Memo

To: Thad Kuntz, Adaptive Resources, Inc.
John Berge, North Platte NRD
From: Kara Sobieski, Wilson Water Group
Date: 11/4/2014
Re: WWUM Historical Calibrated Surface Water Allocation Model

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The Western Water Use Management Model Water Resources Planning Model (WWUM Model) is a water allocation model, which determines availability of water to individual users and projects, based on hydrology, water rights, operating rules and irrigation practices. Additionally, the model reflects the inter-connectivity between surface and ground water uses in the basin. This model was created and analyzed through StateMod, a publically available FORTRAN-based modeling tool.

The WWUM Historical Calibrated Scenario was developed first to assist with the integration of surface water information into the WWUM ground water model. This model scenario reflects historical diversions, well pumping, irrigation consumptive use, and historical operations as they occurred over the 1953 to 2012 period. The model was calibrated by comparing diversions, reservoir contents, and streamflow simulated by the model to the historical gaged records. If the simulated results match or closely mimic the historical gaged records, the model is considered to be "calibrated". This provides the user with confidence that the model reasonably reflects the actual conditions in the basin and can reproduce these conditions using the model inputs (e.g. hydrology, diversions, return flows and operations). Comparison graphs at key gages and diversion points can be found at the end of this memorandum.

The key results of the WWUM Historical Calibrated Modeling efforts are as follows:

- A water resources planning model that can make comparative analyses of historical and future water management policies in the North Platte River Valley and the WWUM study area, over the 1953 to 2012 period and including 100 percent of the basin's surface water use.
- The model provides information to parallel WWUM modeling efforts (e.g. the WWUM Ground Water model) through calibration of overland and sub-surface flows that accrue to tributaries, drains, and the mainstem.

- The model encompasses irrigated acreage and operations for major irrigation districts located in Wyoming, accounting for the impact of upstream water use on downstream users in Nebraska.
- The model provides system-wide information in the basin, specifically on how different water rights "drive" the river and the river reaches that are more susceptible to shortages in drought.
- The model provides information on irrigation practices, including trends in surface water vs. ground water use and seasonality of when supplies are used.

In addition to providing information to other models, the Historical Calibrated Scenario can serve as a platform to run "what-if" scenarios. "What-if" model scenarios are based on the original historical model but also include a future potential change in operations or demands. The "what-if" scenario is then simulated and the results are compared to the original model to identify how the future potential change would perform or impact the existing uses and water rights. Examples of future potential "what-if" scenarios include:

- a new reservoir
- changed water rights for municipal or recharge uses
- changes in irrigation practices or efficiencies
- new depletions or demands in the basin or downstream of the basin.

The model is a planning tool and can provide information to decision-makers at a planning level. The model is not an operational model, therefore it is not appropriate to predict day-to-day operations. The power of the model is to implement a specific potential future operation and then analyze the results to understand the impact over the entire modeled system.

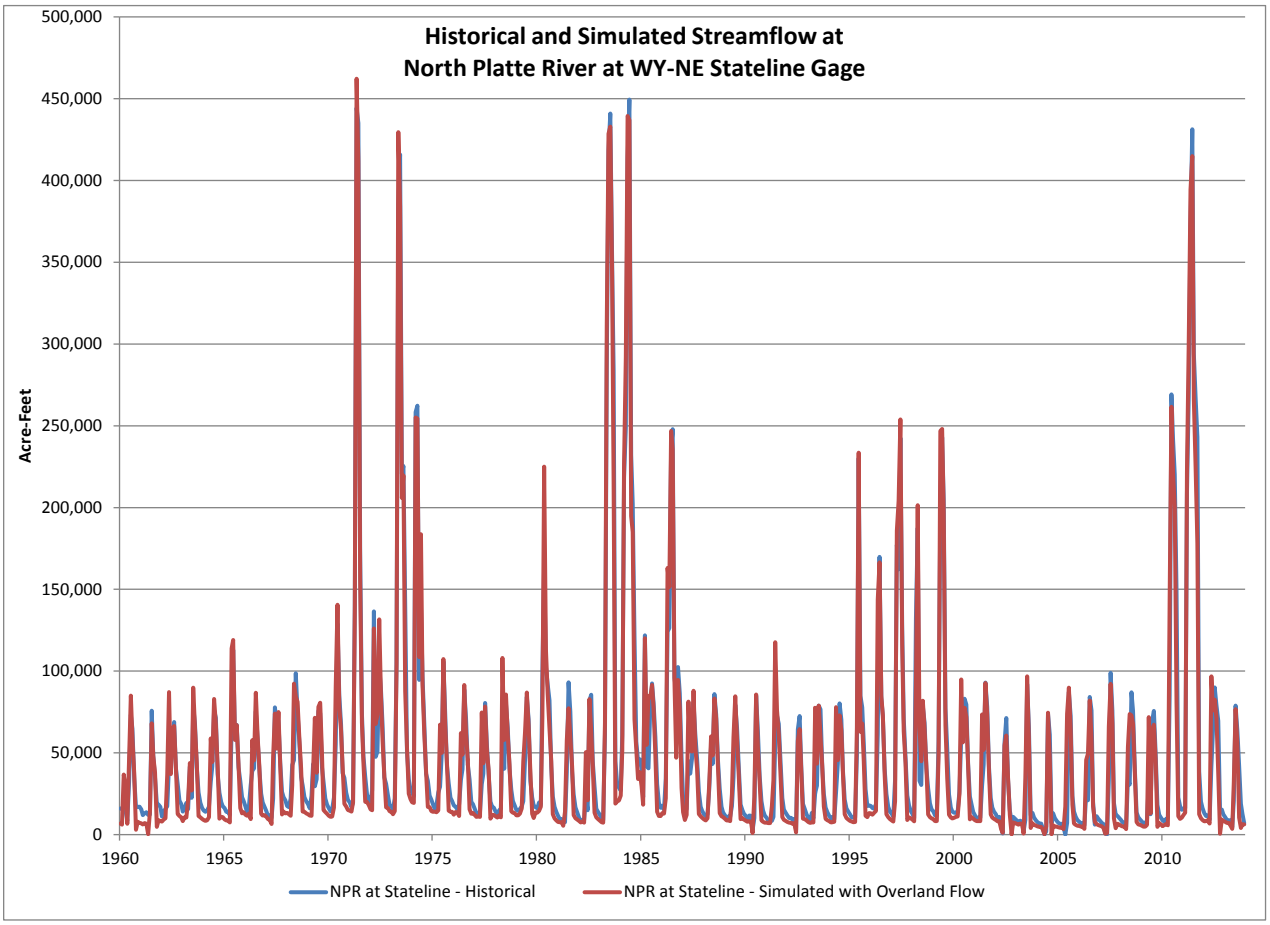
The next steps for this modeling effort are anticipated to be the completion of model documentation and training of the other WWUM modelers on the inputs, outputs, and functionality of the model. Additionally, it is anticipated that the model will be used to investigate conservation practices in support of the POAC effort and as a source of information for, or as a platform for comparison to, future modeling efforts in the basin.

Historical vs. Simulated Results from the Historical Calibrated Model

As discussed above, the model developer can assess the level of calibration based on how well it can mimic historical results. The graphs below show the historical diversions and streamflow compared to those simulated by the model at key locations. The comparison indicates that the model is reasonably calibrated and can be used for future planning efforts. Some of the calibration challenges included:

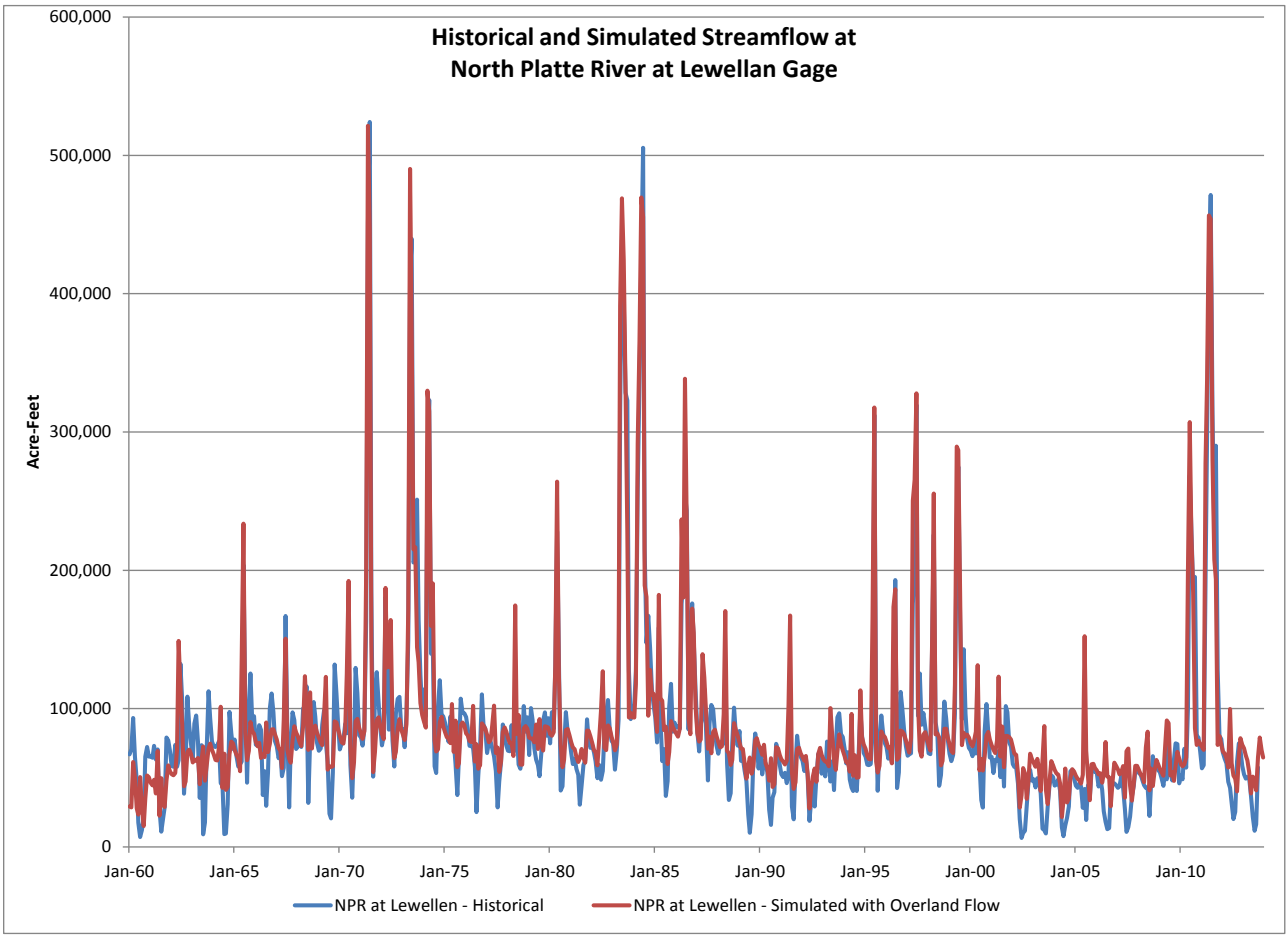
- The model operates according to Prior Appropriation and user-specified model input; it can be difficult to simulate historical irrigation practices that vary overtime or are based on water user decisions, such as:
    - Pumping of ground water in lieu of taking surface water supplies
    - Operations and measures taken during flood events
    - The variability or option of diverting from the mainstem, diverting from a carrier on a smaller tributary, or releasing from a reservoir
    - Localized precipitation events and decisions to irrigate or not irrigate based on these events
- The model allows for variable efficiency whereby the efficiency of a ditch system will be lower during times the system is “water-long” and higher when a system is “water-short”. This allows flexibility with the efficiency in the system, however it cannot replicate the variable efficiency seen on a day-to-day basis at the farm level, or the variable conveyance efficiency that changes with the amount of water that is conveyed. The extreme length of many of the larger canals in the North Platte Basin, as well as lack of good efficiency information, further compounds this issue.

