APPENDIX 3D – DETAILS OF RECONSTRUCTION MODELING
GAGE D – GREEN RIVER AT GREEEN RIVER, UTAH

This reconstruction uses two sub-period models (M1 and M2), with data starting in A.D. 1196 and A.D. 1513. The predictand for modeling is water-year average daily flow in units of cms.

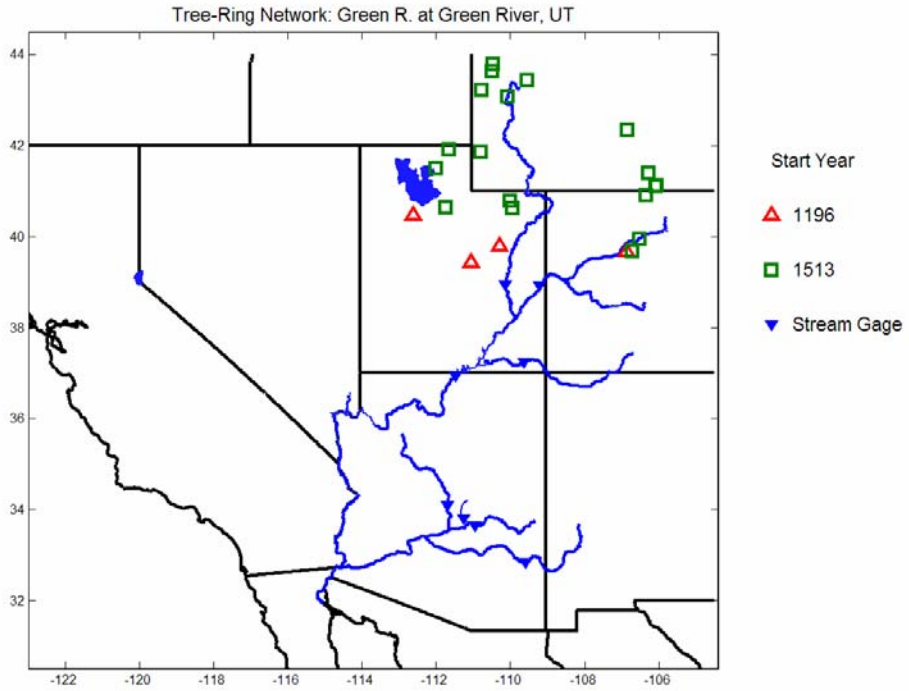

Figure 3D_1. Map showing tree-ring site locations for sub-period models used in reconstructing Green River at Green River, Utah.

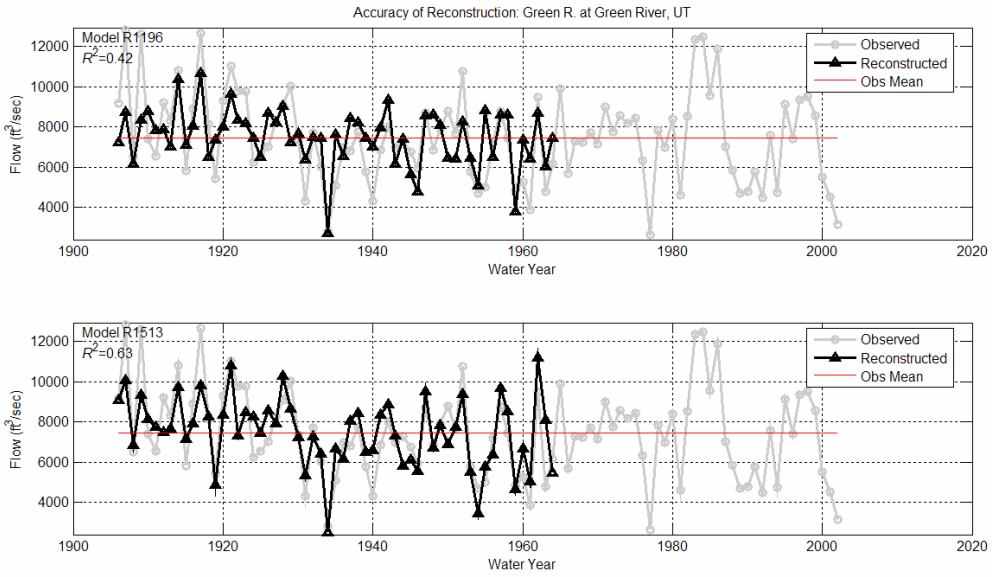

Figure 3D-2. Time series plots of observed and reconstructed flows for calibration period, Green River at Green River, Utah. Top: earliest model, allowing reconstruction to A.D. 1196. Bottom: most recent model, allowing reconstruction to A.D. 1513.

