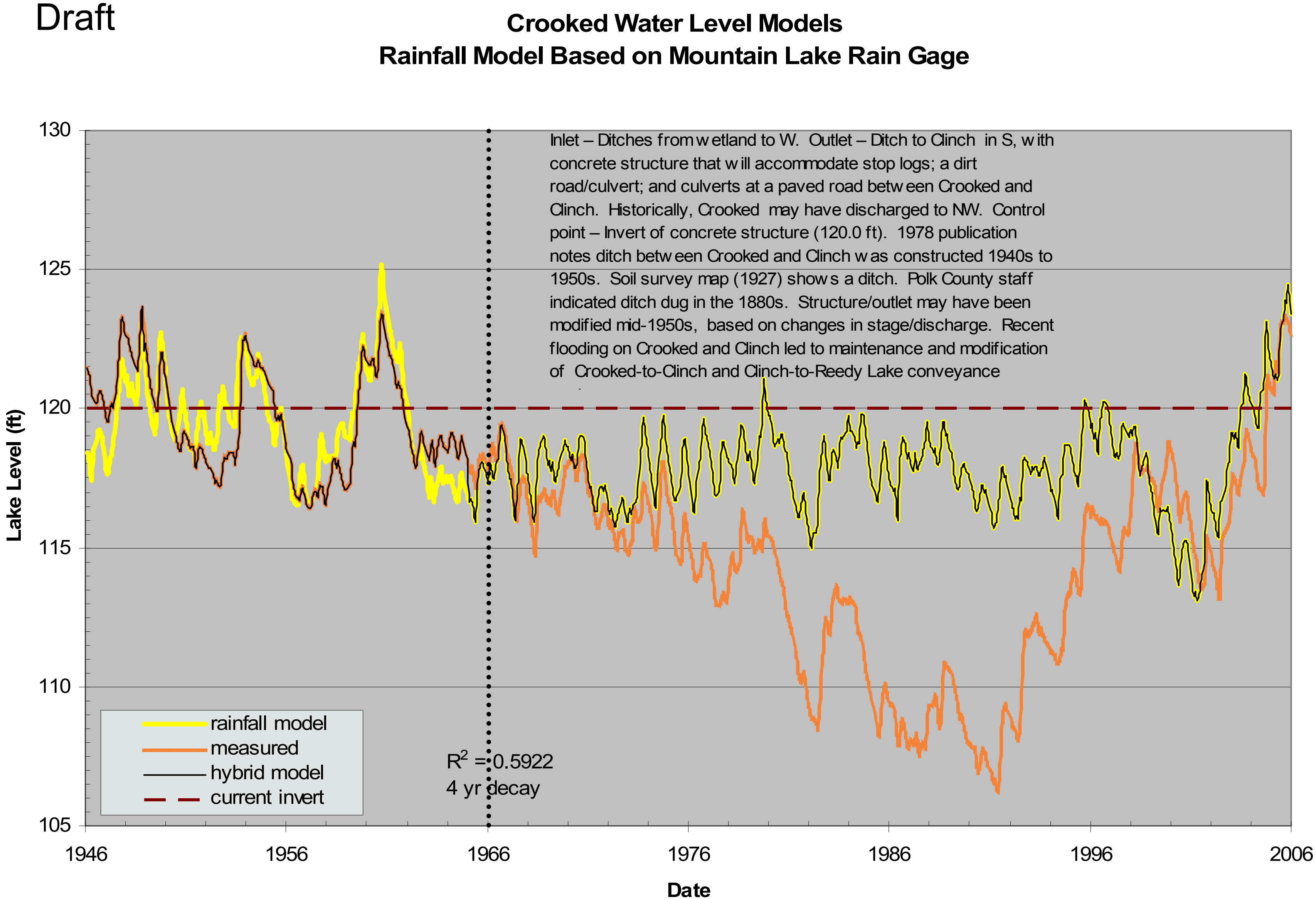
4. Check for structural changes.

5. Evaluate for sink hole activity.

Constructing a Lake Compliance Graph

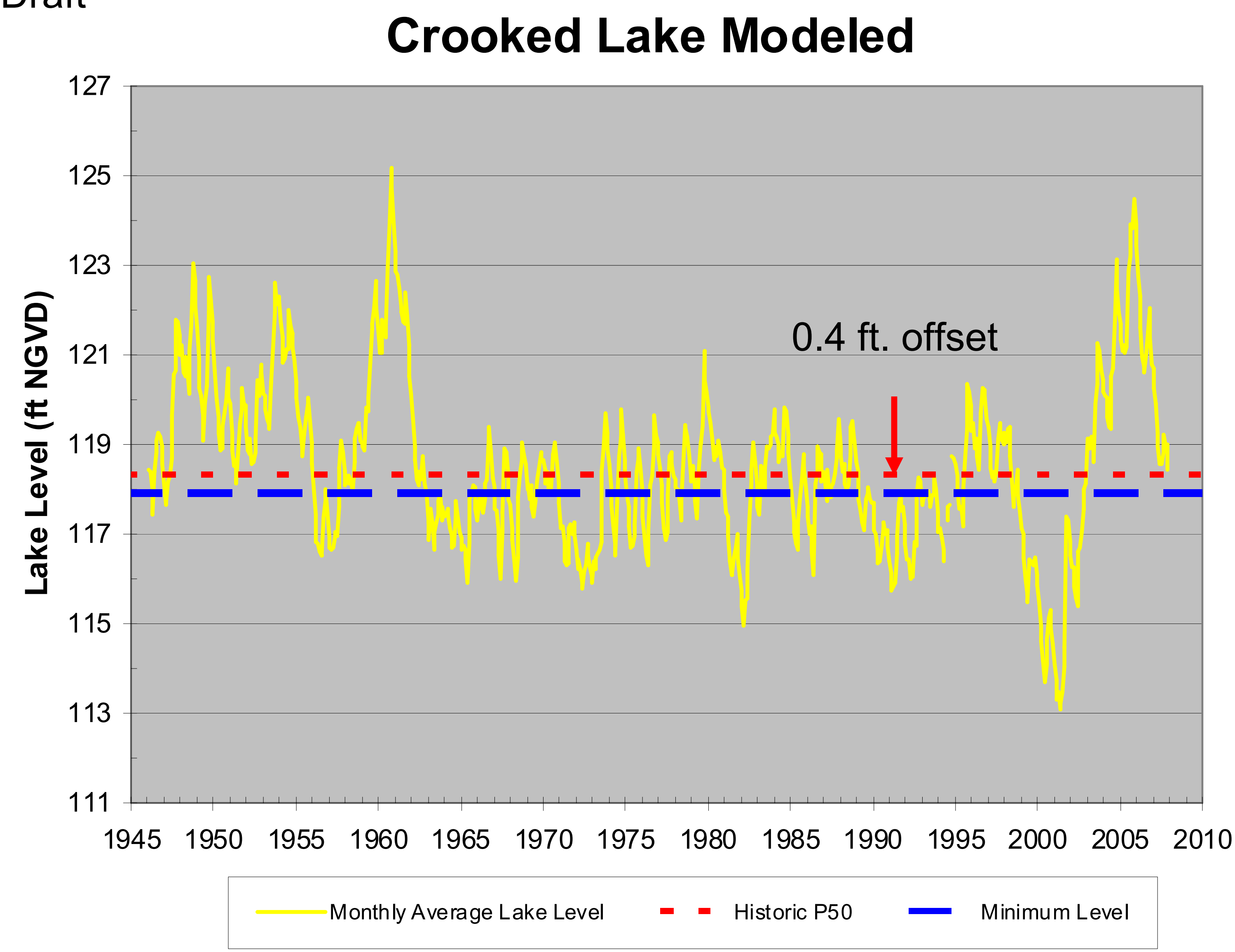
1. Graph LOC
2. Shift the LOC by the difference between the Historic P50 and the MLL.
3. Calculate and graph the 95% upper and lower prediction intervals (PI).
4. Calculate the 99.9% upper and lower PI.
5. Plot predicted monthly average versus measured monthly average in 6 year sets.

Draft



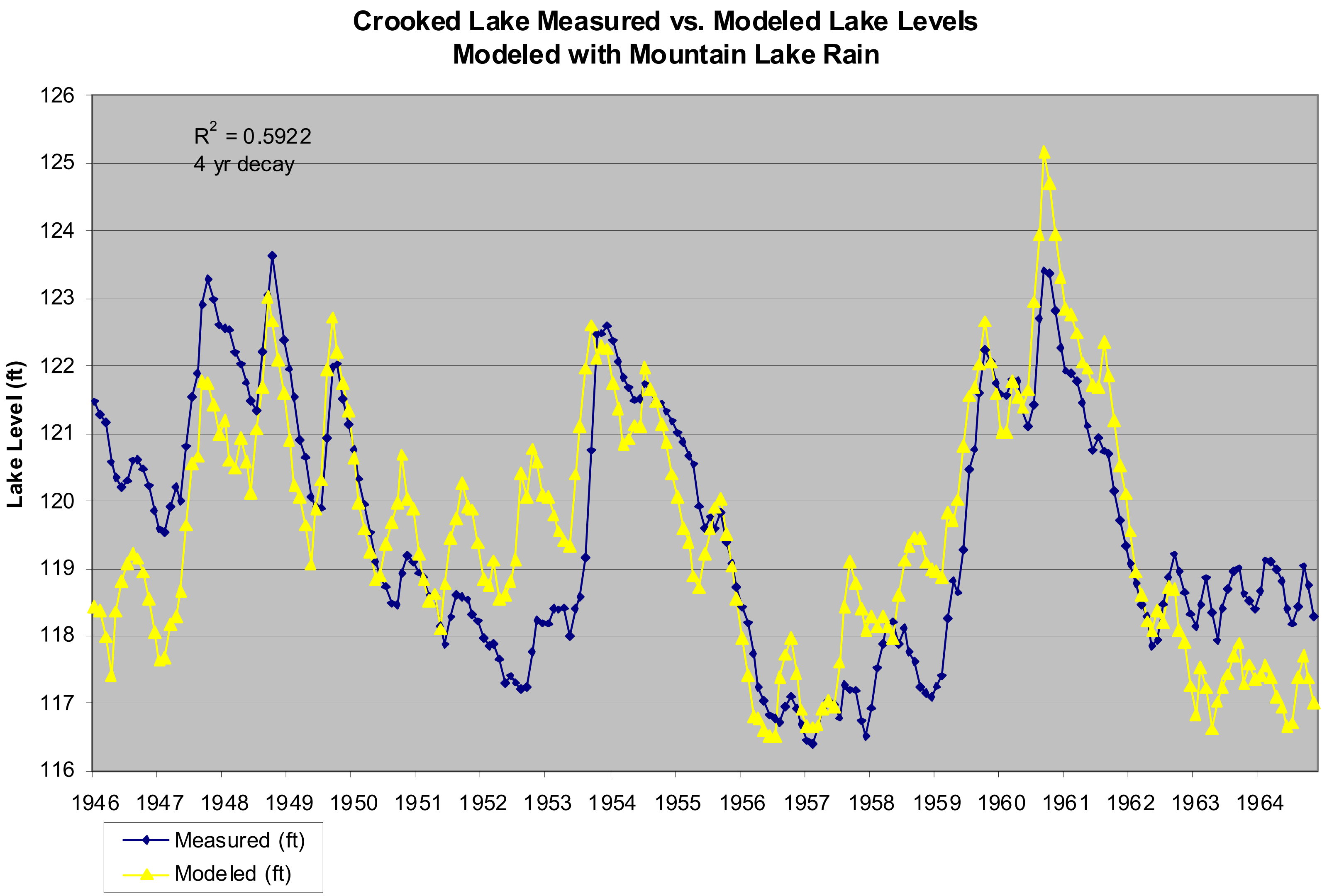
Crooked Water Level Models
Rainfall Model Based on Mountain Lake Rain Gage
Inlet – Ditches from wetland to W. Outlet – Ditch to Clinch in S, with concrete structure that will accommodate stop logs; a dirt road/culvert; and culverts at a paved road between Crooked and Clinch. Historically, Crooked may have discharged to NW. Control point – Invert of concrete structure (120.0 ft). 1978 publication notes ditch between Crooked and Clinch was constructed 1940s to 1950s. Soil survey map (1927) shows a ditch. Polk County staff indicated ditch dug in the 1880s. Structure/outlet may have been modified mid-1950s, based on changes in stage/discharge. Recent flooding on Crooked and Clinch led to maintenance and modification of Crooked-to-Clinch and Clinch-to-Reedy Lake conveyance
130
125
120
115
110
105
Lake Level (ft)
1946
1956
1966
1976
1986
1996
2006
Date
rainfall model
measured
hybrid model
current invert
R^2 = 0.5922
4 yr decay