Figure 1: Simulated vs. Historical Streamflow Gages at the Stateline Gage



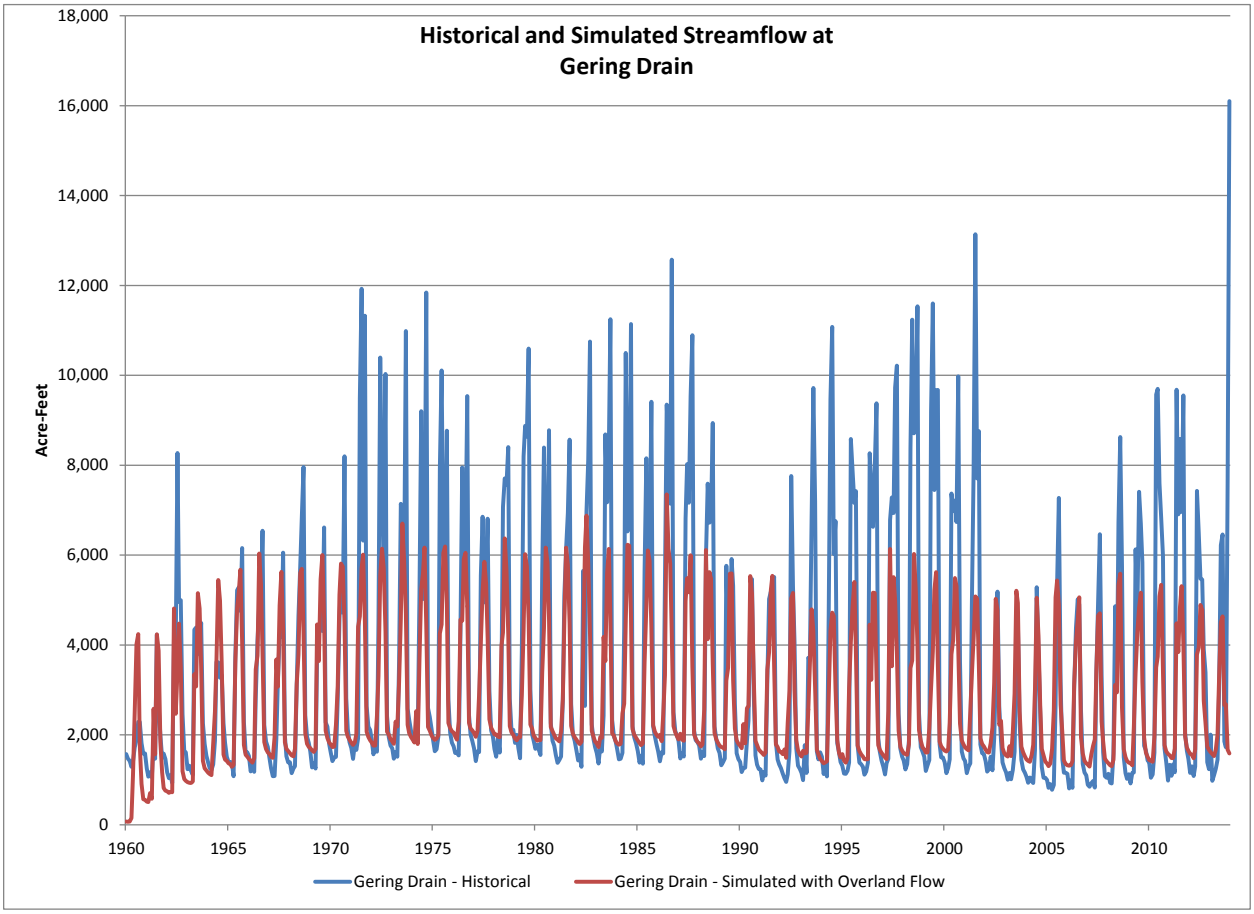
As illustrated, this gage shows excellent correlation between the simulated and historical streamflow records, indicating that modeled diversions, efficiencies, and return flow patterns in Wyoming mimic the historical conditions.

Figure 2: Simulated vs. Historical Streamflow Gages at the Lewellan Gage



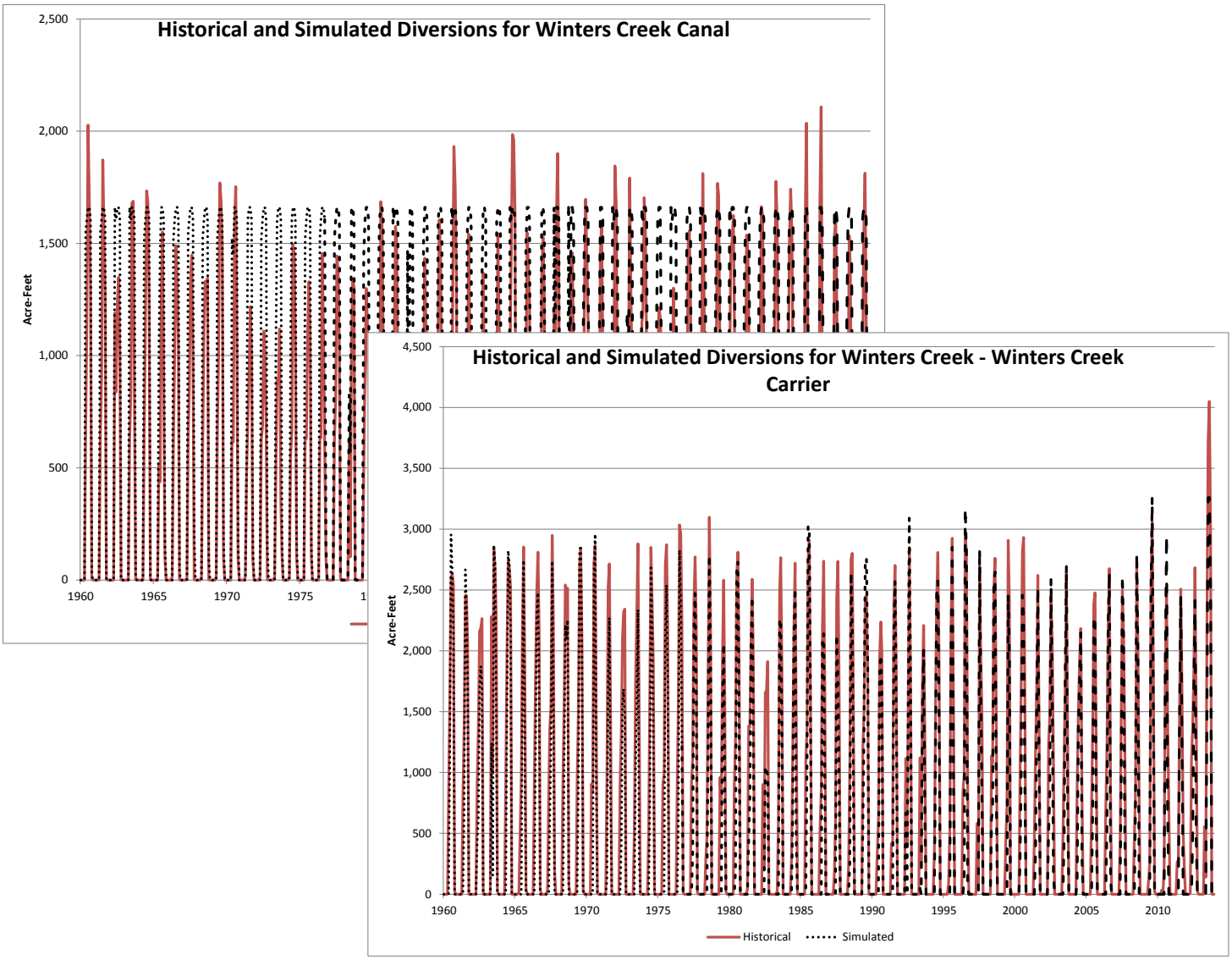
At the downstream gage in the model, the simulated streamflow follows the general trend seen in the historical gage record; the simulated flow however does not mimic the summer low flows. This variation is likely caused by differences between modeled and actual return flows and estimated natural flow. The large spikes in simulated flow seen in June of 1991 and 2005, for example, can be directly linked to the operational differences of Inland Lakes storage and releases in the model compared to actual operations. Overall, the model can reasonably reflect the basin operations and demand from Whalen Dam down to Lewellan through variable hydrological conditions.

Figure 3: Simulated vs. Historical Streamflow Gages at Gering Drain



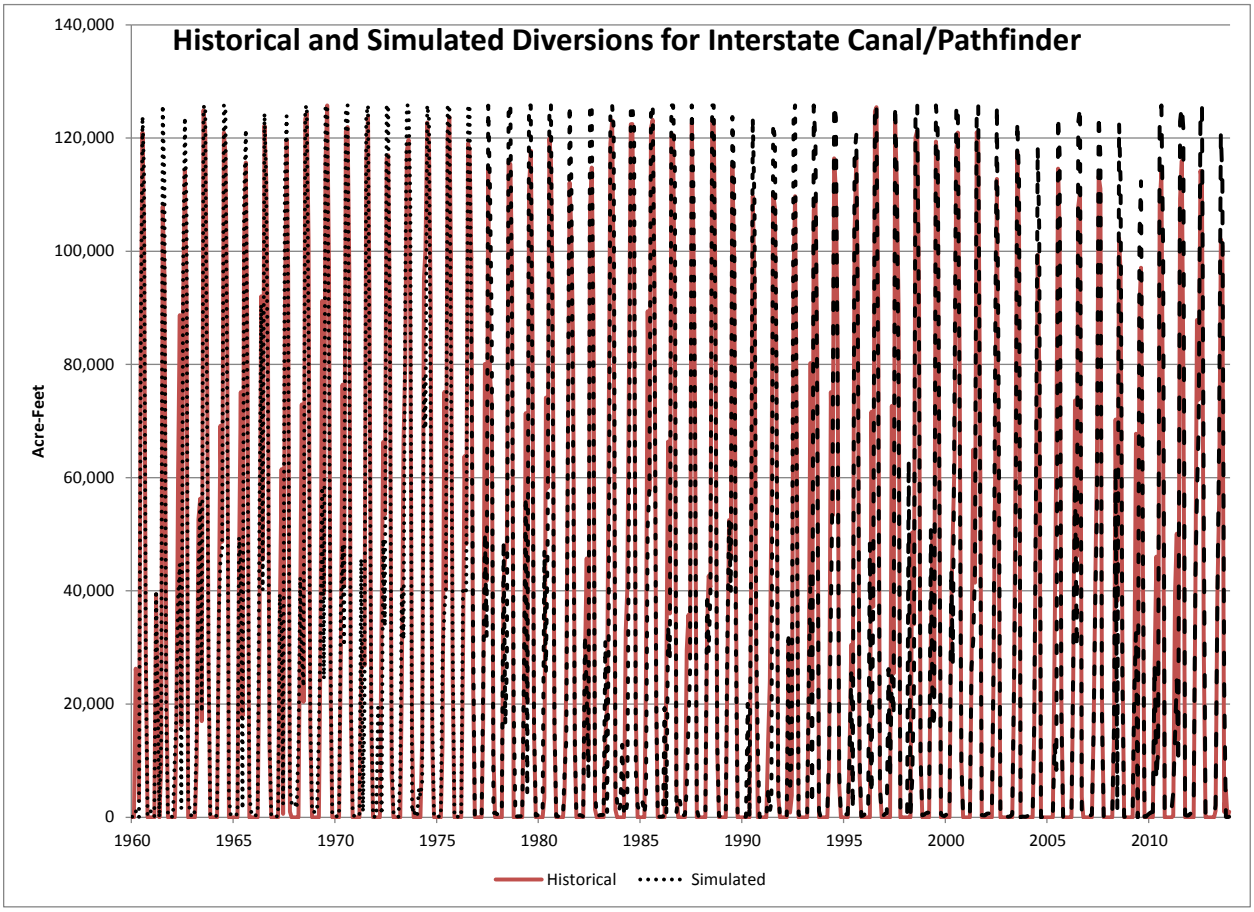
The amount of non-consumed irrigation water in the model is estimated based on the amount of diversions, conveyance and application efficiencies, and the irrigation demand. The timing and location of how these return flows accrue back to the river is supplied by the user. For this model, the timing and location of sub-surface return flows were based on output from the WWUM Ground Water Model. The portion of the return flows that accrue back the river via overland flow was developed through analysis of simulated flow in the drains, such as the Gering Drain. An initial estimate of overland flow (e.g. 10% of return flows) was simulated in the model, and the resulting flow in the drains was compared to the historical gaged record. If the simulated flow in the drain was too low, the overland return flow percent was increased and the model was simulated again. As shown in the graph above for Gering Drain, the simulated flow mimics the actual flow reasonably well indicating that the sub-surface and overland return flow timing and locations are reasonable for the planning model.

Figure 4: Simulated vs. Historical Diversions at Winter's Creek Canal and Carrier



These figures reflect the simulated vs. historical diversions from two headgates that carry water to serve a common irrigation demand. As shown, the mainstem headgate generally diverts more than historical, and the carrier generally diverts less. This occurs because the model requires preference be given to one diversion point over another, even though they divert under water rights with the same priority. In the case of Winter's Creek, the mainstem diversion was given preference, and a capacity limitation prevented the entire irrigation demand be met from the mainstem headgate. The remaining irrigation demand is met by diversions from the carrier headgate, and together they meet the entire irrigation demand. Carrier operations affect many of the irrigation systems in the basin, most notably Northport Irrigation District, Enterprise Canal, Winter's Creek Canal and Ninemile Canal.

Figure 5: Simulated vs. Historical Diversions at Interstate Canal



The model simulates diversions directly to irrigation and to storage based on user-specified and legally and physically available flow in the river. As water users are aware of, there is not one specific trigger as to when diversions to storage are diverted or released for use. With respect to Interstate Canal, the WWUM Team spoke with NDNR staff and Pathfinder Irrigation District to understand how Inland Lakes are used in their system. This operational information was translated into model input and resulted in simulated diversions that reasonably reflect the historical diversions. Interstate Canal generally diverts less water in June and more water in July than historical diversions reflect, causing a difference in flow throughout the entire system in those months. Although the over- or under- simulation of diversions is small percentage-wise, a small difference in diversions at Interstate Canal or storage in Inland Lakes can equate to 50,000 acre-feet of water in a single month.