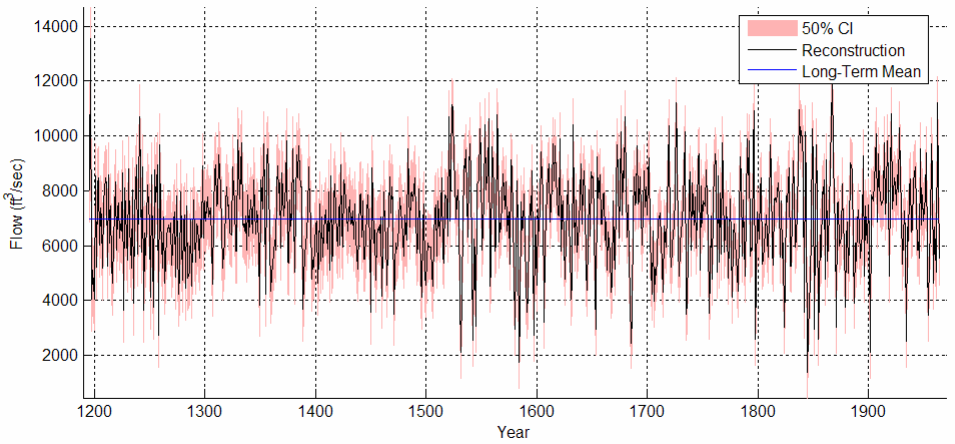

Figure 3D_3. Time series plot of reconstructed annual flows, Green River at Green River, Utah. Confidence interval based on root-mean-square error of cross-validation. Reconstruction for given interval of time based on the most accurate sub-period reconstruction available for that period. Accuracy measured by root-mean-square error of cross-validation.

Table 3D_1. Summary of multi-site regression modeling for Green River at Green River, Utah.

		Calibration[3]			Validation[4]	
N[1]	Start[2]	Years	n-p-q	R^2adj	m	RE	RMSE
1*	1196	1906-1964	4-4-1	0.42	7	0.37	48.9308
2*	1513	1906-1964	22-4-1	0.63	9	0.58	39.7378
3	1513	1906-1964	22-4-1	0.63	9	0.58	39.7378

[1]Sub-period model number (1 is earliest; * marks sub-period models actually used in final reconstruction)
[2]Start year of reconstruction period
[3]Calibration statistics:
Years=calibration period
n=number of chronologies
p=number of potential predictors
q=number of predictors in final model
R^2adj = adjusted coefficient of determination
[4]Validation statistics (cross-validation)
m = number of observations left out in "leave-m-out" cross-validation
RE = reduction of error statistic
RMSE = root-mean-square error of cross-validation (units of RMSE are same as units of the predictand in regression)

NOTES:
Predictand is flow (not transformed)
Predictors = Principal components (covariance matrix) from PCA on full reconstruction + calibration period
Units of predictand in regression = cms
Maximum p-value of overall F for any model = 2.607359E-0083

Table 3D_M1_1. Chronology listing and statistics on prewhitening, model M1196.

				LOCATION[5]			TIME COVERAGE[6]		AR[7]	
N[1]	CHRONOLOGY[2]	FILE[3]	SPECIES[4]	LAT	LON	EL(M)	START	END	p	var
1	Eagle	co052	PSME	39.6	-106.9	1951	1107(1404)	1964	3	37.9
2	Desert Peak	deseret	PSME	40.5	-112.6	-9999	1185(1185)	1986	3	42.7
3	Nine Mile Ca	ut505	PSME	39.8	-110.3	1920	1194(1232)	1964	2	20.3
4	Wild Horse R	UT508	PILO	39.4	-111.1	-9999	286(286)	1985	3	18.7

[1]sequential site number
[2]short form of chronology name
[3]computer file (.crn) identifying chronology in ITRDB and elsewhere (e.g., ca528.crn is unique file at International Tree-Ring Data Bank). File “ad1000s” are chronologies from Ni et al. (2002).
[4]species code(see Appendix 2)
[5]latitude and longitude in decimal degrees; elevation in meters above sea level; N/A indicates information not available
[6]first year of standard chronology (first year sub-sample signal strength – see text -- exceeds 0.85); last year of chronology; N/A means not available
[7]order of autoregressive model used to prewhiten chronology, and percent chronology variance due to modeled autocorrelation

Table 3D_M1_2. Summary of single-site regression/reconstruction, model M1196.