Draft



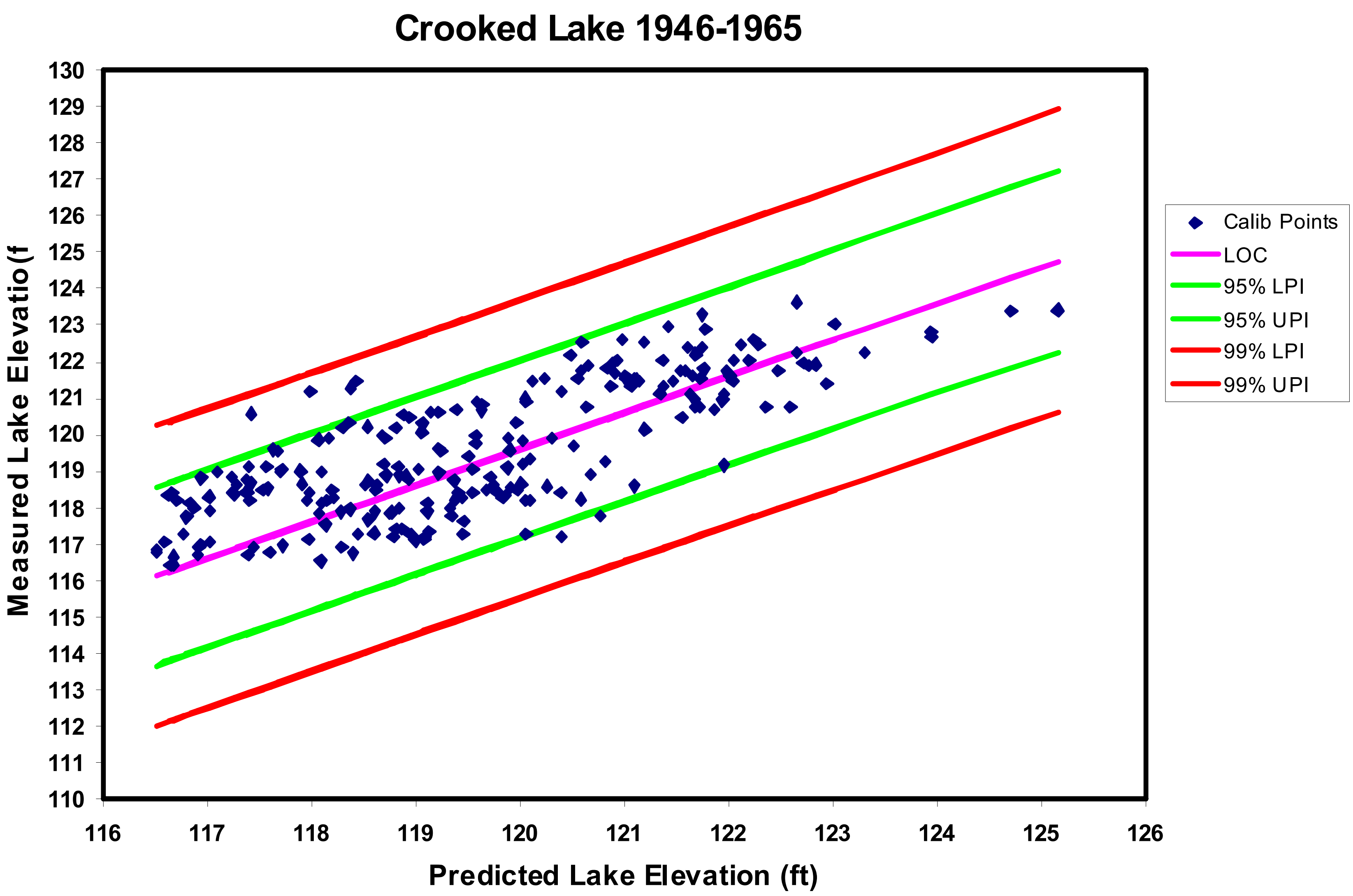
Crooked Lake Modeled
Lake Level (ft NGVD)
127
125
123
121
119
117
115
113
111
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
0.4 ft. offset
Monthly Average Lake Level
Historic P50
Minimum Level

Draft



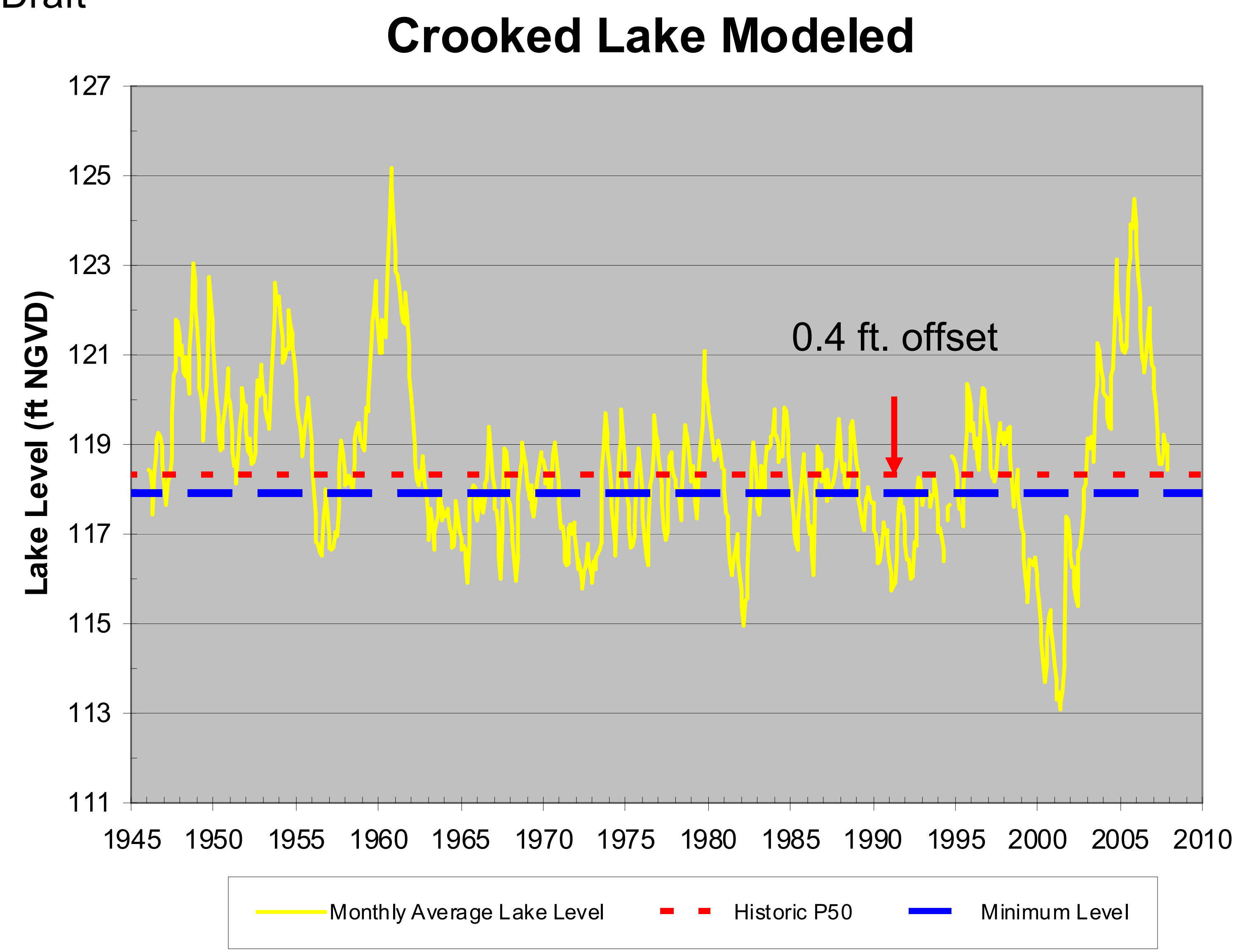
Crooked Lake Measured vs. Modeled Lake Levels
Modeled with Mountain Lake Rain
R^2 = 0.5922
4 yr decay
Lake Level (ft)
126
125
124
123
122
121
120
119
118
117
116
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
Measured (ft)
Modeled (ft)

Draft

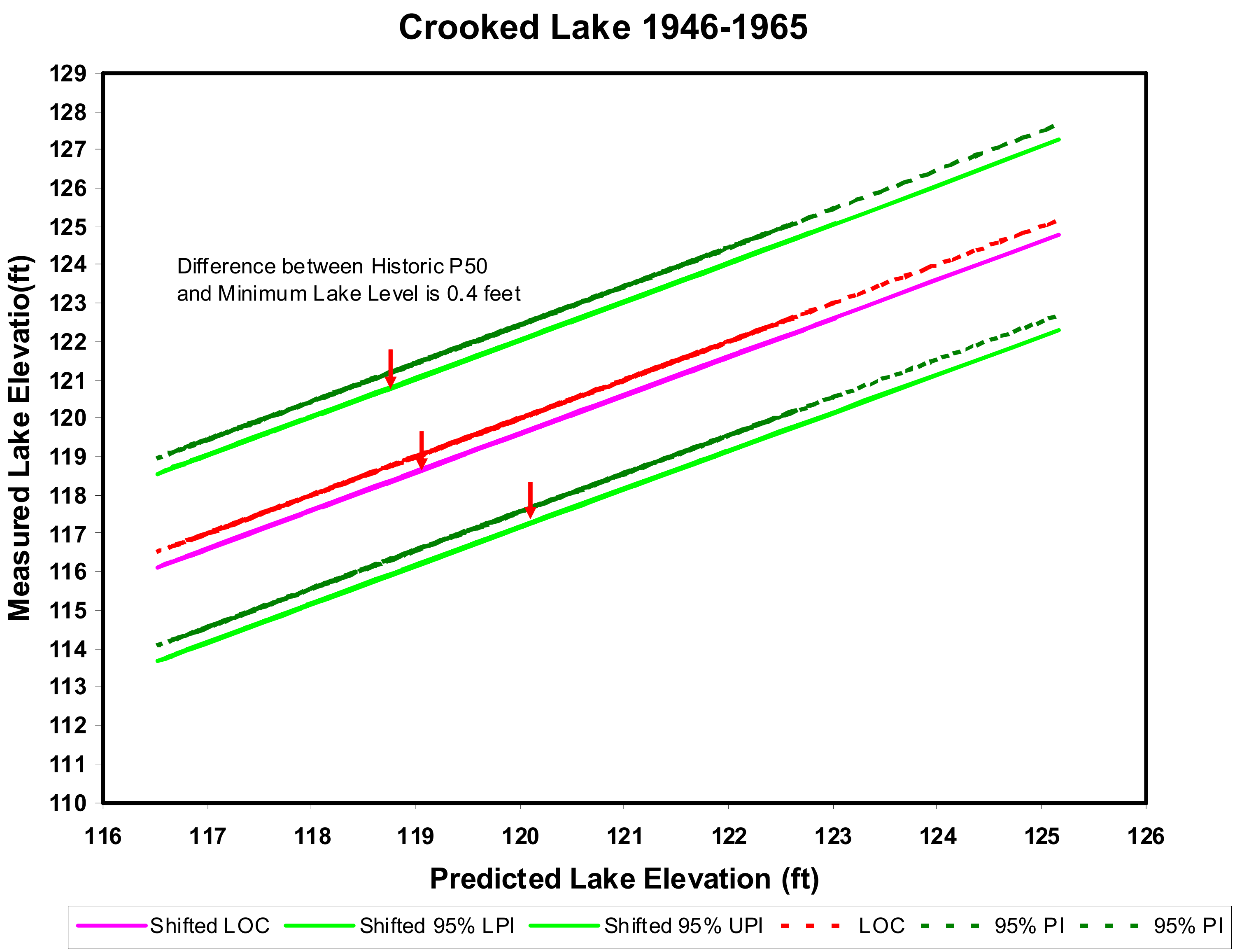


Crooked Lake 1946-1965
Measured Lake Elevatio(f
Predicted Lake Elevation (ft)
130
129
128
127
126
125
124
123
122
121
120
119
118
117
116
115
114
113
112
111
110
116
117
118
119
120
121
122
123
124
125
126
Calib Points
LOC
95% LPI
95% UPI
99% LPI
99% UPI