In general however, the simulated results correlate reasonably well with the historical records; a complete set of comparison graphs is provided with the model deliverable. Recommended areas for improvement would be additional calibration of efficiency information and refinement of natural flows.

Wyoming/Nebraska Stateline

Interstate
9-19-1904, 1,572 cfs

Inland Lakes

Northport
9-19-1904, 230.07 cfs
(NPR & 5 tributaries)

North Platte River

Tri-State Canal
9-16-1887, 847.18 cfs
3-20-1893, 0.74 cfs
4-14-1902, 45 cfs

Sheep Creek

Enterprise Canal
3-28-1889, 133 cfs

3-28-1889
10 cfs

Morrill Drain

Akers Draw

Dry Spotted Tail Creek

3-28-1889
3.77 cfs

Wet Spotted Tail Creek

3-28-1889
39.1 cfs

Tub Springs

Winters Creek Canal
10-18-1888, 42 cfs

3-28-1889
2.43 cfs

Winters Creek

10-18-1888
53 cfs

Minatare Canal
1-14-1888, 116 cfs

Ninemile Creek

12-6-1893, 77 cfs

Ninemile Canal
1-14-1888, 2.28 cfs
12-6-1893, 105.42 cfs

Shortline Canal
5-1-1893, 53 cfs

Gering Irrig. Dist.
6-23-1890, 0.27 cfs
3-15-1897, 208.21 cfs

Mitchell-Gering Canal

Mitchell Irrig. Dist.
6-20-1890, 191.86 cfs

Horse Creek

Owl Creek

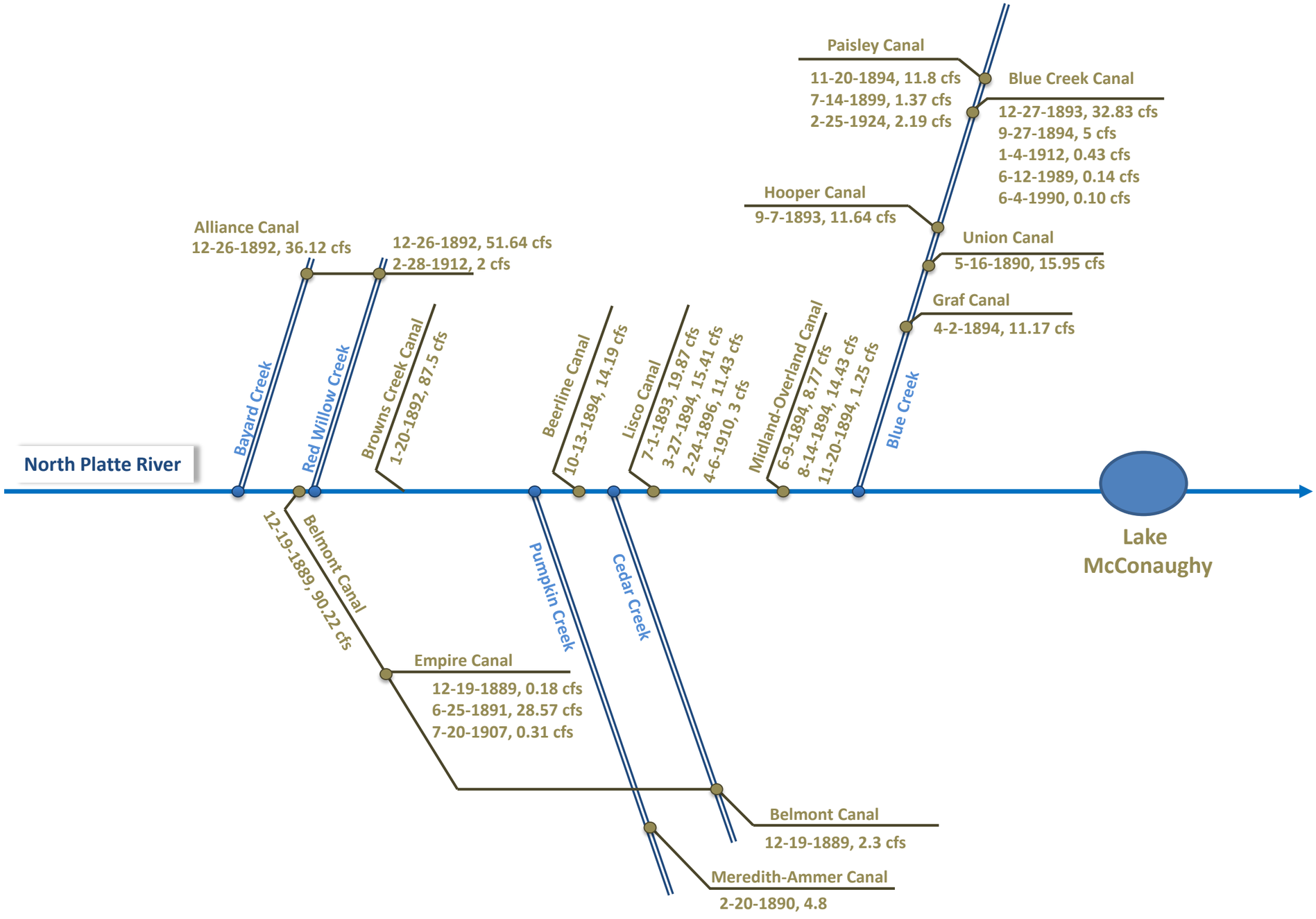
Gering-Ft Laramie Canal
9-19-1904, 780.59 cfs

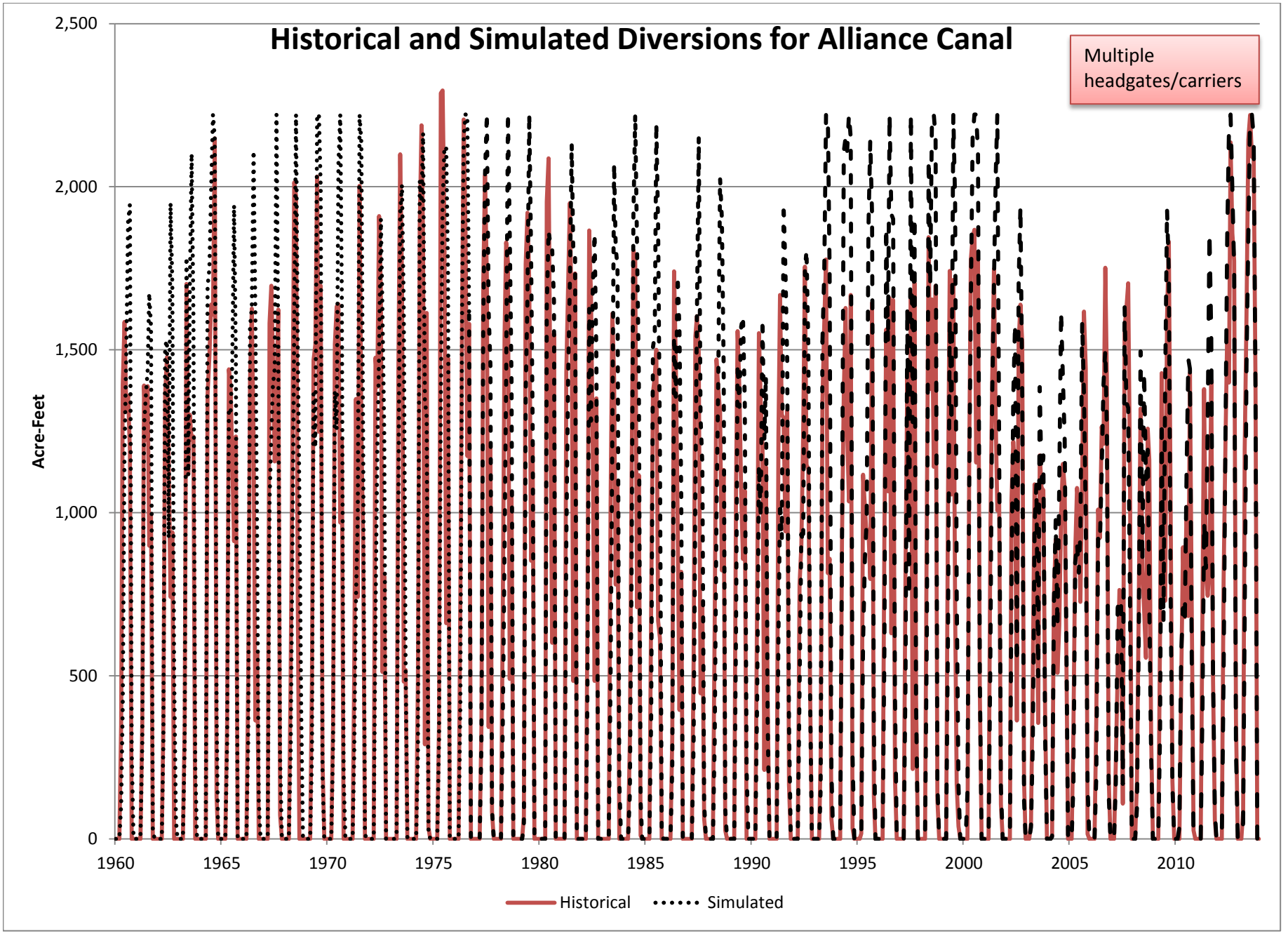
9-17-1897, 0.79 cfs
10-10-1904, 1.14 cfs
11-29-1907, 1.71 cfs

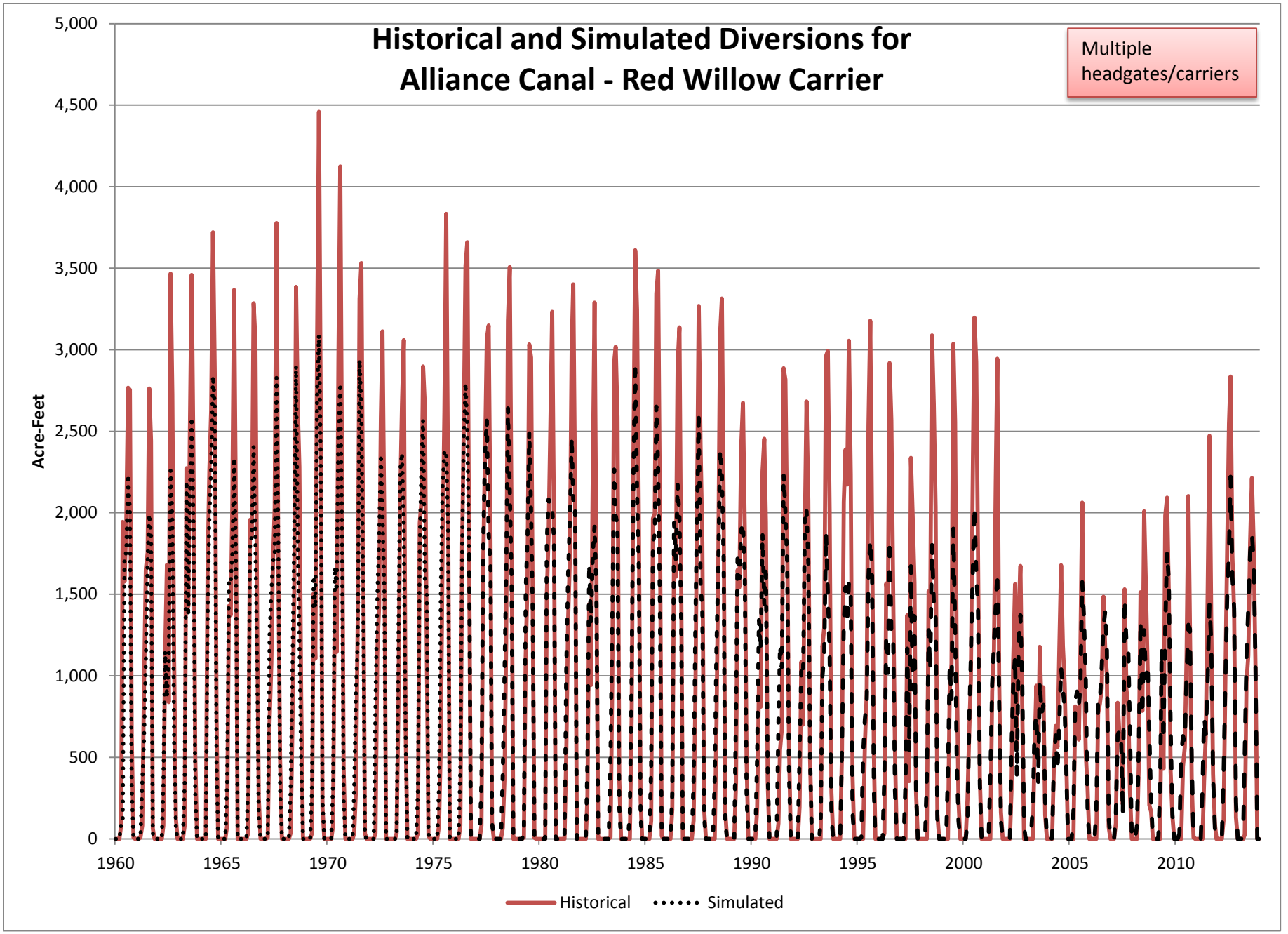
Central Canal
6-23-1890, 33.17 cfs
8-17-1992, 0.13 cfs