N[1]	CHRONOLOGY[2]	REGRESSION MODEL[3] LAGS	R^2	F	RE[4] A	B
1	Eagle	0	0.29	22.5***	0.44	0.09
2	Desert Peak	0	0.12	10.2**	0.15	0.09
3	Nine Mile Ca	0	0.20	14.0***	0.23	0.25
4	Wild Horse R	0,-2,-3	0.19	9.4***	0.15	0.26

[1]sequential site number
[2]chronology name (truncated)
[3]regression modeling specifications and statistics:
LAGS = lags included on predictors
R^2 = variance explained by regression, adjusted
F = F-level and significance (*, **, *** indicate 0.05, 0.01 and 0.001 alpha-levels)
[4]Reduction of error statistic for split-sample validation;
A = validation on second half of data (calibration on first)
B = validation on first half of data (calibration on second)

Table 3D_M1_3. Summary of stepwise estimation of multi-site reconstruction model M1196.

Step	Variables[1]	R^2adj	RE Statistic[2] A	B	cv	RMSEcv[3]	Residuals[4] r_1	T	N
1	1	0.42	0.30	0.39	0.37	48.9308	P	-	P

[1]Variables included as predictors in the model at the indicated step. Variables are principal components (covariance matrix) from PCA on full period of reconstruction and calibration. Variable 1 is PC#1, variable 2 is PC#2, and so forth.
[2]Reduction of error statistics from (A) calibration on 1906-1934 and validation on 1935-1964, (B) calibraton on 1935-1964 and validation on 1906-1934, (cv)cross-validation with 7 observations left out at each iteration
[3]Root-mean-square error of cross-validation, in cms
[4]Results of analysis of residuals: r_1 is Durbin-Watson(DW) test for first-order autocorrelation of residuals; T is test for significant slope in regression of residuals on time (trend); N is Lilliefors test for normality of residuals; "P" for DW and N tests indicates “pass”, or test statistic not significant at 0.05 alpha-level; 0 indicates slope of trend line not significant at 0.05 level, while - or + indicates significant negative or positive trend in residuals

Model Equation: constant term, coefficients, confidence interval, selected statistics:

Var	Coef	95% CI	
Con	193.8285	(180.1786	207.4784)
X1	1.018138	(0.7020567	1.334218)

R-squared = 0.42194
F-level = 41.6051
sig = 2.607359E-0089

Table 3A_M1_4. Weights[1] of chronologies in principal components and final regression.

		LOADINGS		

N	CHRONOLOGY	X1	W	W*
1	Eagle	0.711	0.3867	1.00
2	Desert Peak	0.249	0.0883	0.23
3	Nine Mile Ca	0.499	0.2269	0.59
4	Wild Horse R	0.428	0.2031	0.53

[1]Columns X1, X2,... are the principal component loadings on the chronologies. X1 denotes PC1, X2 denotes PC1, and so forth. Final, or multi-site, reconstruction was generated by regression of flow on the PC scores. The final reconstruction can be generated by applying the estimated regression equation to those PC scores. The final reconstruction can alternatively be generated from the individual filtered, scaled chronologies themselves. To generate the final from the chronologies, the applicable weights are in column "W". ("W*" are the same weights proportionally scaled so that the largest weight is 1.0.) The weights W and W* measure the relative importance of the individual chronologies to the final reconstruction. Steps for generating reconstruction from original chronologies:

1) filter and scale the original chronologies into single-site (ss) reconstructions as described in the text
2) convert ss reconstructions to Z scores, using calibration period means and standard deviations
3) multiply those z-score series by the regression weights in next-to-last column (W) above, and sum the weighted series
4) multiply resulting series by calibration-period standard deviation of flow and add the calibration-period mean observed flow

Table 3D_M2_1. Chronology listing and statistics on prewhitening, model M1513.