Draft

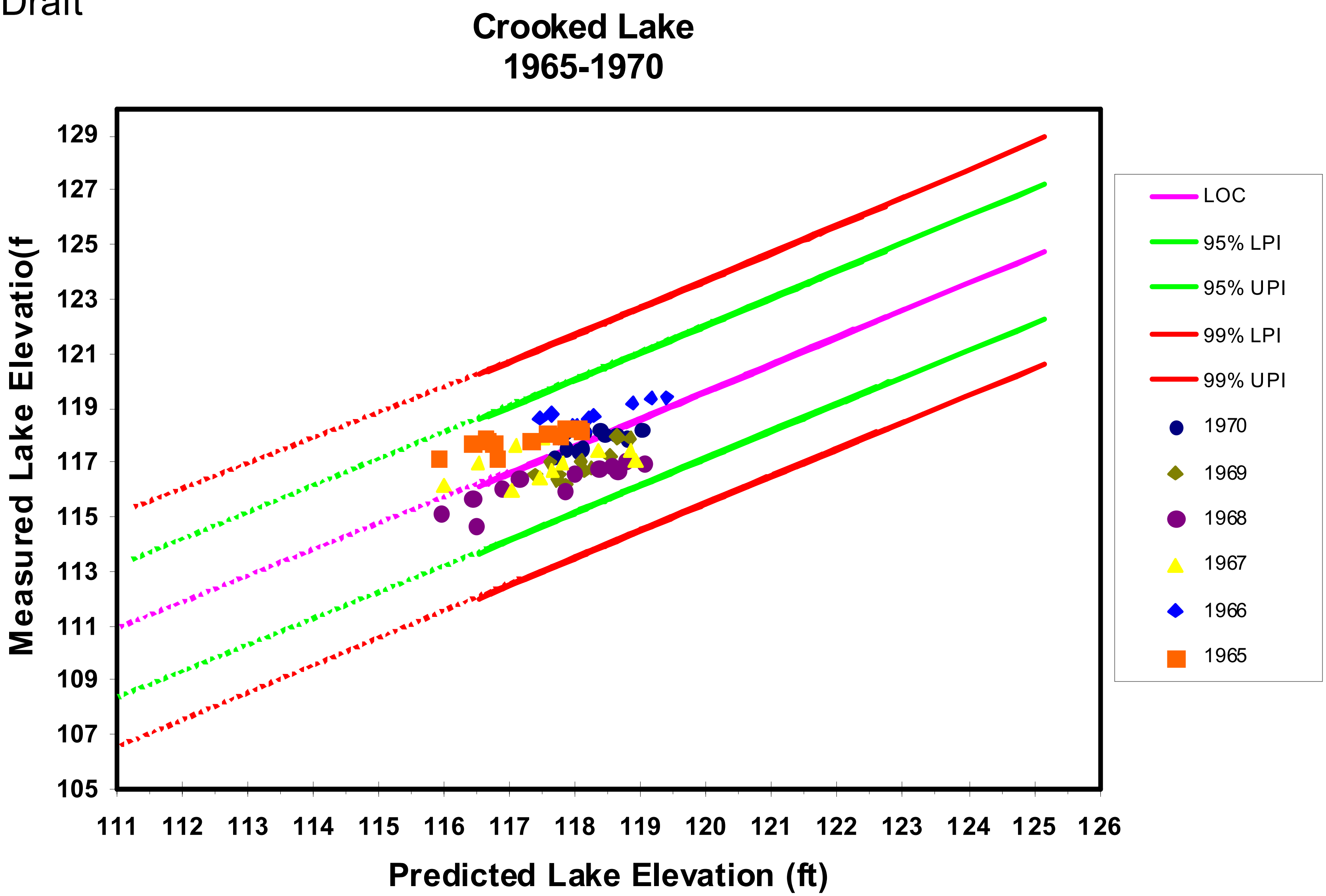


Crooked Lake Modeled
127
125
123
121
119
117
115
113
111
Lake Level (ft NGVD)
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
0.4 ft. offset
Monthly Average Lake Level
Historic P50
Minimum Level



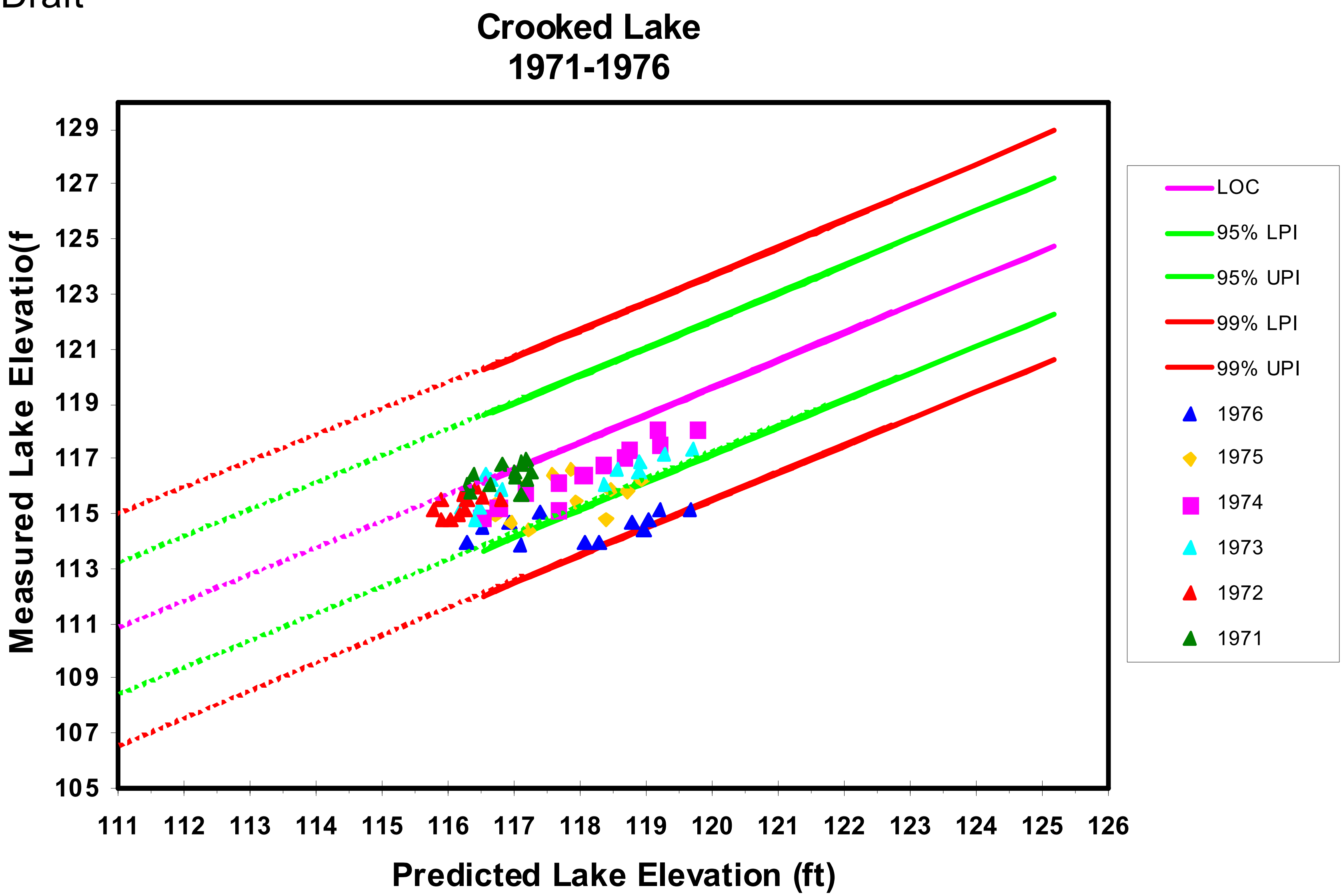
Crooked Lake 1946-1965
Measured Lake Elevatio(ft)
Predicted Lake Elevation (ft)
129
128
127
126
125
124
123
122
121
120
119
118
117
116
115
114
113
112
111
110
116
117
118
119
120
121
122
123
124
125
126
Difference between Historic P50
and Minimum Lake Level is 0.4 feet
Shifted LOC
Shifted 95% LPI
Shifted 95% UPI
LOC
95% PI
95% PI

Draft



Crooked Lake
1965-1970
Measured Lake Elevatio(f
129
127
125
123
121
119
117
115
113
111
109
107
105
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
Predicted Lake Elevation (ft)
LOC
95% LPI
95% UPI
99% LPI
99% UPI
1970
1969
1968
1967
1966
1965

Draft



Crooked Lake
1971-1976
Measured Lake Elevatio(f
129
127
125
123
121
119
117
115
113
111
109
107
105
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
Predicted Lake Elevation (ft)
LOC
95% LPI
95% UPI
99% LPI
99% UPI
1976
1975
1974
1973
1972
1971

Determining Compliance

1. For the 95% PI there are 2.5% of the points above and 2.5% below the LPI and the UPI each.

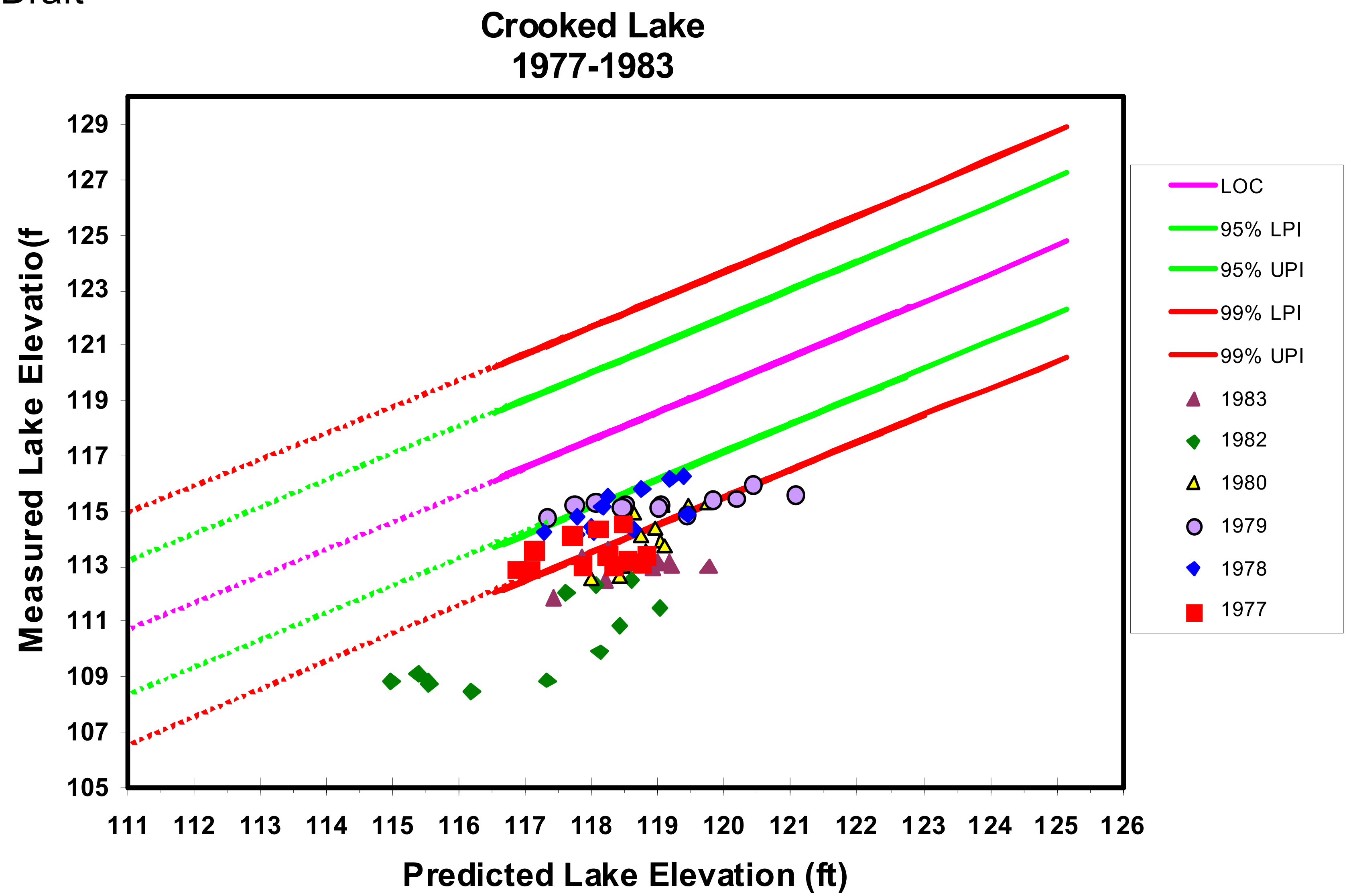
2. For a 72 month period 2.5% equals 1.8 points.