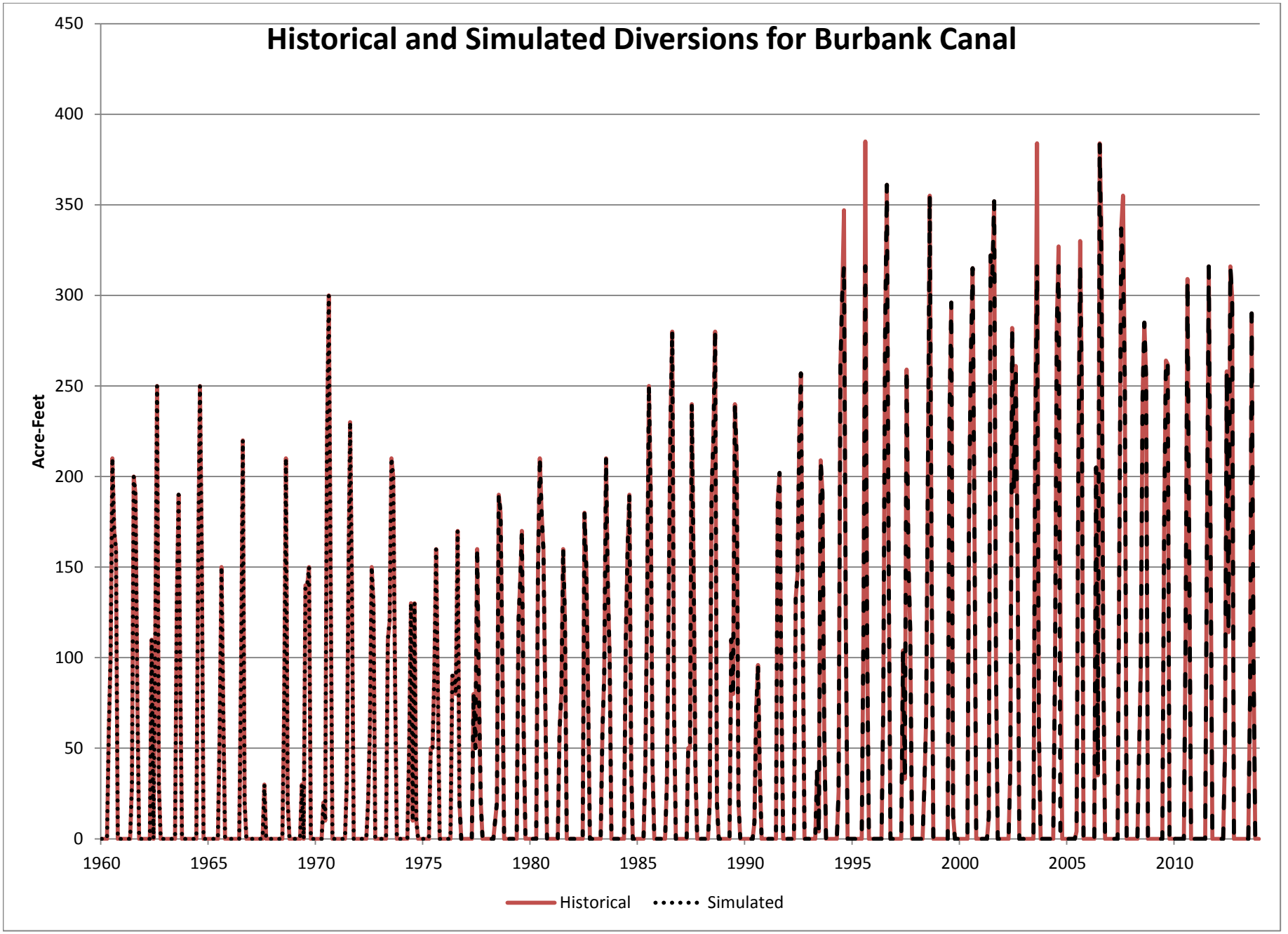
Castle Rock Canal
4-18-1889, 82.39 cfs
10-22-1895, 4.84 cfs
7-22-1896, 0.85 cfs

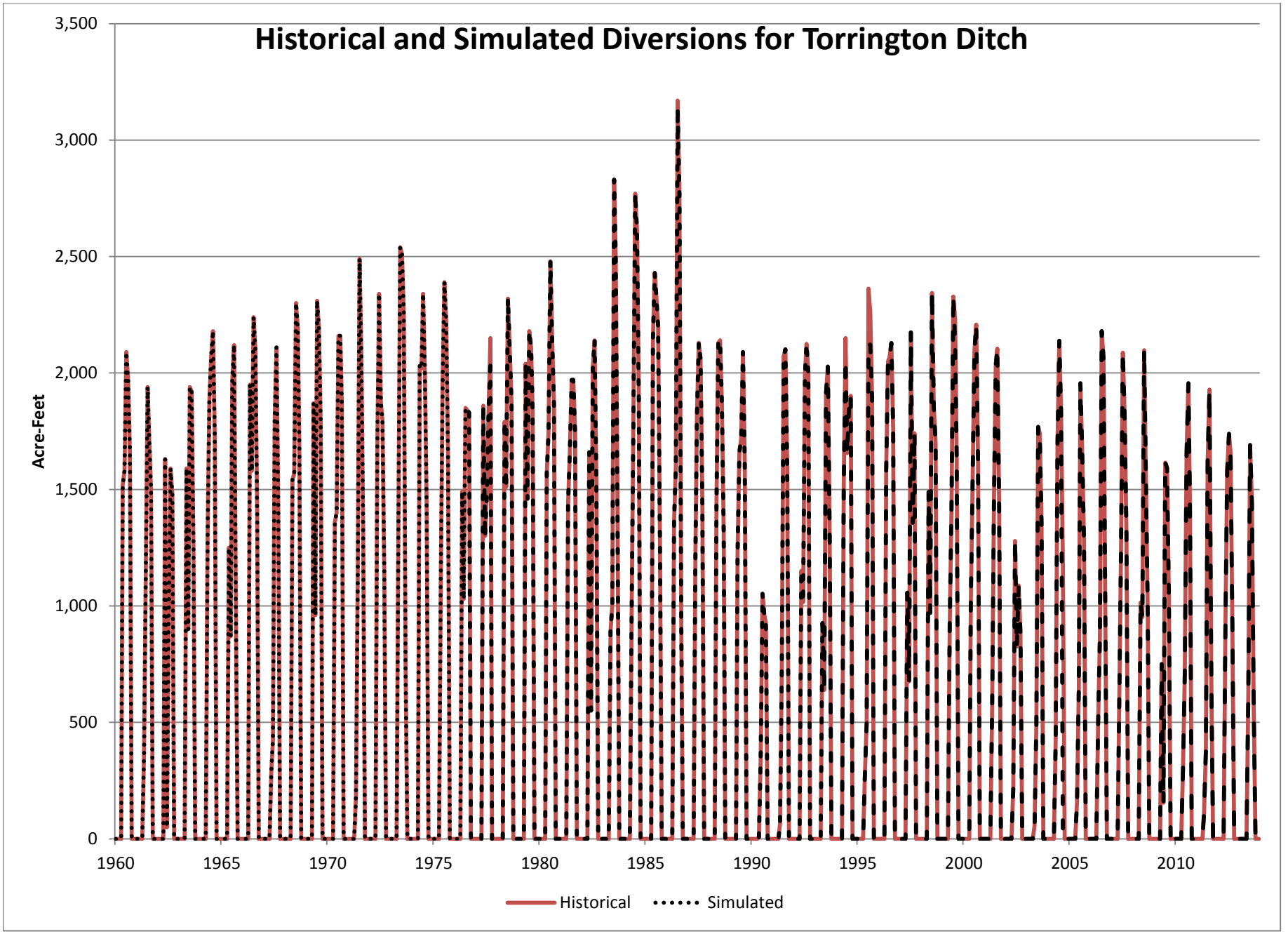
Chimney Rock Canal
12-3-1890, 60 cfs
2-2-1931, 0.67 cfs

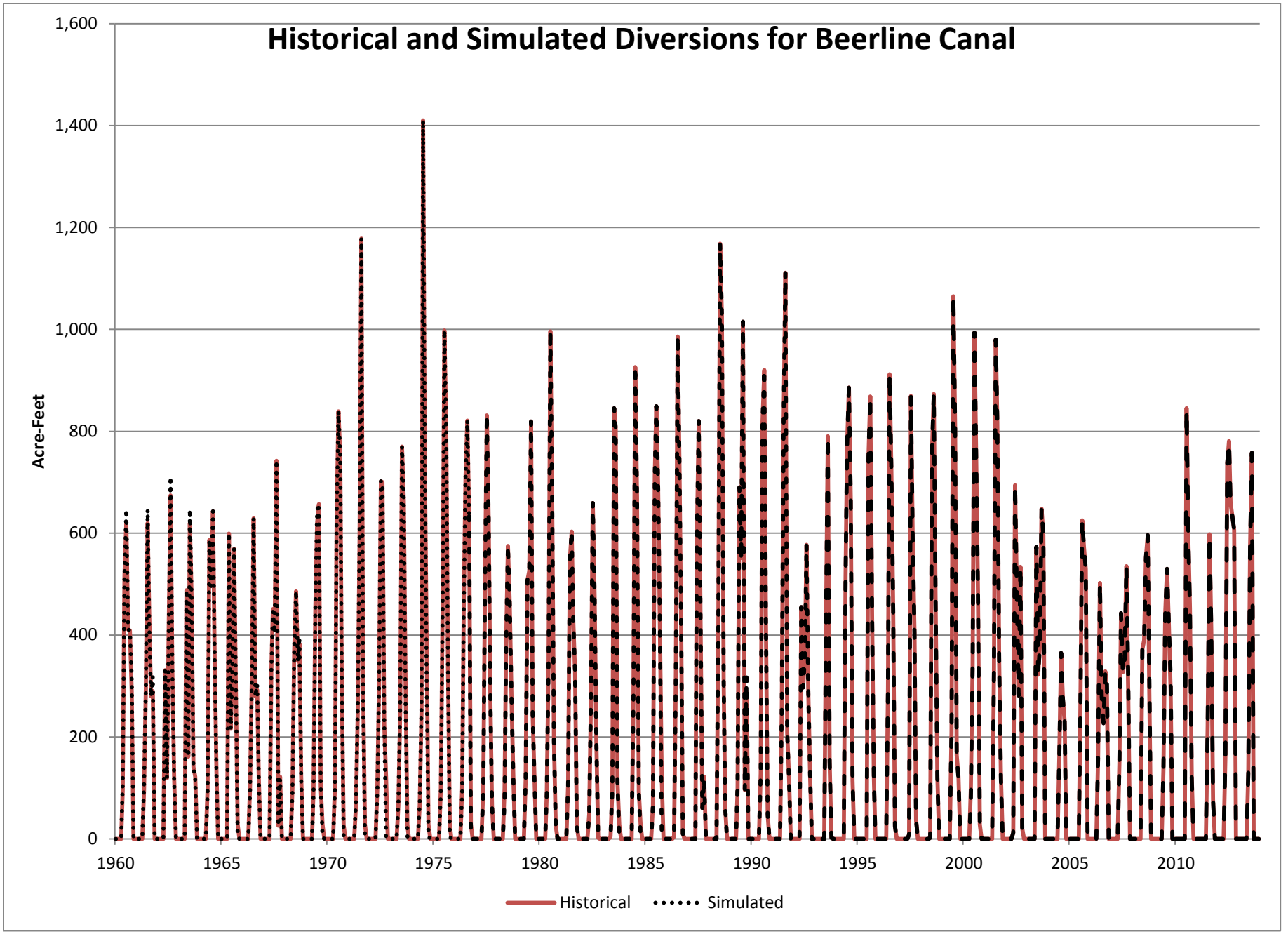

Paisley Canal
11-20-1894, 11.8 cfs
7-14-1899, 1.37 cfs
2-25-1924, 2.19 cfs
Blue Creek Canal
12-27-1893, 32.83 cfs
9-27-1894, 5 cfs
1-4-1912, 0.43 cfs
6-12-1989, 0.14 cfs
6-4-1990, 0.10 cfs
Hooper Canal
9-7-1893, 11.64 cfs
Union Canal
5-16-1890, 15.95 cfs
Graf Canal
4-2-1894, 11.17 cfs
Alliance Canal
12-26-1892, 36.12 cfs
12-26-1892, 51.64 cfs
2-28-1912, 2 cfs
Bayard Creek
Red Willow Creek
Browns Creek Canal
1-20-1892, 87.5 cfs
Beerline Canal
10-13-1894, 14.19 cfs
Lisco Canal
7-1-1893, 19.87 cfs
3-27-1894, 15.41 cfs
2-24-1896, 11.43 cfs
4-6-1910, 3 cfs
Midland-Overland Canal
6-9-1894, 8.77 cfs
8-14-1894, 14.43 cfs
11-20-1894, 1.25 cfs
Blue Creek
North Platte River
Lake
McConaughy
Belmont Canal
12-19-1889, 90.22 cfs
Pumpkin Creek
Cedar Creek
Empire Canal
12-19-1889, 0.18 cfs
6-25-1891, 28.57 cfs
7-20-1907, 0.31 cfs
Belmont Canal
12-19-1889, 2.3 cfs
Meredith-Ammer Canal
2-20-1890, 4.8