N[1]	CHRONOLOGY[2]	FILE[3]	SPECIES[4]	LOCATION[5] LAT	LON	EL(M)	TIME COVERAGE[6] START	END	AR[7] p	var
1	New North Pa	co050	PSME	40.9	-106.3	2469	1354(1650)	1964	3	27.8
2	Eagle	co052	PSME	39.6	-106.9	1951	1107(1404)	1964	3	37.9
3	Eagle East	co063	PIED	39.7	-106.7	2164	1314(1403)	1964	3	16.5
4	Pumphouse	CO579	PIED	40.0	-106.5	-9999	1320(1379)	1999	2	21.6
5	Desert Peak	deseret	PSME	40.5	-112.6	-9999	1185(1185)	1986	3	42.7
6	Mt Naomi	mtnaomi	PSME	41.9	-111.7	-9999	1312(1312)	1986	3	32.9
7	Mt Raymond,	raymond	PSME	40.6	-111.8	-9999	1473(1473)	1986	2	34.5
8	South of Pea	speak78	PSME	41.5	-112.0	-9999	1429(1429)	1990	3	24.5
9	Uinta Mounta	ut013	PCEN	40.8	-110.0	3353	1433(1584)	1971	3	52.5
10	Uinta Mounta	ut502	PIED	40.6	-110.0	2289	1423(1423)	1971	2	24.7
11	Nine Mile Ca	ut505	PSME	39.8	-110.3	1920	1194(1232)	1964	2	20.3
12	Wild Horse R	UT508	PILO	39.4	-111.1	-9999	286(286)	1985	3	18.7
13	Uhl Hill	wy001	PIFL	43.8	-110.5	2225	1400(1400)	1971	3	48.3
14	Wind River M	wy002	PIFL	43.1	-110.1	2500	1492(1577)	1972	3	27.7
15	Gros Ventre	wy008	PIFL	43.6	-110.5	2179	1462(1462)	1971	2	27.2
16	Laramie, Sit	WY010	PSME	41.1	-106.1	-9999	1444(1444)	1964	3	22.0
17	Elbow Campgr	WY013	PSME	43.2	-110.8	-9999	1490(1490)	1965	3	35.1
18	Pedro Mounta	WY016	PIFL	42.4	-106.8	-9999	1508(1508)	1964	3	19.7
19	Sheep Mounta	WY019	PSME	41.1	-106.1	-9999	1412(1412)	1990	3	10.9
20	Medicine Bow	WY020	PCEN	41.4	-106.3	-9999	1421(1421)	1990	3	62.4
21	Fossil Butte	WY026	PIFL	41.9	-110.8	-9999	1480(1480)	1998	2	26.4
22	Whiskey Moun	WY028	PSME	43.4	-109.6	-9999	1459(1459)	2000	2	14.1

[1]sequential site number
[2]short form of chronology name
[3]computer file (.crn) identifying chronology in ITRDB and elsewhere (e.g., ca528.crn is unique file at International Tree-Ring Data Bank). File “ad1000s” are chronologies from Ni et al. (2002).
[4]species code(see key on Appendix 2)
[5]latitude and longitude in decimal degrees; elevation in meters above sea level; N/A indicates information not available
[6]first year of standard chronology (first year sub-sample signal strength -- see text -- exceeds 0.85), last year of chronology; N/A indicated information not available
[7]order of autoregressive model used to prewhiten chronology, and percent chronology variance due to modeled autocorrelation

Table 3D_M2_2. Summary of single-site regression/reconstruction, model M1513

		REGRESSION MODEL[3]			RE[4]	
N[1]	CHRONOLOGY[2]	LAGS	R^2	F	A	B
1	New North Pa	0	0.10	6.0*	0.08	0.11
2	Eagle	0	0.29	22.5***	0.44	0.09
3	Eagle East	0,-1	0.46	24.0***	0.55	0.52
4	Pumphouse	0,-1	0.44	36.0***	0.39	0.52
5	Desert Peak	0	0.12	10.2**	0.15	0.09
6	Mt Naomi	1	0.19	18.0***	0.07	0.44
7	Mt Raymond,	0,1	0.11	9.3**	0.10	0.16
8	South of Pea	0,-2,1	0.20	7.5***	0.11	0.39
9	Uinta Mounta	0	0.09	6.3*	0.28	0.00
10	Uinta Mounta	0	0.36	35.9***	0.46	0.26
11	Nine Mile Ca	0	0.20	14.0***	0.23	0.25
12	Wild Horse R	0,-2,-3	0.19	9.4***	0.15	0.26
13	Uhl Hill	0	0.07	4.9*	0.16	0.01
14	Wind River M	0	0.10	6.8*	0.11	0.02
15	Gros Ventre	0	0.09	6.3*	0.12	0.08
16	Laramie, Sit	0,-1	0.21	8.1***	0.16	0.24
17	Elbow Campgr	1	0.07	4.4*	0.08	0.05
18	Pedro Mounta	-2	0.13	8.1**	0.11	0.00
19	Sheep Mounta	0,-1,1	0.32	20.0***	0.30	0.37
20	Medicine Bow	1	0.11	10.4**	0.01	0.25
21	Fossil Butte	0,-2	0.15	15.7***	0.11	0.17
22	Whiskey Moun	0,-1	0.07	7.3**	0.02	0.14

[1]sequential site number
[2]chronology name (truncated)
[3]regression modeling specifications and statistics:
LAGS = lags included on predictors
R^2 = variance explained by regression, adjusted
F = F-level and significance (*, **, *** indicate 0.05, 0.01 and 0.001 alpha-levels)
[4]Reduction of error statistic for split sample validation;
A = validation on second half of data (calibration on first)
B = validation on first half of data (calibration on second)

Table 3D_M2_3. Summary of stepwise estimation of multi-site reconstruction, model M1513.