3. To account for error we round it and double it to obtain 4 points.

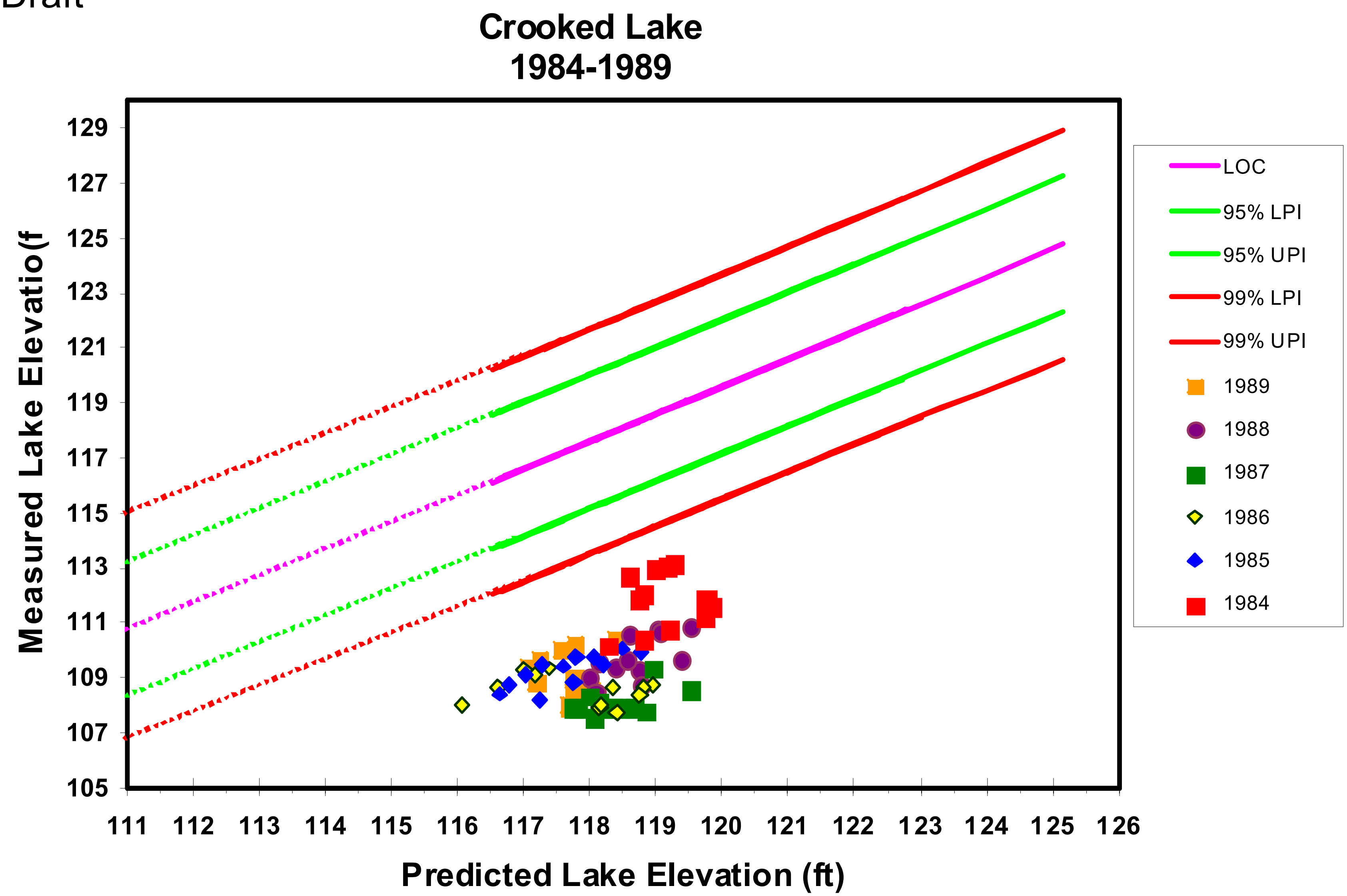
4. More than 4 points below the 95% LPI over a running six year evaluation period is out of compliance.

5. For the 99.9% PI no points can be below.

Draft

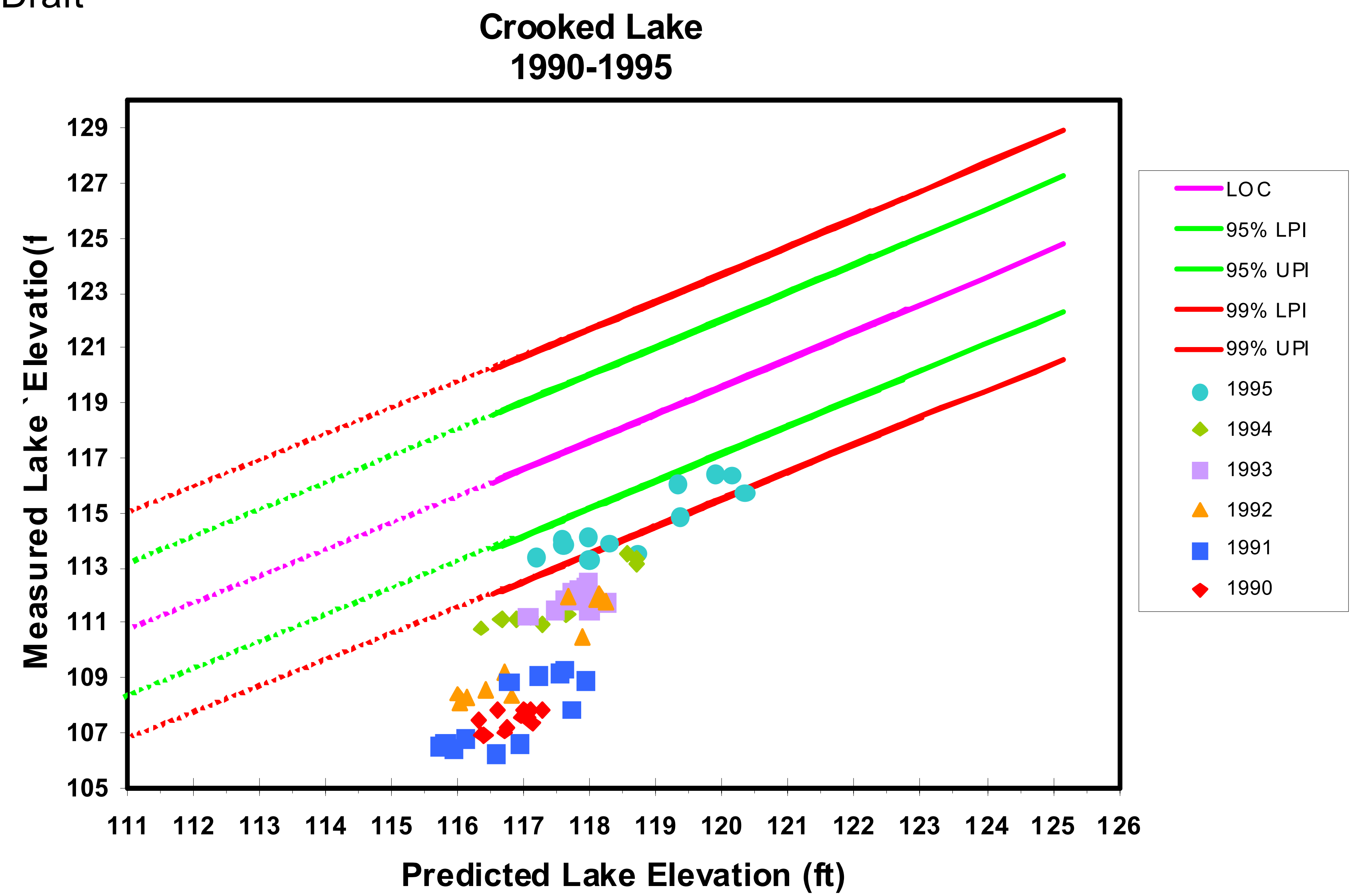

Crooked Lake
1977-1983
Measured Lake Elevatio(f
129
127
125
123
121
119
117
115
113
111
109
107
105
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
Predicted Lake Elevation (ft)
LOC
95% LPI
95% UPI
99% LPI
99% UPI
1983
1982
1980
1979
1978
1977

Draft

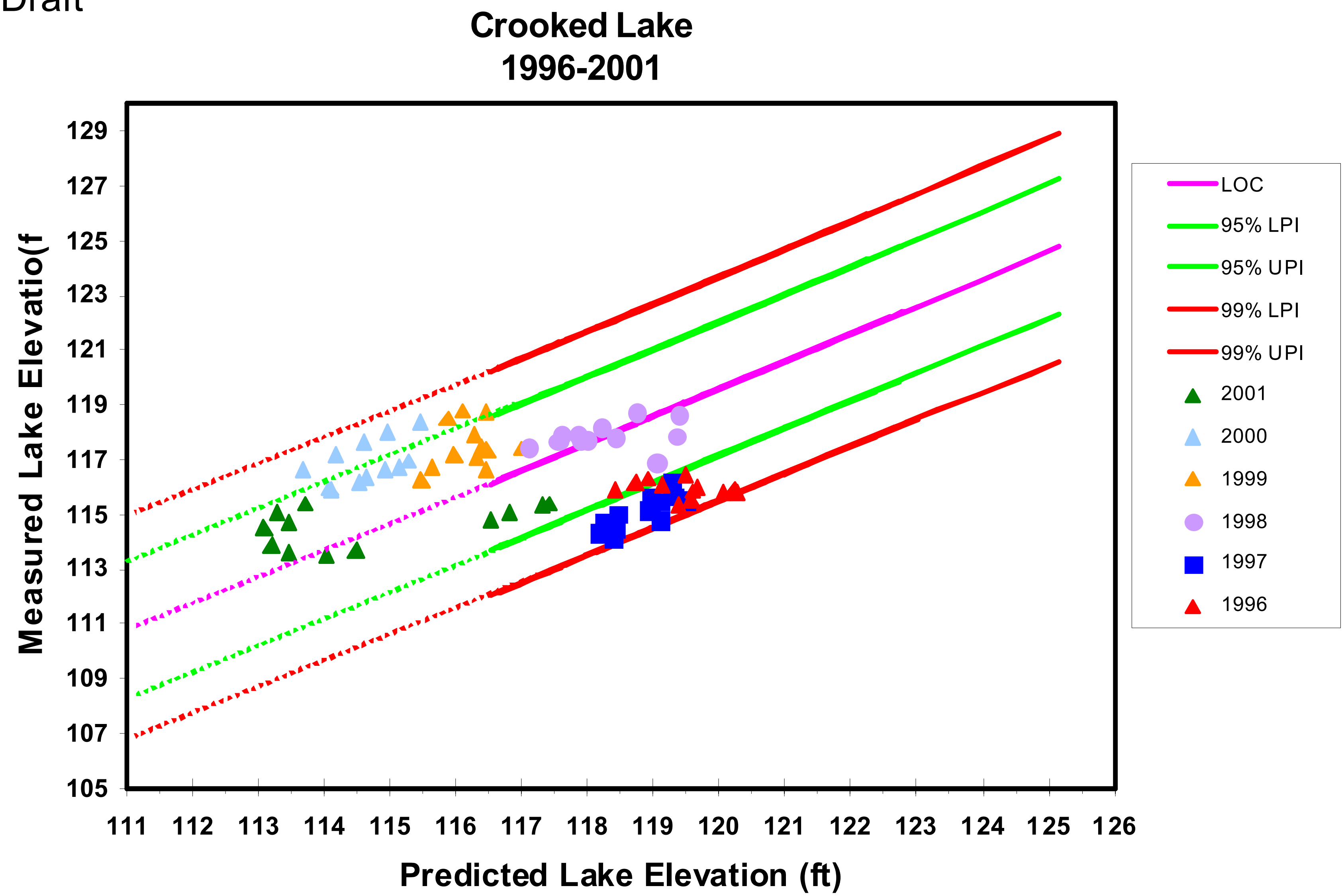


Crooked Lake
1984-1989
Measured Lake Elevatio(f
129
127
125
123
121
119
117
115
113
111
109
107
105
111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126
Predicted Lake Elevation (ft)
LOC
95% LPI
95% UPI
99% LPI
99% UPI
1989
1988
1987
1986
1985
1984