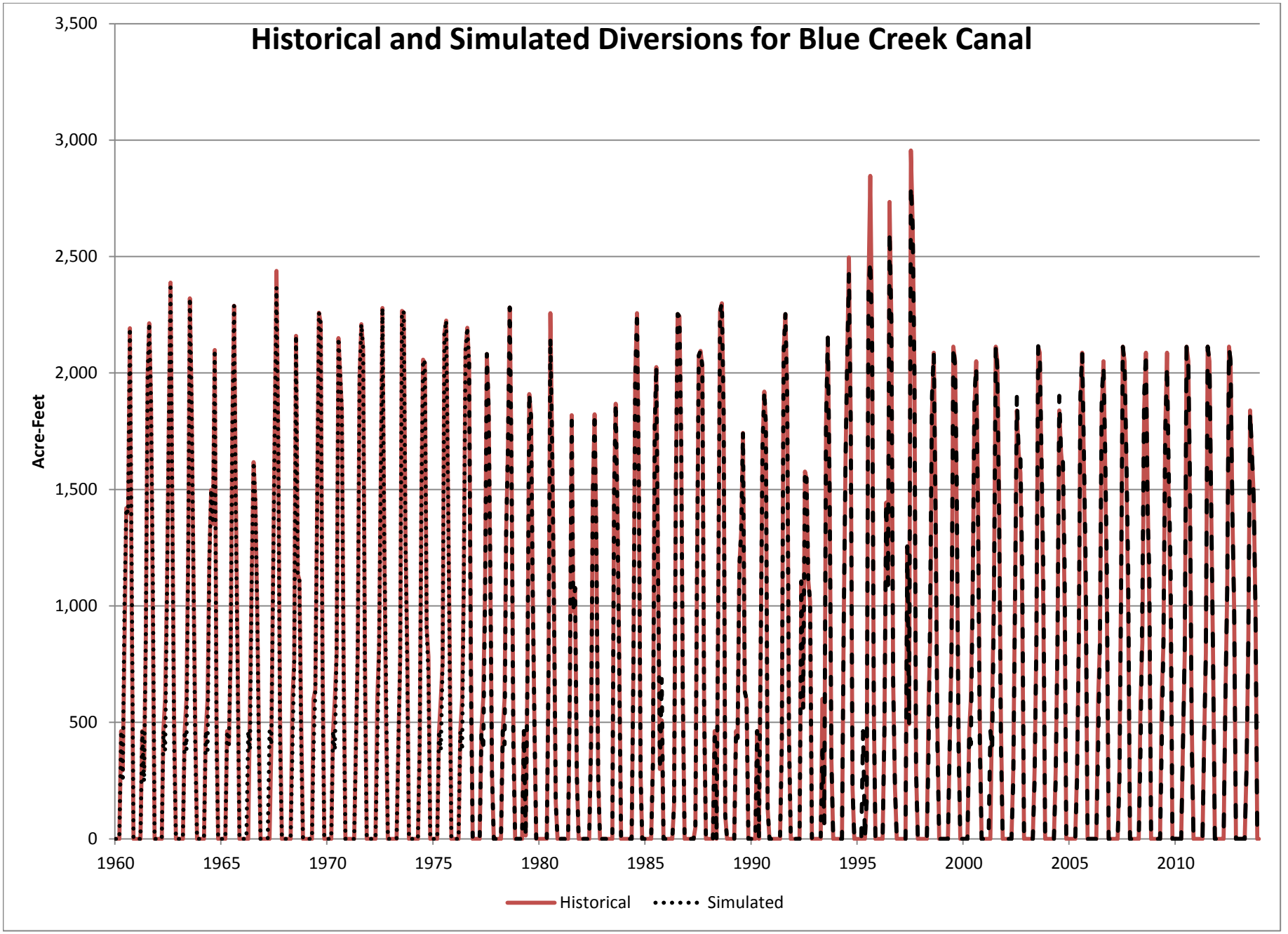

Historical and Simulated Diversions for Alliance Canal
Multiple headgates/carriers
Acre-Feet
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

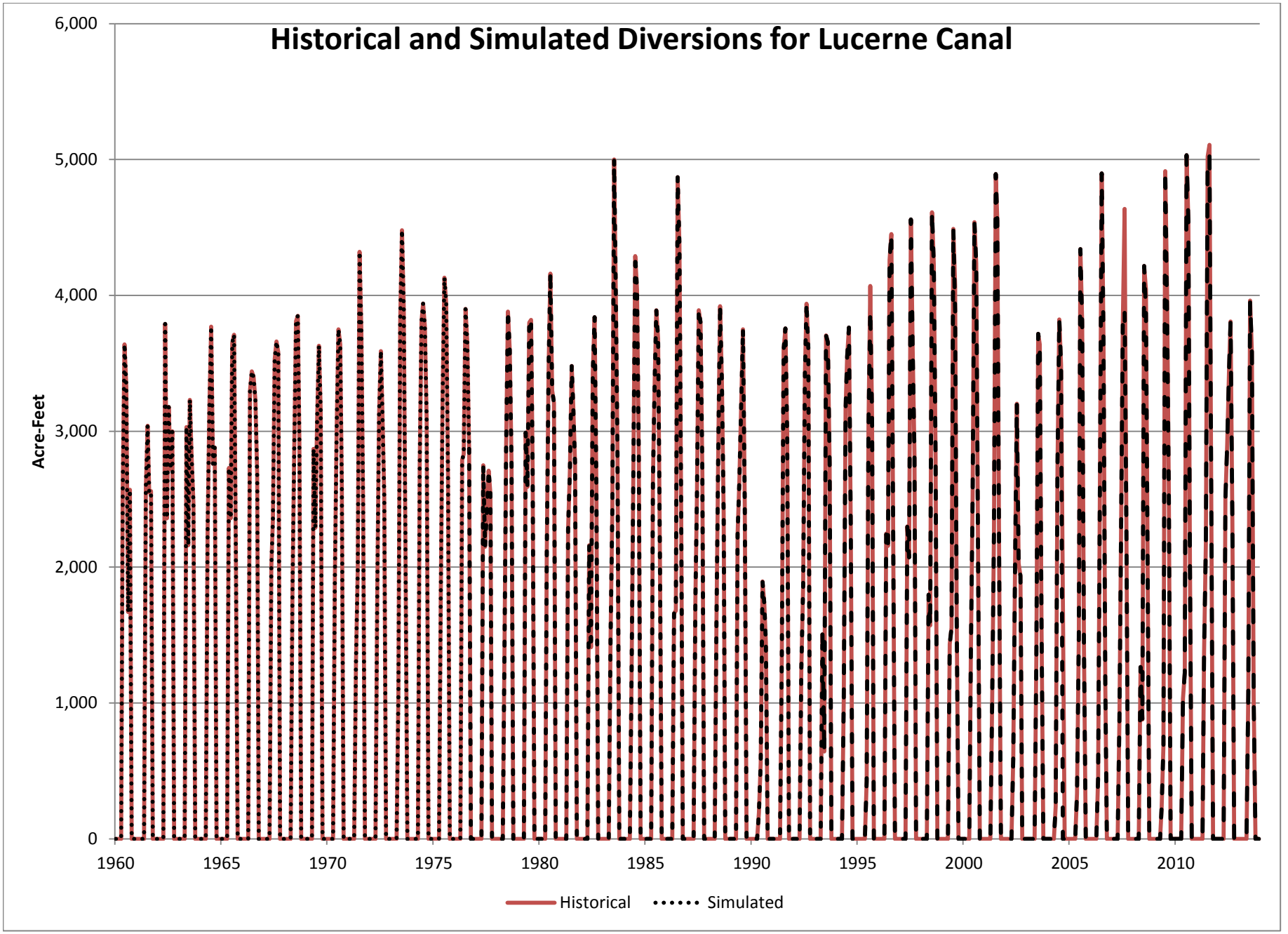

Historical and Simulated Diversions for Alliance Canal - Red Willow Carrier
Multiple headgates/carriers
Acre-Feet
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

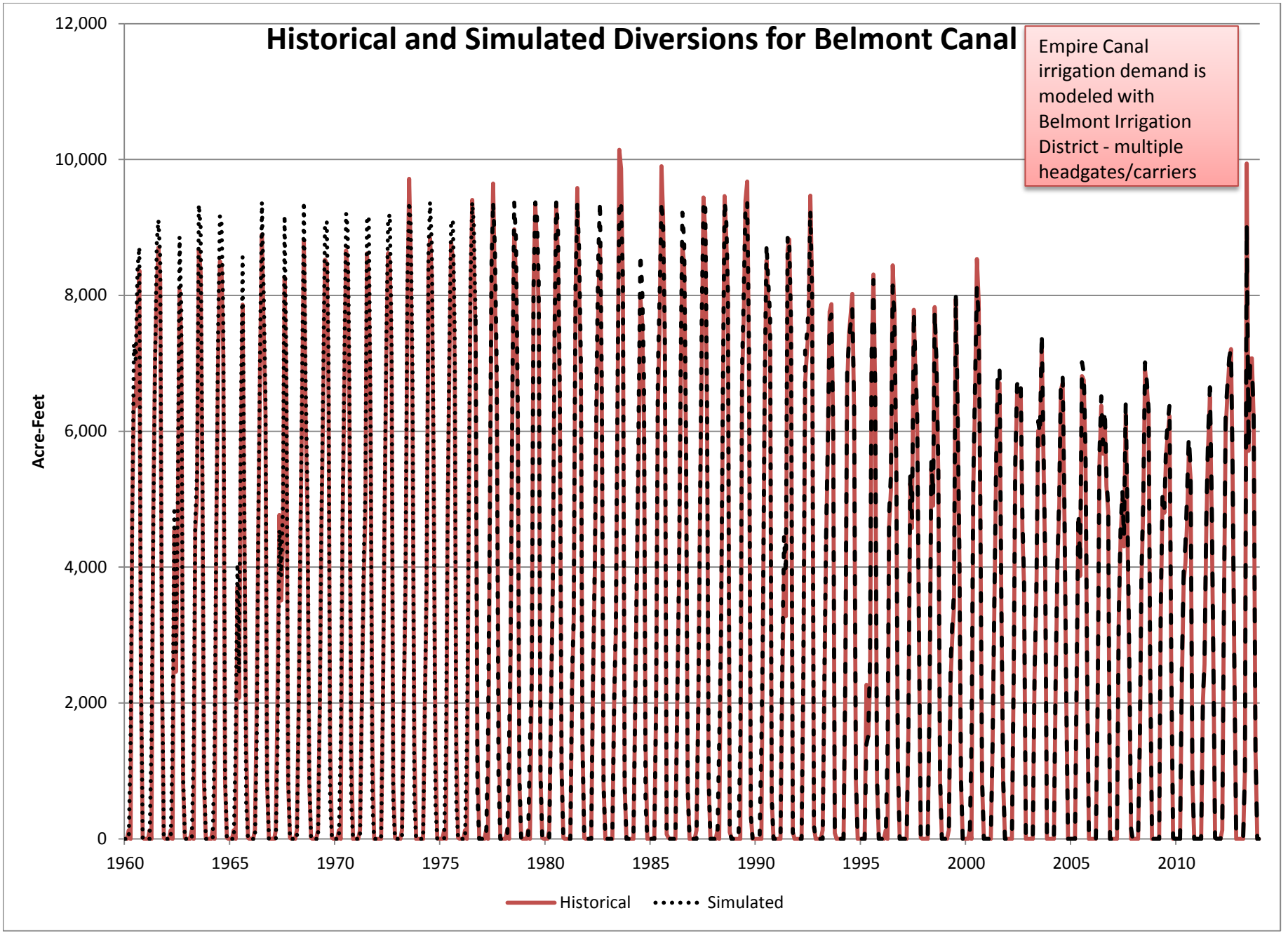

Historical and Simulated Diversions for Burbank Canal
Acre-Feet
450
400
350
300
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