			RE Statistic[2]				Residuals[4]		
Step	Variables[1]	R^2adj	A	B	cv	RMSEcv[3]	r_1	T	N
1	1	0.63	0.57	0.60	0.58	39.7378	P	-	P

[1]Variables included as predictors in the model at the indicated step. Variables are principal components (covariance matrix) from PCA on full period of reconstruction and calibration. Variable 1 is PC#1, variable 2 is PC#2, and so forth.
[2]Reduction of error statistics from (A) calibration on 1906-1934 and validation on 1935-1963, (B) calibraton on 1935-1963 and validation on 1906-1934, (cv) cross-validation with 9 observations left out at each iteration
[3]Root-mean-square error of cross-validation, in cms
[4]Results of analysis of residuals: r_1 is Durbin-Watson (DW) test for first-order autocorrelation of residual; T is test for significant slope in regression of residuals on time (trend); N is Lilliefors test for normality of residuals; "P" for DW and N test indicates "pass", or test statistic not significant at 0.05 alpha-level; 0 indicates slope of trend line not significant at 0.05 level, while - or + indicates significant negative or positive trend in residuals

Model Equation: constant term, coefficients, confidence interval, selected statistics:

Var	Coef	95% CI	
Con	200.5488	(190.3815	210.716)
X1	-0.6692078	(-0.8047193	-0.5336963)

R-squared = 0.63176
F-level = 97.7912
sig = 5.651035E-0149

Table 3D_M2_4. Weights[1] of chronologies in principal components and final regression.

		LOADINGS			
N1	CHRONOLOGY	X1	X2	W	W*
1	New North Pa	-0.128	0.0272	0.12	
2	Eagle	-0.260	0.0928	0.39	
3	Eagle East	-0.517	0.2356	1.00	
4	Pumphouse	-0.538	0.2291	0.97	
5	Desert Peak	-0.093	0.0216	0.09	
6	Mt Naomi	-0.054	0.0145	0.06	
7	Mt Raymond,	-0.073	0.0135	0.06	
8	South of Pea	-0.095	0.0300	0.13	
9	Uinta Mounta	-0.032	0.0063	0.03	
10	Uinta Mounta	-0.284	0.1120	0.48	
11	Nine Mile Ca	-0.172	0.0513	0.22	
12	Wild Horse R	-0.134	0.0419	0.18	
13	Uhl Hill	-0.069	0.0123	0.05	
14	Wind River M	-0.113	0.0229	0.10	
15	Gros Ventre	-0.085	0.0172	0.07	
16	Laramie, Sit	-0.233	0.0742	0.31	
17	Elbow Campgr	-0.008	0.0015	0.01	
18	Pedro Mounta	0.002	-0.0004	-0.00	
19	Sheep Mounta	-0.301	0.1151	0.49	
20	Medicine Bow	-0.058	0.0119	0.05	
21	Fossil Butte	-0.158	0.0403	0.17	
22	Whiskey Moun	-0.070	0.0132	0.06	

[1]Columns X1, X2,... are the principal component loadings on the chronologies. X1 denotes PC1, X2 denotes PC1, and so forth. Final, or multi-site, reconstruction was generated by regression of flow on the PC scores. The final reconstruction can be generated by applying the estimated regression equation to those PC scores. The final reconstruction can alternatively be generated from the individual filtered, scaled chronologies themselves. To generate the final from the chronologies, the applicable weights are in column "W". ("W*" are the same weights proportionally scaled so that the largest weight is 1.0.) The weights W and W* measure the relative importance of the individual chronologies to the final reconstruction. Steps for generating reconstruction from original chronologies:

1) filter and scale the original chronologies into single-site (ss) reconstructions as described in the text
2) convert ss reconstructions to Z scores, using calibration period means and standard deviations
3) multiply those z-score series by the regression weights in next-to-last column (W) above, and sum the weighted series
4) multiply resulting series by calibration-period standard deviation of flow and add the calibration-period mean observed flow