Draft

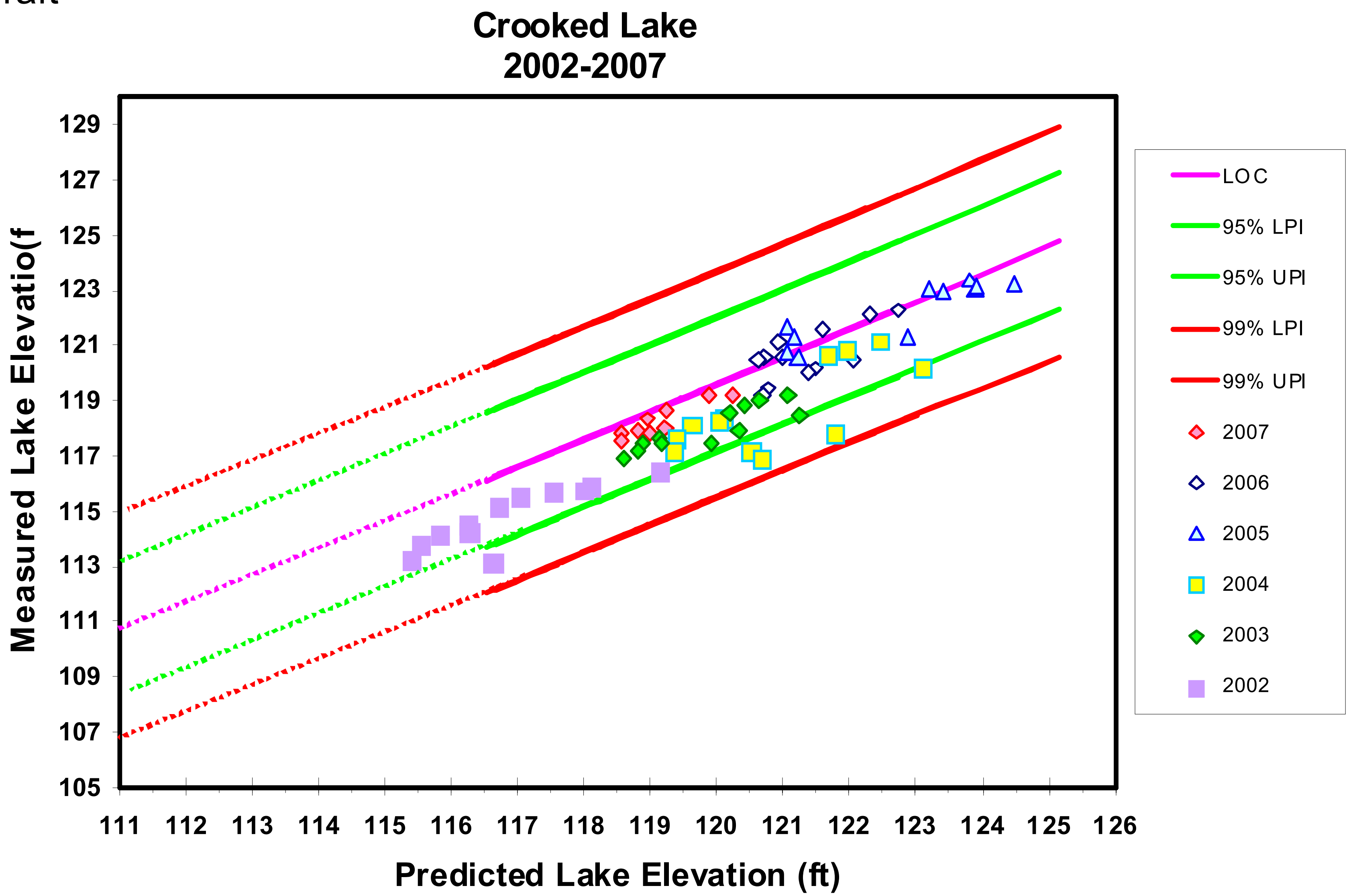

Crooked Lake
1990-1995
Measured Lake `Elevatio(f
Predicted Lake Elevation (ft)
129
127
125
123
121
119
117
115
113
111
109
107
105
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
LOC
95% LPI
95% UPI
99% LPI
99% UPI
1995
1994
1993
1992
1991
1990

Draft



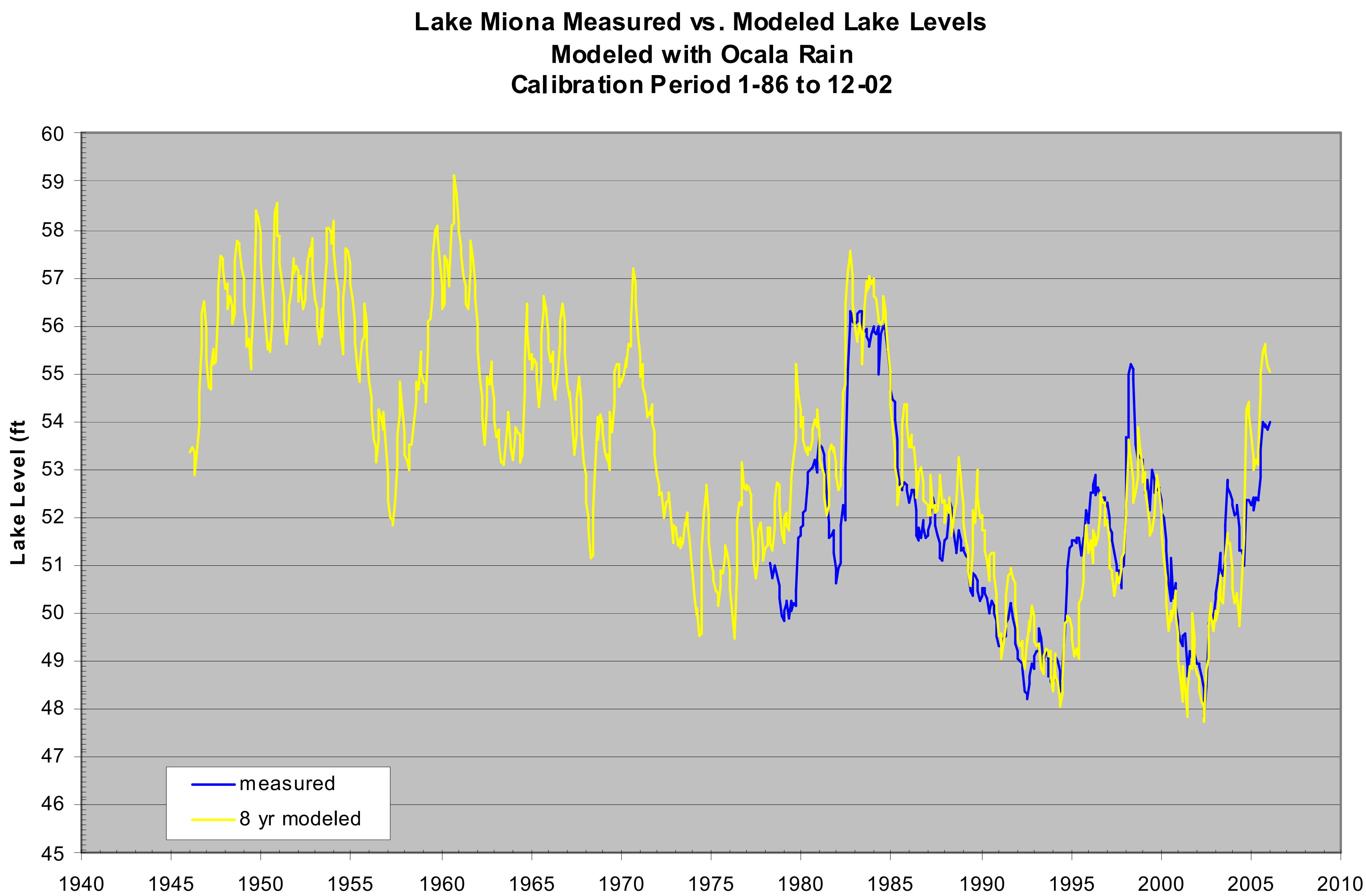
Crooked Lake
1996-2001
Measured Lake Elevatio(f
129
127
125
123
121
119
117
115
113
111
109
107
105
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
Predicted Lake Elevation (ft)
LOC
95% LPI
95% UPI
99% LPI
99% UPI
2001
2000
1999
1998
1997
1996

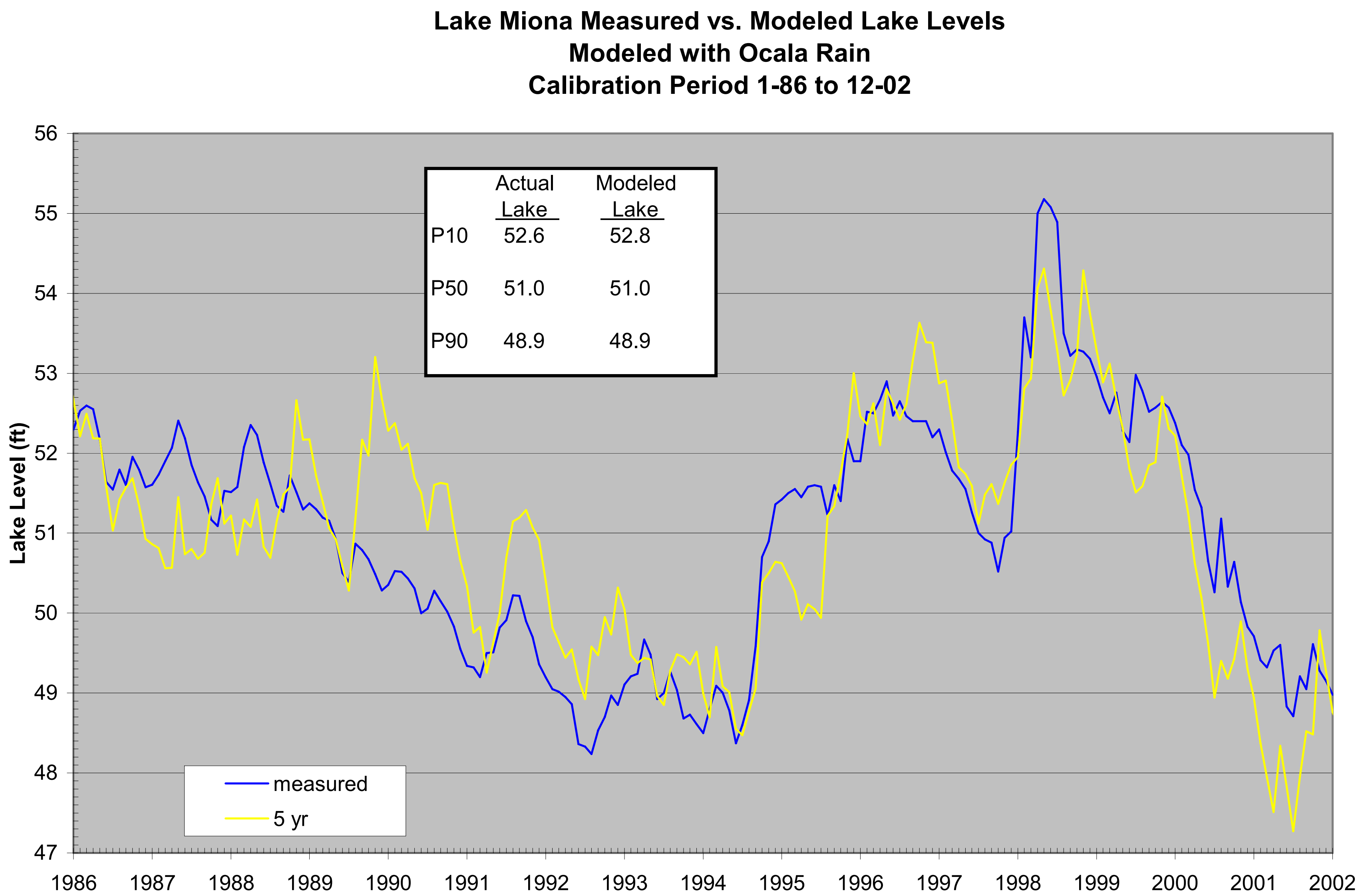
Draft



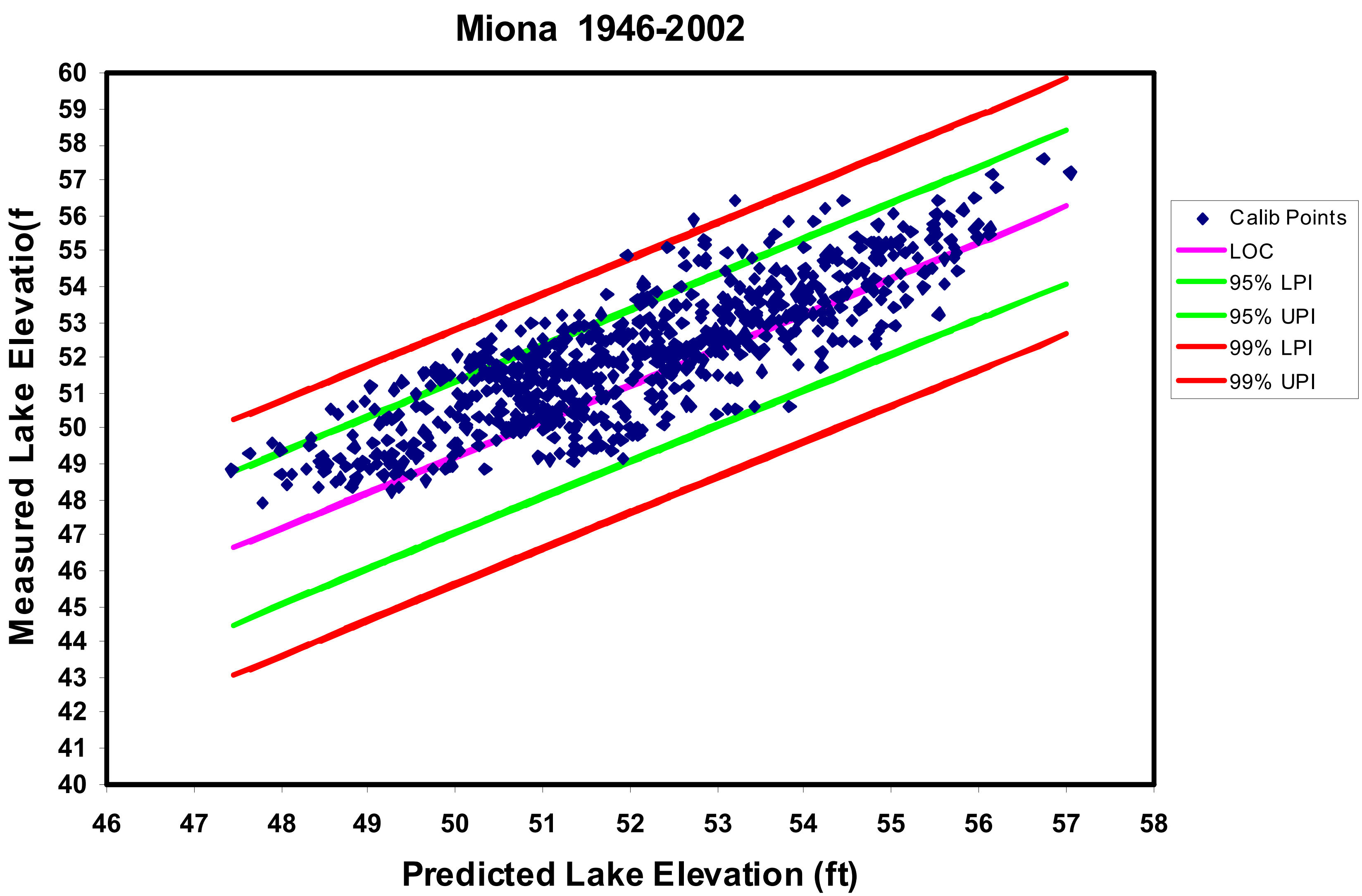
Crooked Lake
2002-2007
Measured Lake Elevatio(f
129
127
125
123
121
119
117
115
113
111
109
107
105
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
Predicted Lake Elevation (ft)
LOC
95% LPI
95% UPI
99% LPI
99% UPI
2007
2006
2005
2004
2003
2002