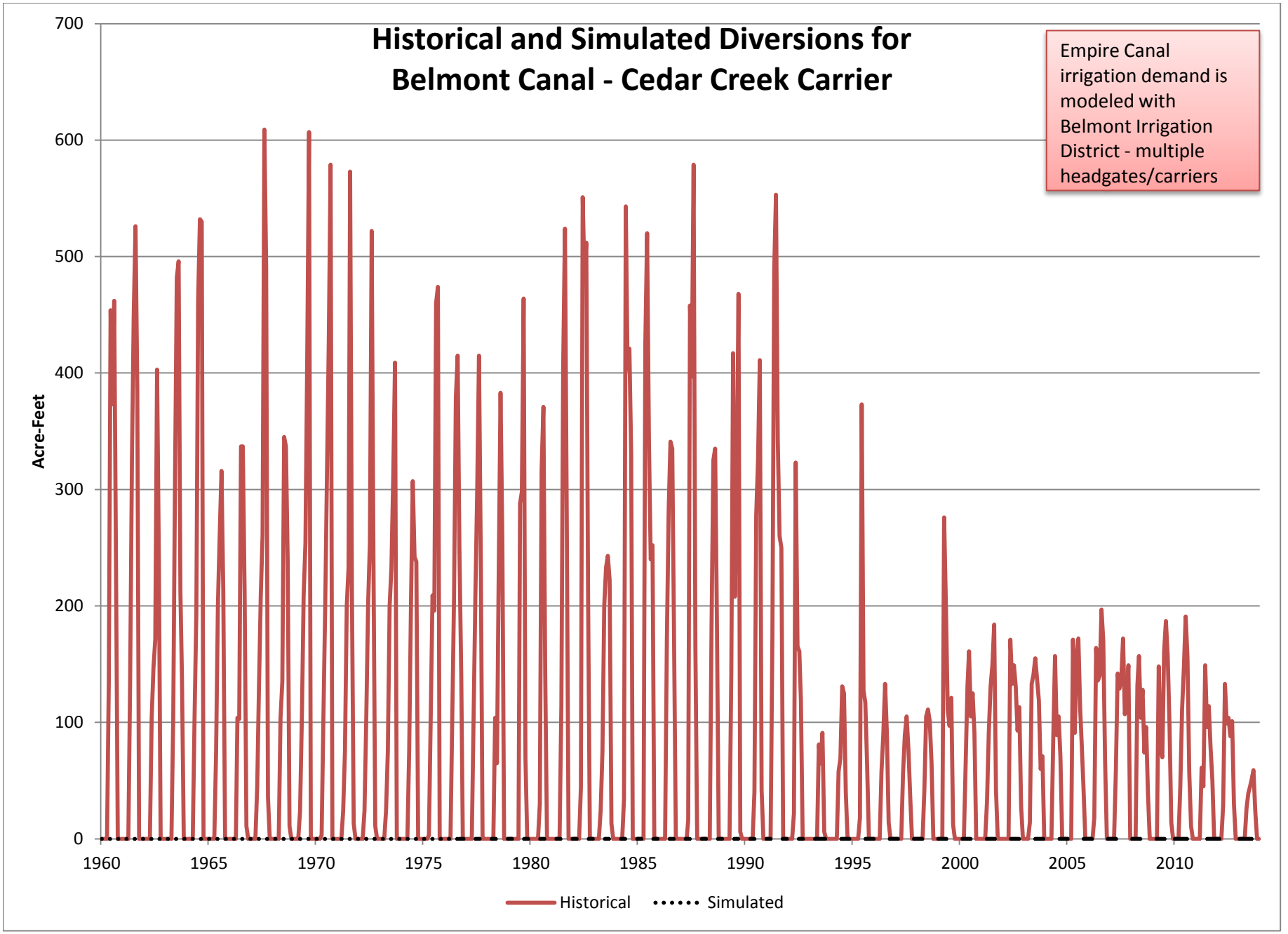

Historical and Simulated Diversions for Torrington Ditch
Acre-Feet
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

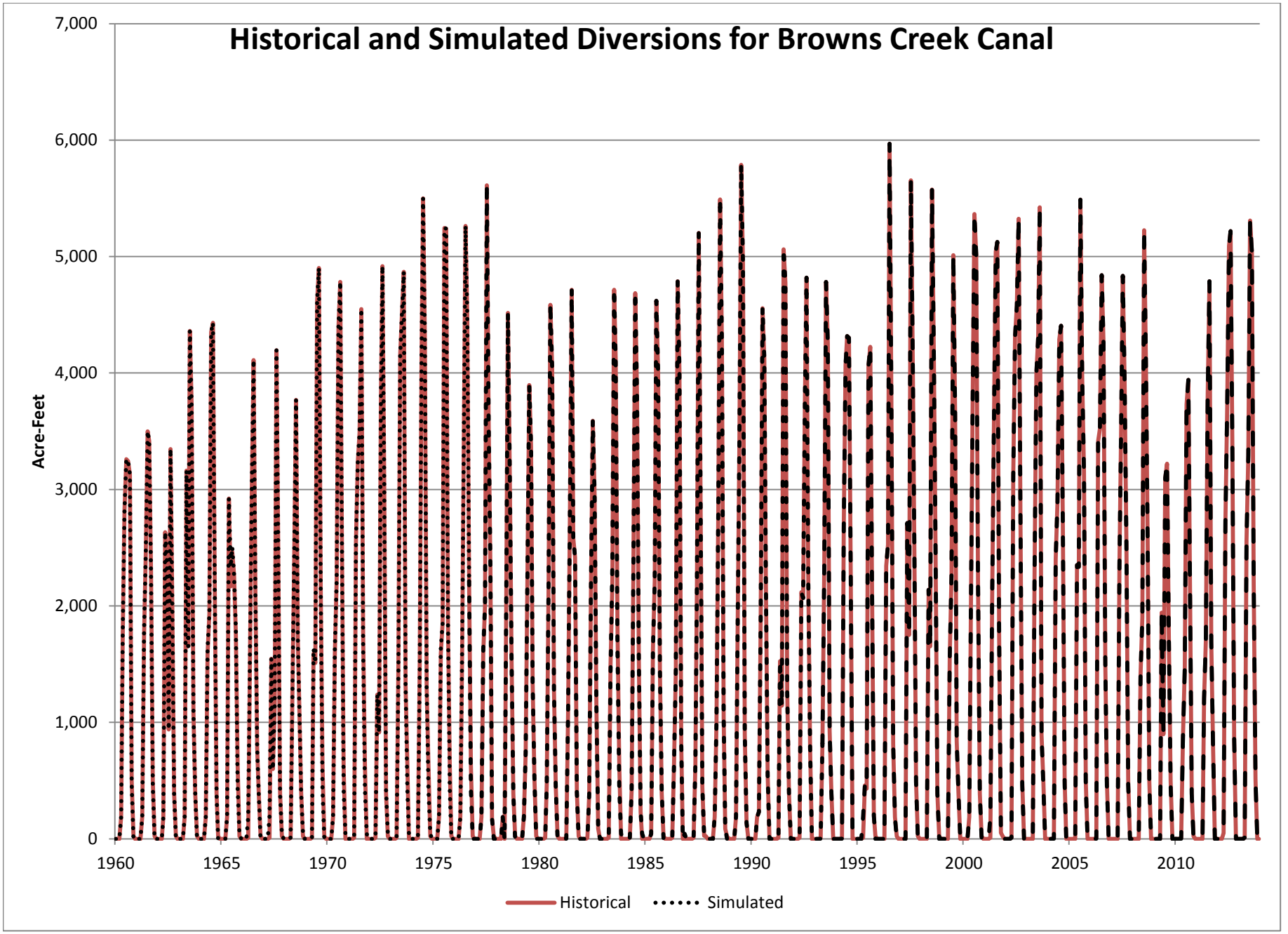

Historical and Simulated Diversions for Beerline Canal
Acre-Feet
1,600
1,400
1,200
1,000
800
600
400
200
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

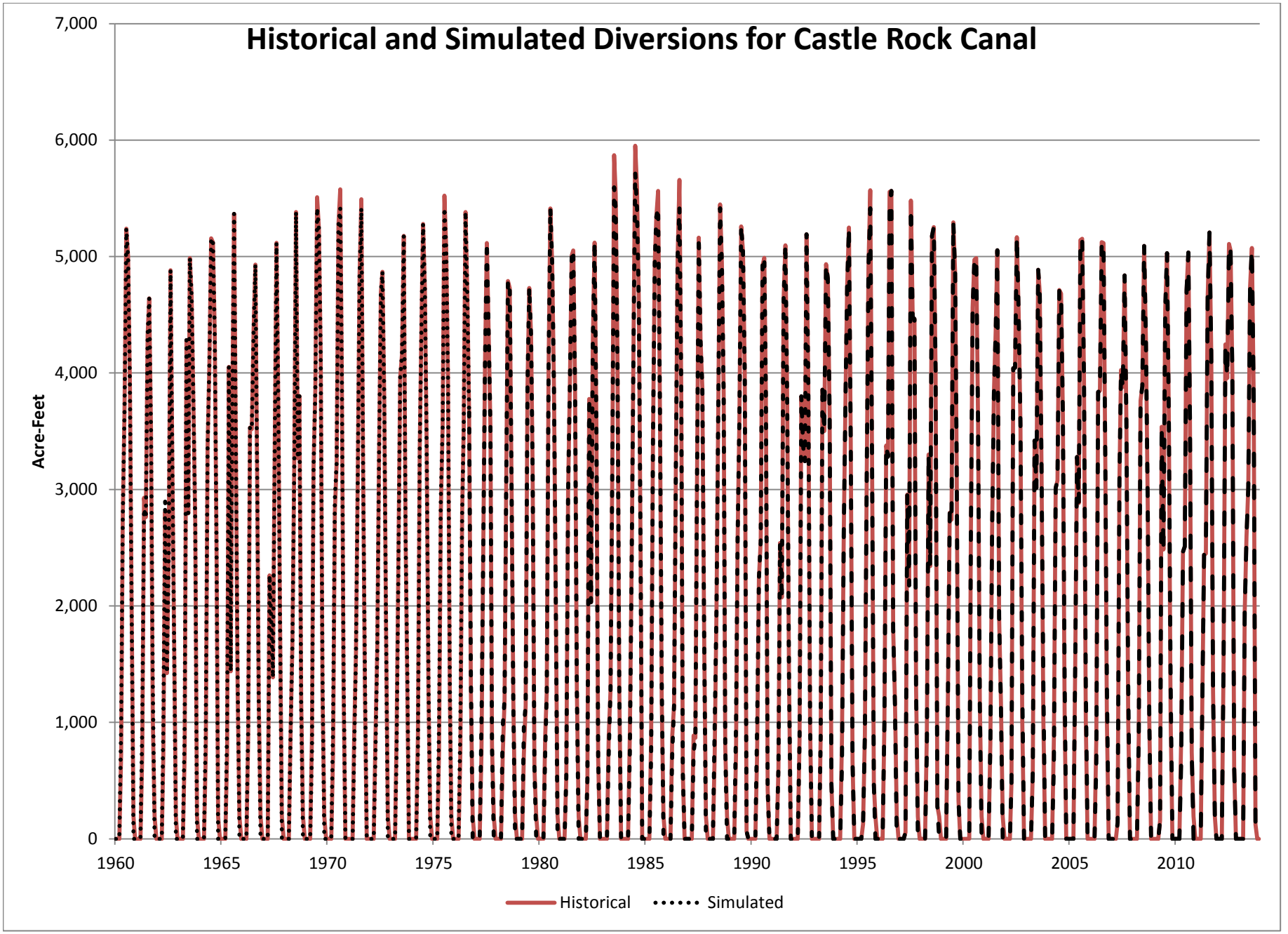

Historical and Simulated Diversions for Blue Creek Canal
Acre-Feet
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

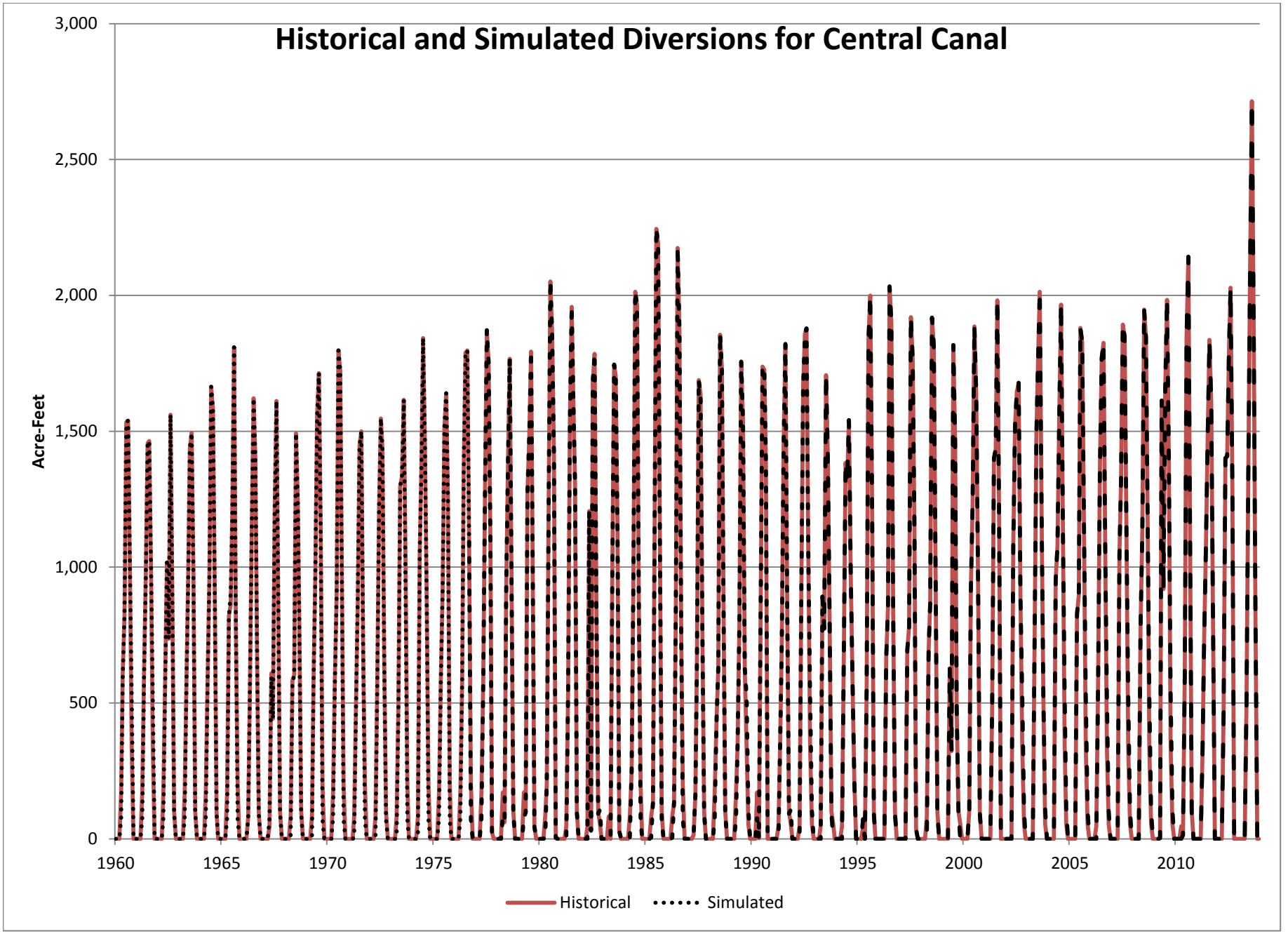

Historical and Simulated Diversions for Lucerne Canal
Acre-Feet
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

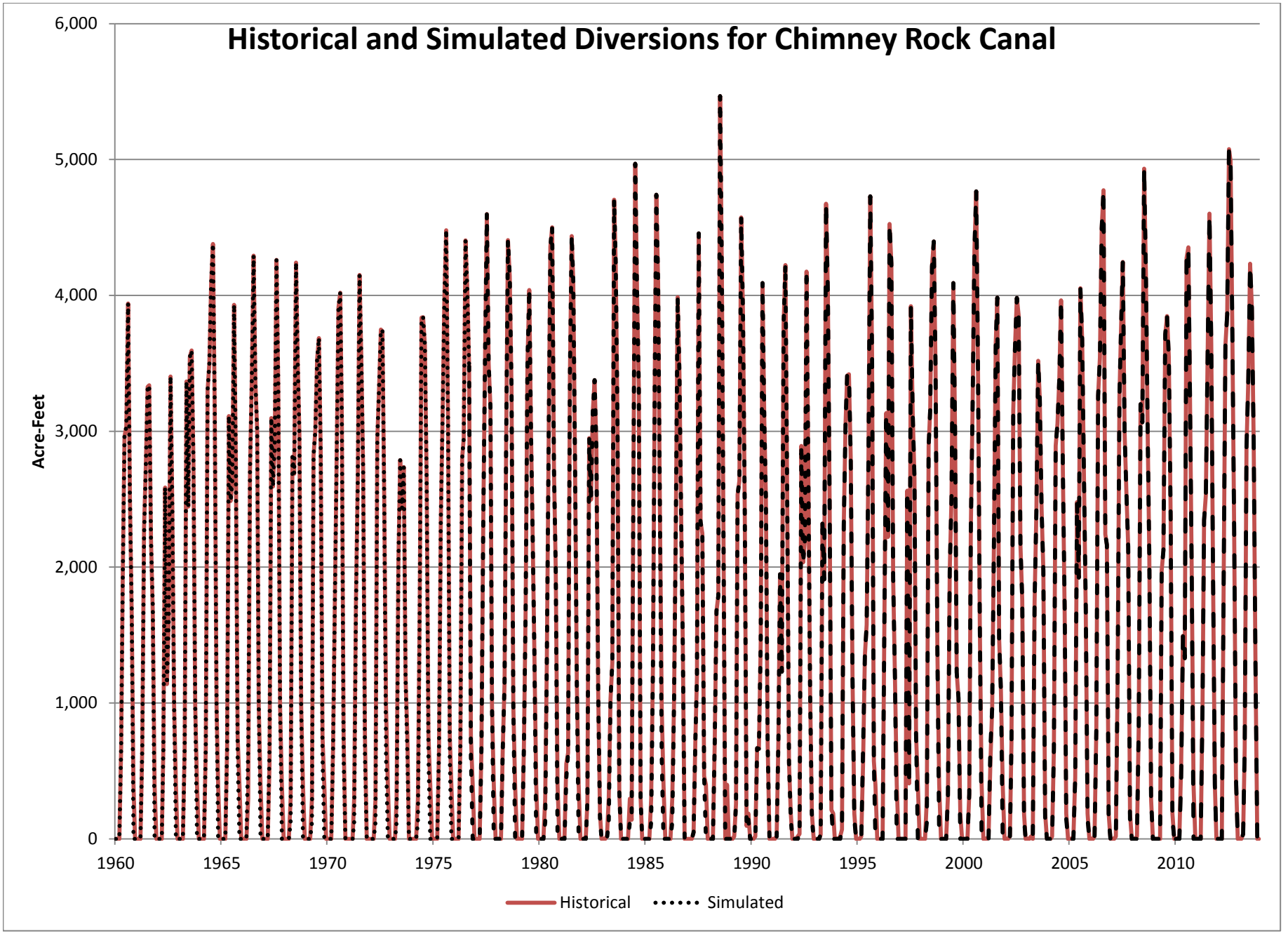

Historical and Simulated Diversions for Belmont Canal
Empire Canal irrigation demand is modeled with Belmont Irrigation District - multiple headgates/carriers
Acre-Feet
12,000
10,000
8,000
6,000
4,000
2,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

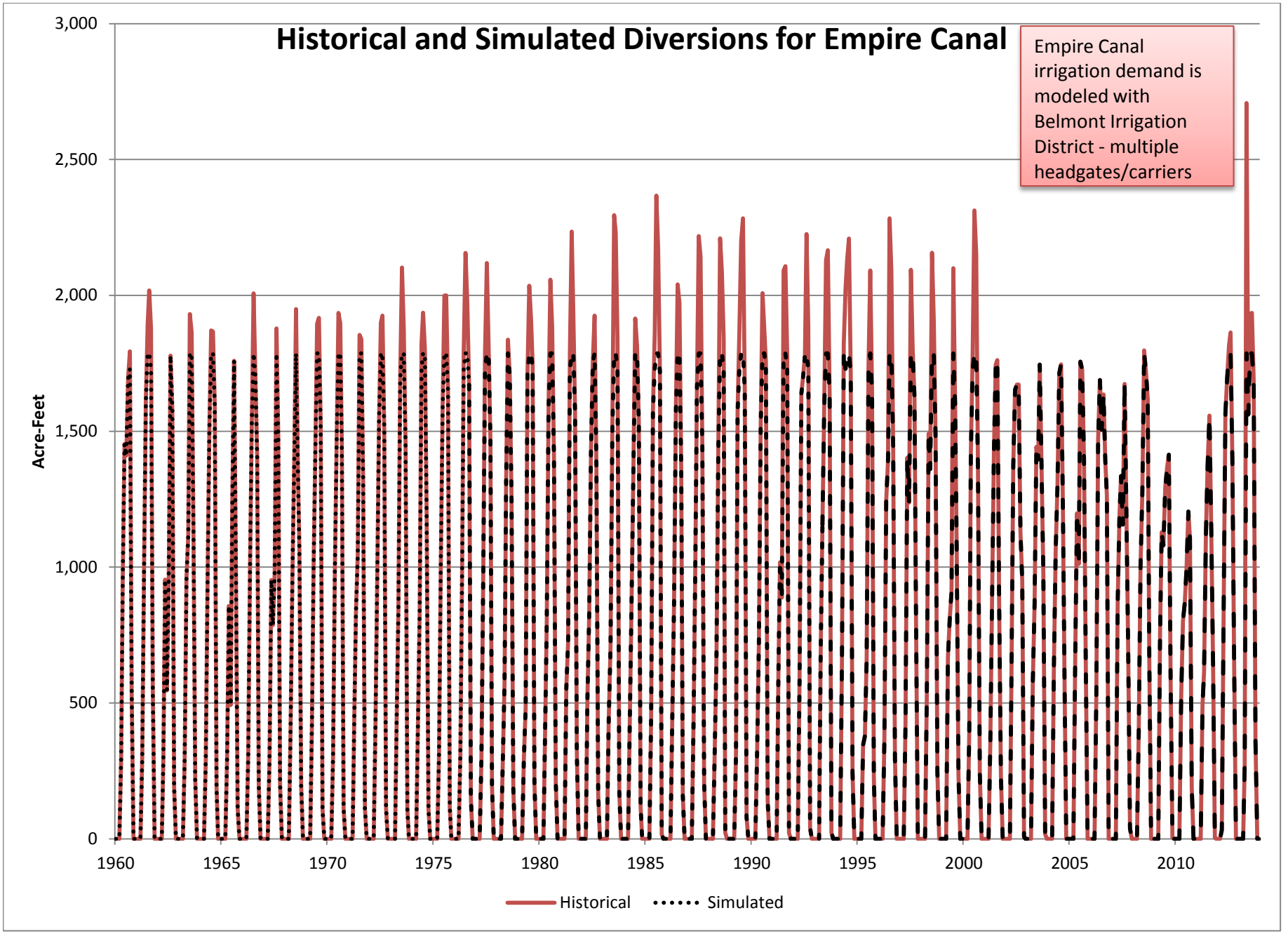

Historical and Simulated Diversions for Belmont Canal - Cedar Creek Carrier
Empire Canal irrigation demand is modeled with Belmont Irrigation District - multiple headgates/carriers
Acre-Feet
700
600
500
400
300
200
100
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

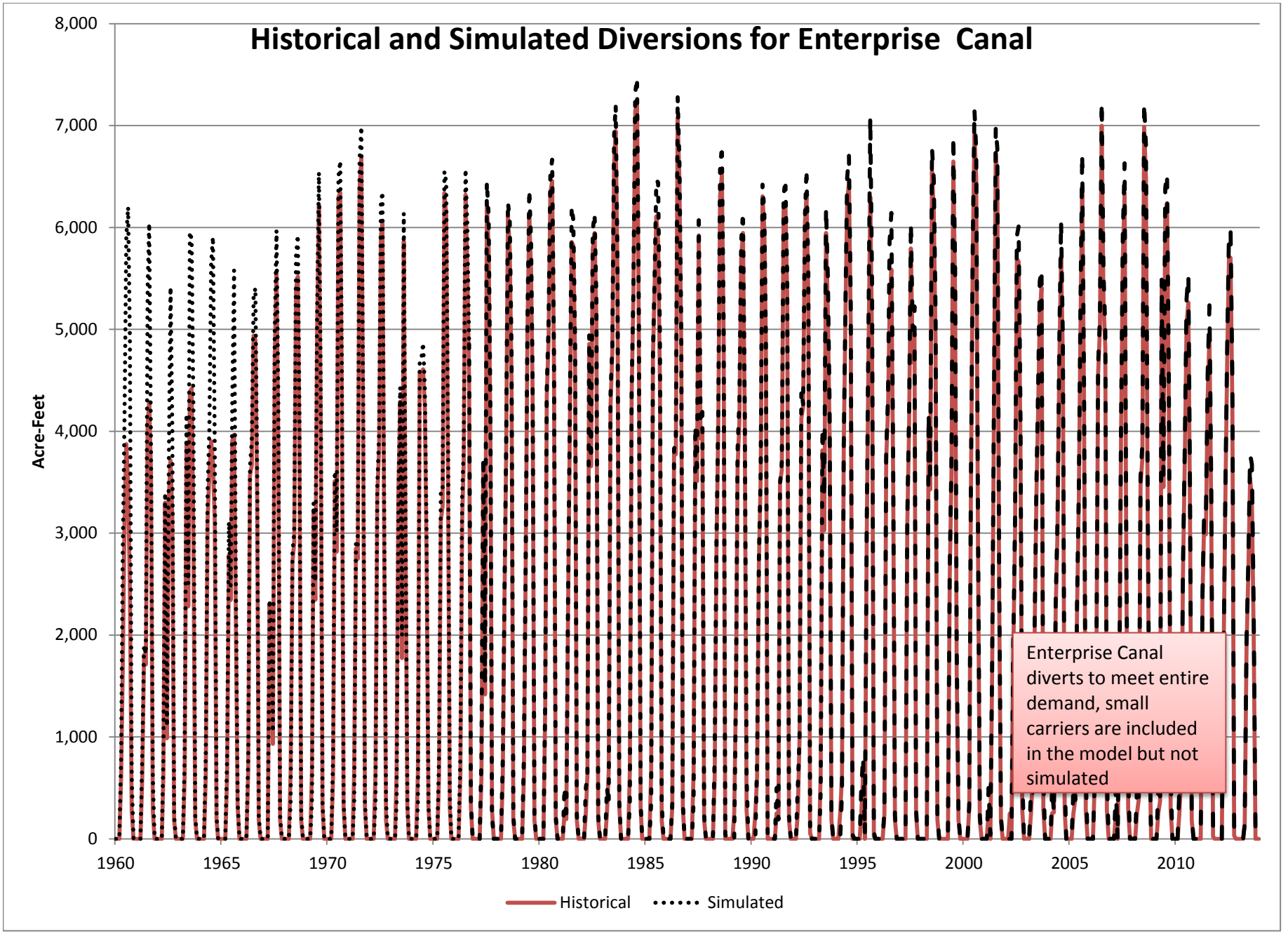

Historical and Simulated Diversions for Browns Creek Canal
Acre-Feet
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