Lake Miona


Lake Miona Measured vs. Modeled Lake Levels
Modeled with Ocala Rain
Calibration Period 1-86 to 12-02
Lake Level (ft
60
59
58
57
56
55
54
53
52
51
50
49
48
47
46
45
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
measured
8 yr modeled

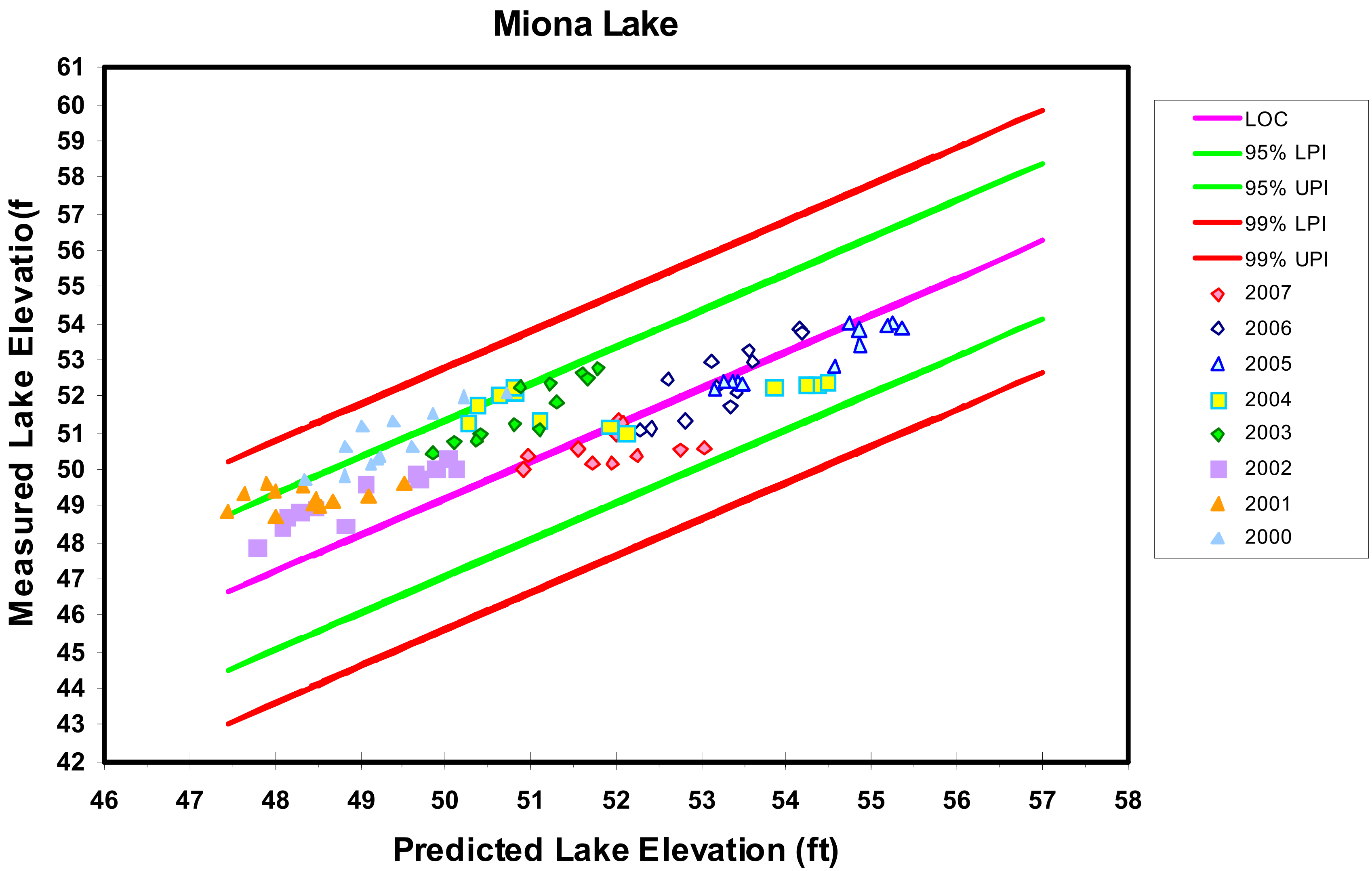

Lake Miona Measured vs. Modeled Lake Levels
Modeled with Ocala Rain
Calibration Period 1-86 to 12-02
Lake Level (ft)
56
55
54
53
52
51
50
49
48
47
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Actual Lake
Modeled Lake
P10 52.6 52.8
P50 51.0 51.0
P90 48.9 48.9
measured
5 yr

Draft



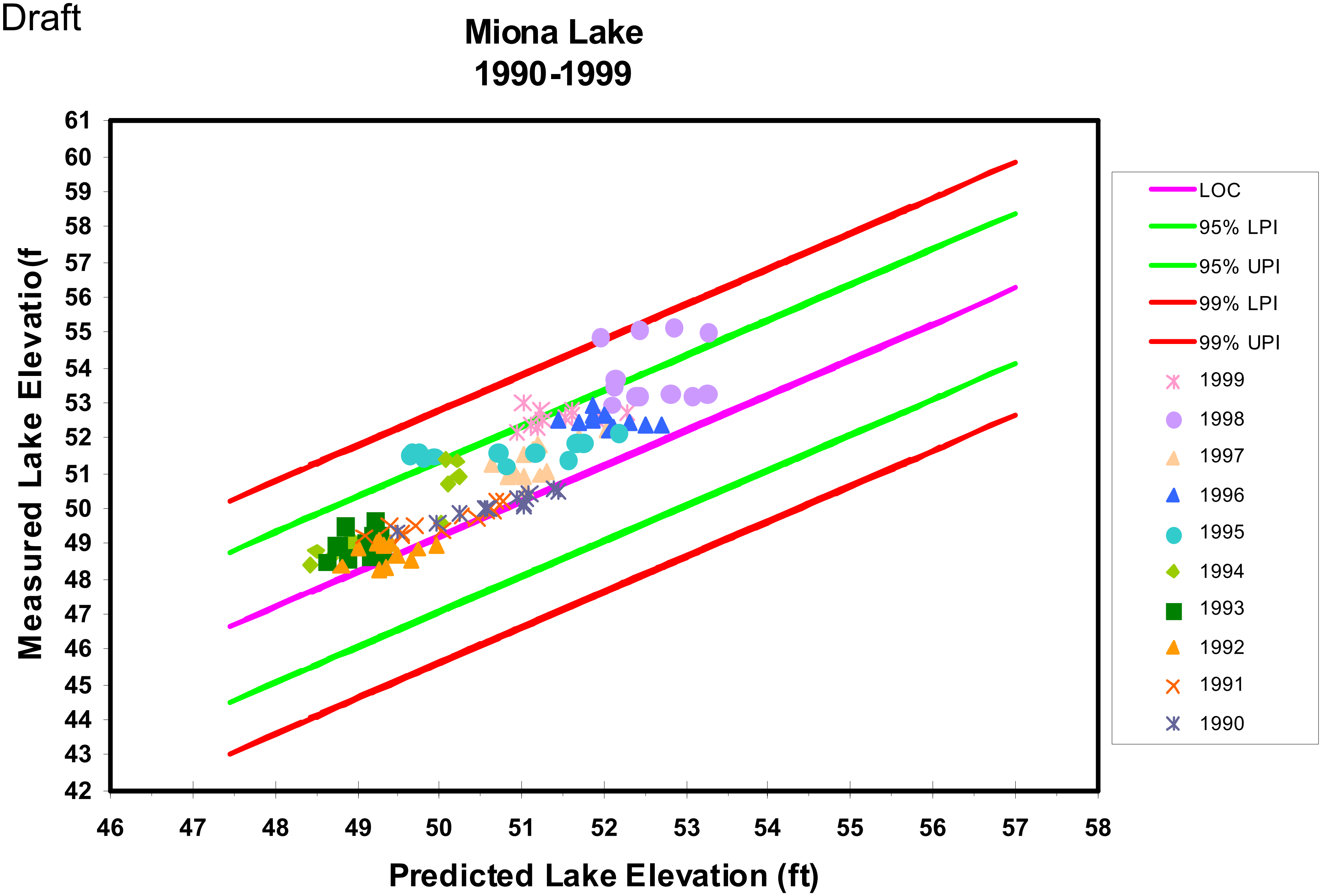
Miona 1946-2002
Measured Lake Elevatio(f
60
59
58
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
42
41
40
46
47
48
49
50
51
52
53
54
55
56
57
58
Predicted Lake Elevation (ft)
Calib Points
LOC
95% LPI
95% UPI
99% LPI
99% UPI

Draft



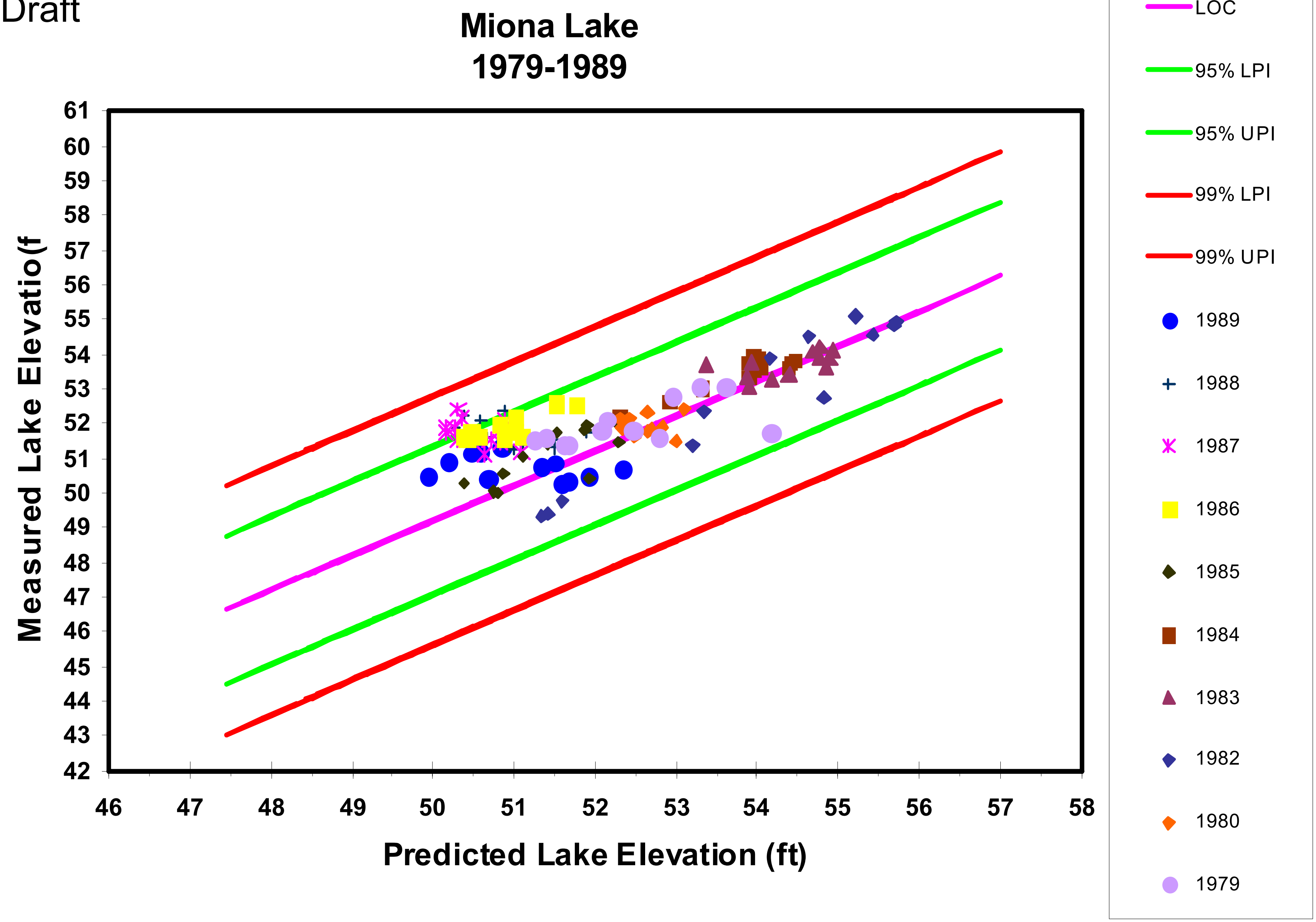
Miona Lake
Measured Lake Elevatio(f
Predicted Lake Elevation (ft)
61
60
59
58
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
42
46
47
48
49
50
51
52
53
54
55
56
57
58
LOC
95% LPI
95% UPI
99% LPI
99% UPI
2007
2006
2005
2004
2003
2002
2001
2000

Draft



Miona Lake
1990-1999
Measured Lake Elevatio(f
Predicted Lake Elevation (ft)
61
60
59
58
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
42
46
47
48
49
50
51
52
53
54
55
56
57
58
LOC
95% LPI
95% UPI
99% LPI
99% UPI
1999
1998
1997
1996
1995
1994
1993
1992
1991
1990

Draft


Miona Lake
1979-1989
Measured Lake Elevatio(f
Predicted Lake Elevation (ft)
61
60
59
58
57
56
55
54
53
52
51
50
49
48
47
46
45
44
43
42
46
47
48
49
50
51
52
53
54
55
56
57
58
LOC
95% LPI
95% UPI
99% LPI
99% UPI
1989
1988
1987
1986
1985
1984
1983
1982
1980
1979

Today's Topics (Presentation 2):

1. Review of Last Presentation (Discussion of Long-term)
    a. Need for Long-term Historic Data
    b. Need a means to determine un-impacted lake stage based on recent climatic conditions.
2. Brief Introduction to Line of Organic Correlation (regression)
    a. Fully discussed in Helsel and Hirsch
    b. Preserves x and y variation
    c. Slightly different form of regression
3. First Application of LOC - Lake Miona Model Based on Sharpes Ferry Well (Water Level Model)
    a. Location Map
    b. Calibration Period
        1. Longest Historic Period Possible (i.e. period with similar structural conditions and no Groundwater impacts)
        2. Complications – Period of Possible Augmentation
    c. Discussions of Water level Based Models Applicability
        a. Sharpe Ferry is unique in state
        b. Distance to Southern Portion of District is great
        c. Some argue it is impacted already
        d. Abandoned 2002
        e. Future impacts are likely to increase
4. Sharpes Ferry Model Based on Ocala Rain Fall – (Example of a Rainfall Model)
    a. Goal is a based Climate Model
        - Predict Un-impacted Monthly Average Lake Level
    b. Rainfall
        1. Rainfall is summed to relate to lake fluctuation
        2. Monthly sums are the starting data
        3. Method of Summing is critical
            1. Lake Stage is dependent on prior months of rainfall
            2. Previous Rainfalls influence diminishes as time passes
            3. Linear Inverse Weighted Sum or a Decay series

Today's Topics:

b. Rainfall cont.
   1. Linear Inverse Weighted Sum or a Decay series

c. Selection of the Best Rainfall Decay Series
   1. Multiple Decay Periods Possible - How Do You Choose
   2. Rain gauge selection
   3. Run all and look for best Calibration Match
   4. Smallest Total Residuals – Absolute Sum of Residuals
   5. R^2

d. Example Models (Lakes with Historic Data)
- Lake Miona/Ocala Rain
- Crooked Lake/ Avon Park Rain

Next Discussion (Presentation 3):

5. Methods for Lakes without Historic Data and only Current Data
   1. Develop a model of Historic Data using another Lake with both current and historic data.
   2. Develop a rainfall based model

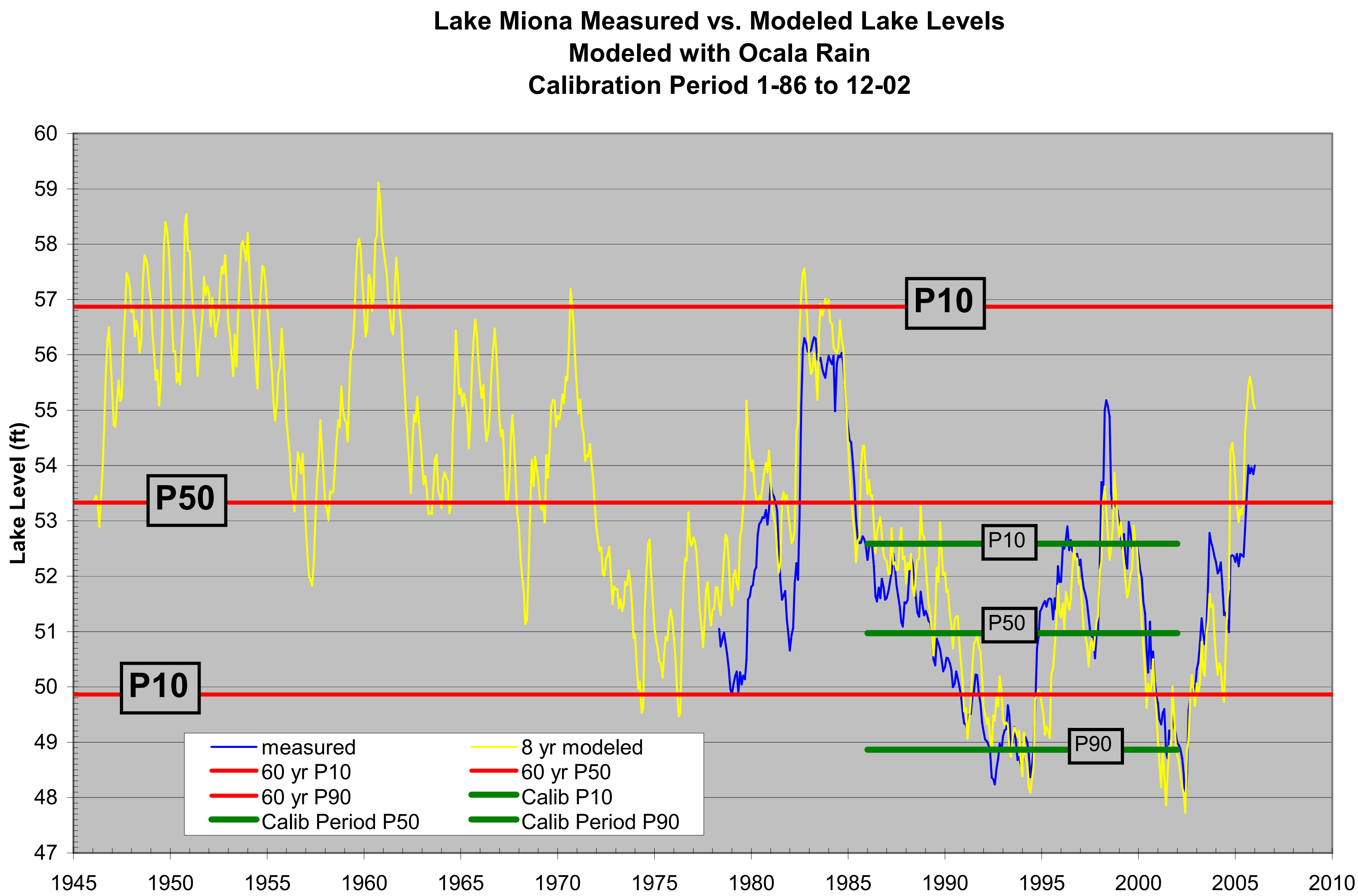
Topics (continued)

6. Other Factors Considered
   a. Structural Changes (i.e. Drainage)
   b. Sink Holes
   c. Augmentation
7. Understanding Uncertainty (Error)
   a. Rain Gauge Location
   b. Short Calibration Period
   c. Unknown changes to the lake
   d. Monthly average = ?, One reading per month for average lake level
   e. Zero Rain = continued decline, need ET to fully describe decline
   f. Linear Decay applied to non-linear problem?
   g. Rain gauge change, location, equipment, readers
8. Incorporating Uncertainty into the MFL Process
   a. Prediction Intervals
   b. Two methods to present data rating curve (predicted vs. actual) and time versus predicted and actual.
9. Adjusting the models to reflect the MFL
   a. MFL = P50, Difference between the HistP50 and MFL equals the offset.
   b. Offset is simply applied to the model results and the entire data set is shifted down by offset.

Topics (cont.):

10. Lake MFL Compliance Process
    a. Need to determine compliance using shorter periods of record.
    b. MFL is a long-term Percentile (i.e. 60 yr value) need 60 yrs before Apples to apples comparison can be made.
    c. Model produces monthly averages, but best when applied to longer periods (many months of data)
    d. 95% prediction interval 2.5% above and below 95% interval
    e. 2.5% using 60 years is 18 points.
    f. Goal is to predict lake based on climate and compare to actual.
    g. Continue running model as time passes and compare to actual.

11 Lake Compliance Rules
    1. All newly predicted points plotting above and below the LOC and within the PI's with some at or above upper PI = Excellent, some to give
        a. Quantification of how much to give is not part of MFL evaluation
    2. All points below LOC but above lower MFL PI then meeting level but nothing to give.
    3. More than 16? points below the lower PI = not meeting the level and nothing left to give.



Lake Miona Measured vs. Modeled Lake Levels
Modeled with Ocala Rain
Calibration Period 1-86 to 12-02
Lake Level (ft)
60
59
58
57
56
55
54
53
52
51
50
49
48
47
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
P10
P50
P10
P10
P50
P90
measured
8 yr modeled
60 yr P10
60 yr P50
60 yr P90
Calib P10
Calib Period P50
Calib Period P90

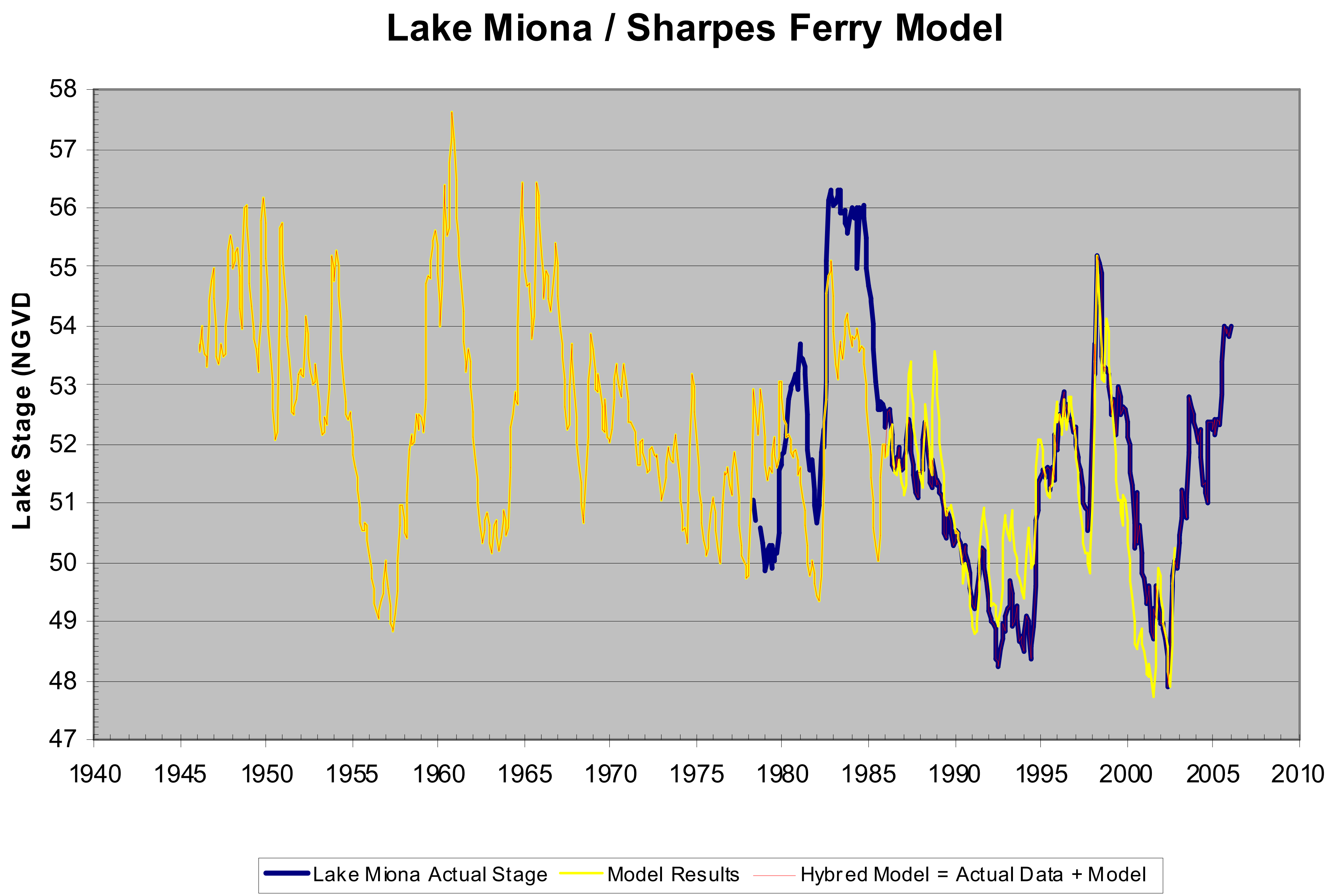
Decay Period	R^2	ppt Lake Model minus Measured/Lake Level Model Calib Per P50	ppt Lake Model minus Measured/Lake Level Model Calib Per P10	ppt Lake Model minus Measured/Lake Level Model Calib Per P90	ABS P50	ABS P10	ABS P90	Sum ABS	Absolute Residuals Sum	Absolute Residuals Avg
6 months	0.0564	-0.22	0.45	0.12	0.22	0.45	0.12	0.80	314.96	3.07
1 year	0.2123	-0.22	0.22	0.07	0.22	0.22	0.07	0.51	269.82	2.63
2 years	0.3904	-0.12	0.24	0.11	0.12	0.24	0.11	0.48	222.86	2.17
3 years	0.5196	-0.01	0.41	-0.01	0.01	0.41	0.01	0.43	192.96	1.88
4 years	0.6081	-0.03	0.33	0.02	0.03	0.33	0.02	0.37	173.62	1.69
5 years	0.6806	0.01	0.22	0.01	0.01	0.22	0.01	0.24	147.97	1.44
6 years	0.7308	0.16	0.11	-0.09	0.16	0.11	0.09	0.36	132.92	1.30
7 years	0.7351	0.13	0.08	-0.12	0.13	0.08	0.12	0.34	**130.25**	1.27
8 years	0.6894	-0.05	0.18	-0.02	0.05	0.18	0.02	**0.25**	140.70	1.37
9 years	0.6071	-0.10	0.12	-0.04	0.10	0.12	0.04	0.25	162.72	1.59
10 years	0.523	-0.09	0.21	0.03	0.09	0.21	0.03	0.33	189.51	1.85
Minimum	0.0564							0.235	130.246	1.271
Maximum	0.7351							0.799	314.964	3.073

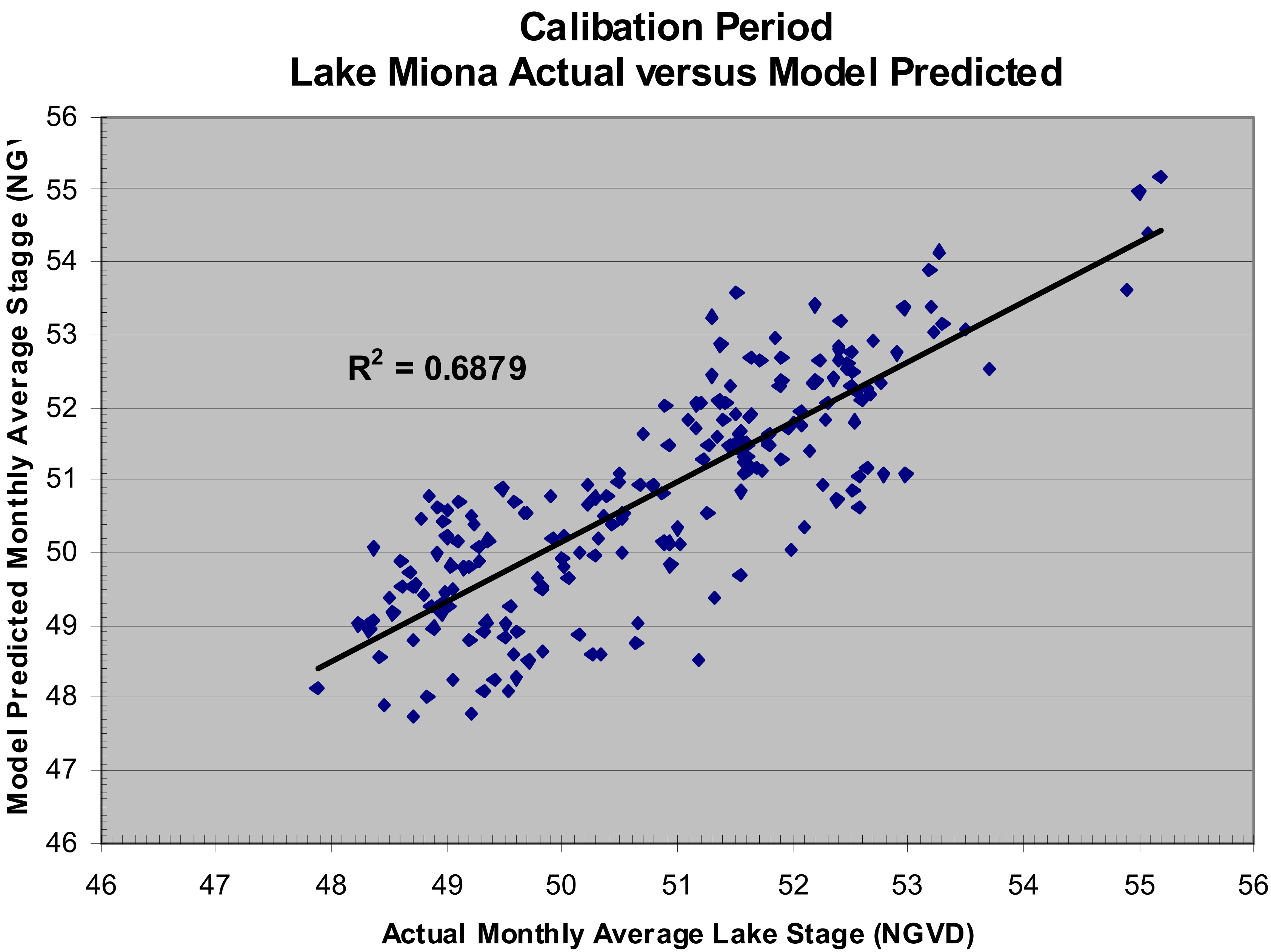
Sharpes Ferry Background

- Data Collected by USGS since 1947
- Located Adjacent to the Ocklawaha River Near Sharpes Ferry
- Floridan Well
- Abandoned in 2002 and not replaced
- Some debate over level of impact by water use, but area has been and still is a low use area.
- Change in Water Levels on Harris Chain of Lakes due to Moss Bluff Structure and thus changes to the Ocklawaha River are reported by Tibbals 2004.
- SWFWMD Considers it one of the few hydrologic records with very minimal impacts. Our best Long-term data set for testing models.

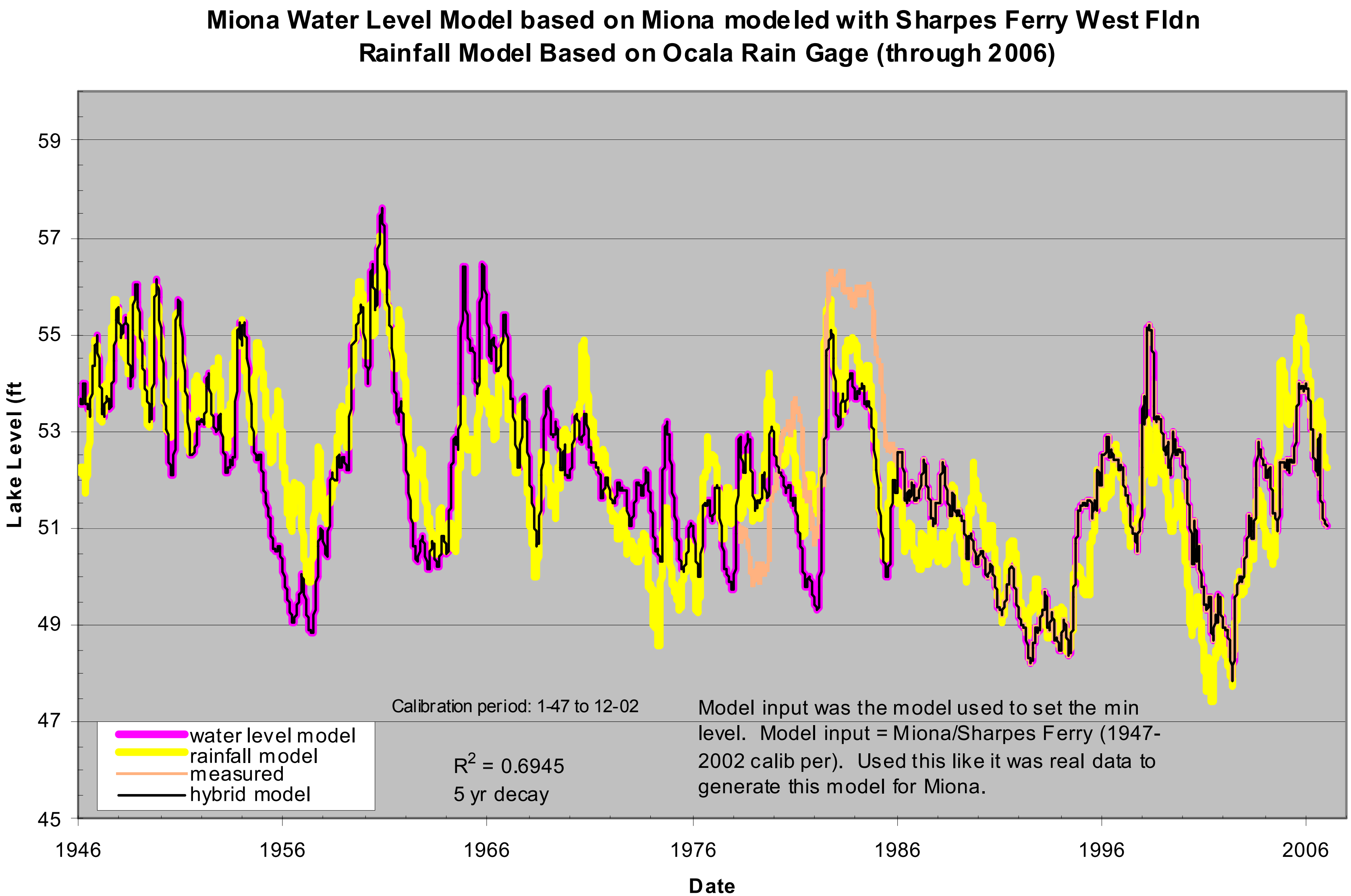
Lake Miona Background

- Lake Stage Data Available from April 1978 to Present
- Past Peat Mining In Basin with Possible Augmentation to Miona from Peat Dewatering Activities (1982-1986)
- Area of Rapid Growth Since 2000 with substantial recent water use increases
- Closed Basin no Structural Alterations
- Good Biological Indicators are Absent
- Analysis of water use impacts suggest little to none up to 2000-2002


Lake Miona / Sharpes Ferry Model
Lake Stage (NGVD
58
57
56
55
54
53
52
51
50
49
48
47
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Lake Miona Actual Stage
Model Results
Hybred Model = Actual Data + Model



Calibation Period
Lake Miona Actual versus Model Predicted
R^2 = 0.6879
Model Predicted Monthly Average Stage (NG
Actual Monthly Average Lake Stage (NGVD)
46
47
48
49
50
51
52
53
54
55
56


Miona Water Level Model based on Miona modeled with Sharpes Ferry West Fldn
Rainfall Model Based on Ocala Rain Gage (through 2006)
Lake Level (ft
Date
59
57
55
53
51
49
47
45
1946
1956
1966
1976
1986
1996
2006
Calibration period: 1-47 to 12-02
Model input was the model used to set the min level. Model input = Miona/Sharpes Ferry (1947-2002 calib per). Used this like it was real data to generate this model for Miona.
water level model
rainfall model
measured
hybrid model
R^2 = 0.6945
5 yr decay