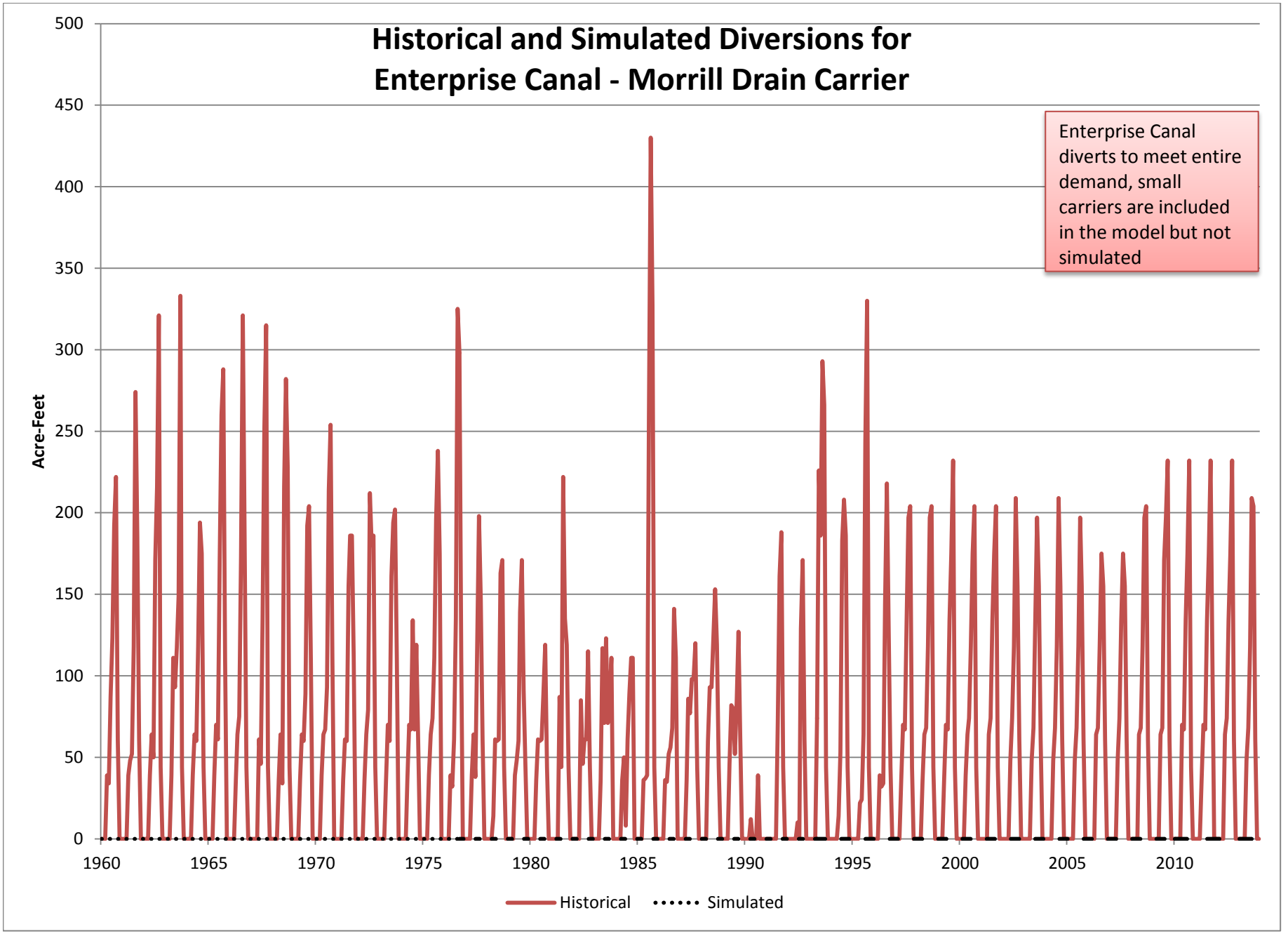

Historical and Simulated Diversions for Castle Rock Canal
Acre-Feet
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

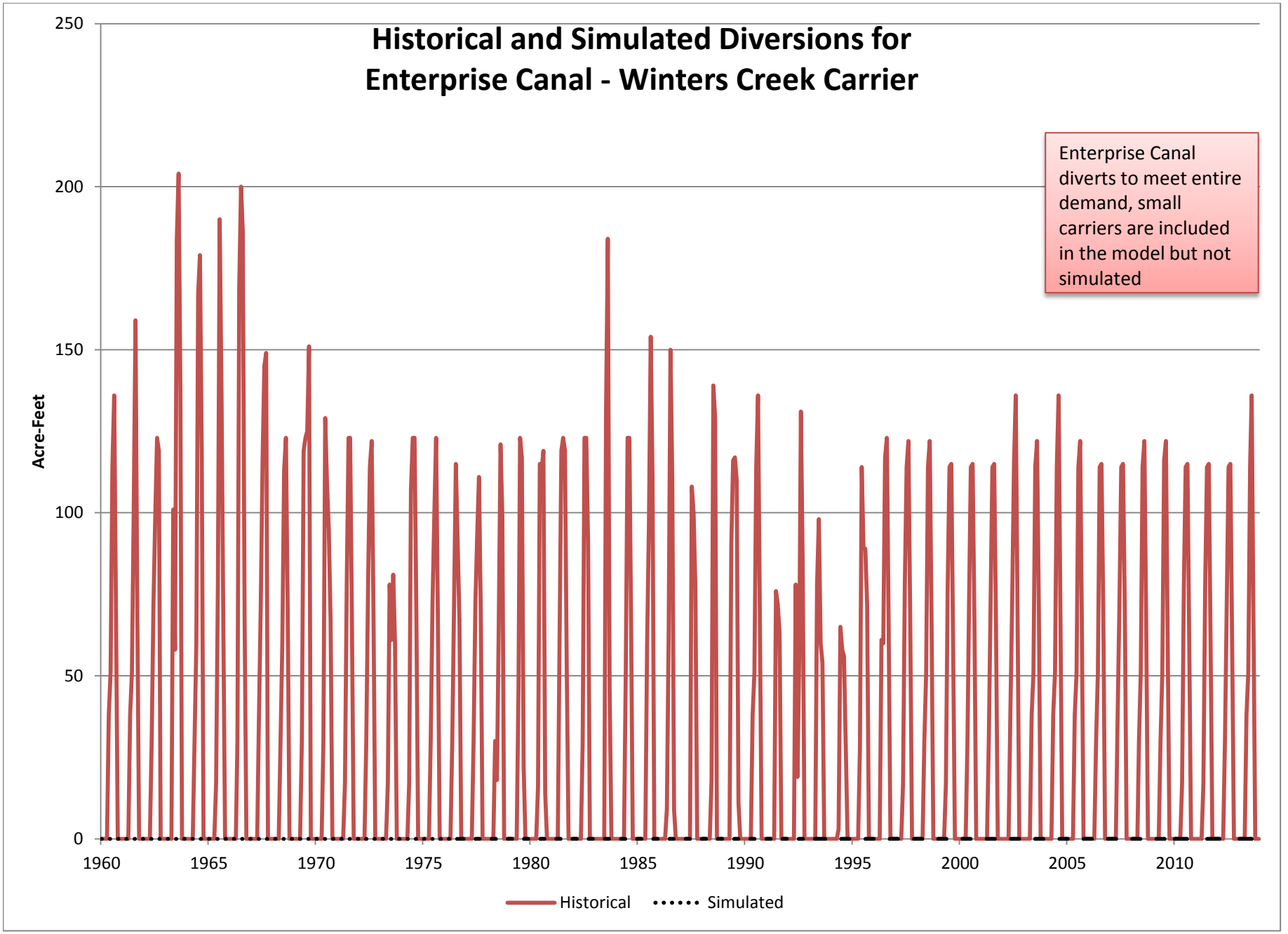

Historical and Simulated Diversions for Central Canal
Acre-Feet
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

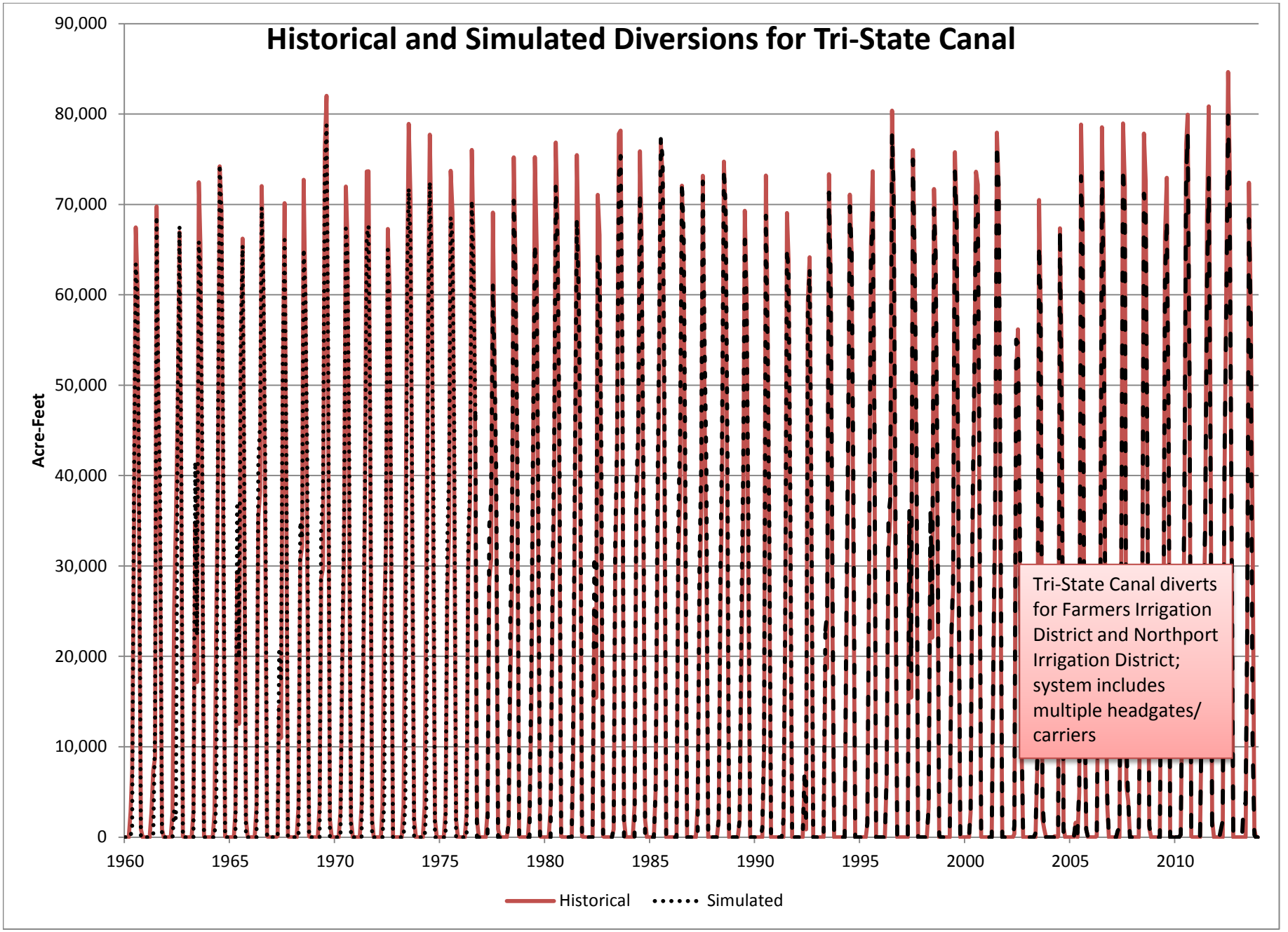

Historical and Simulated Diversions for Chimney Rock Canal
Acre-Feet
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

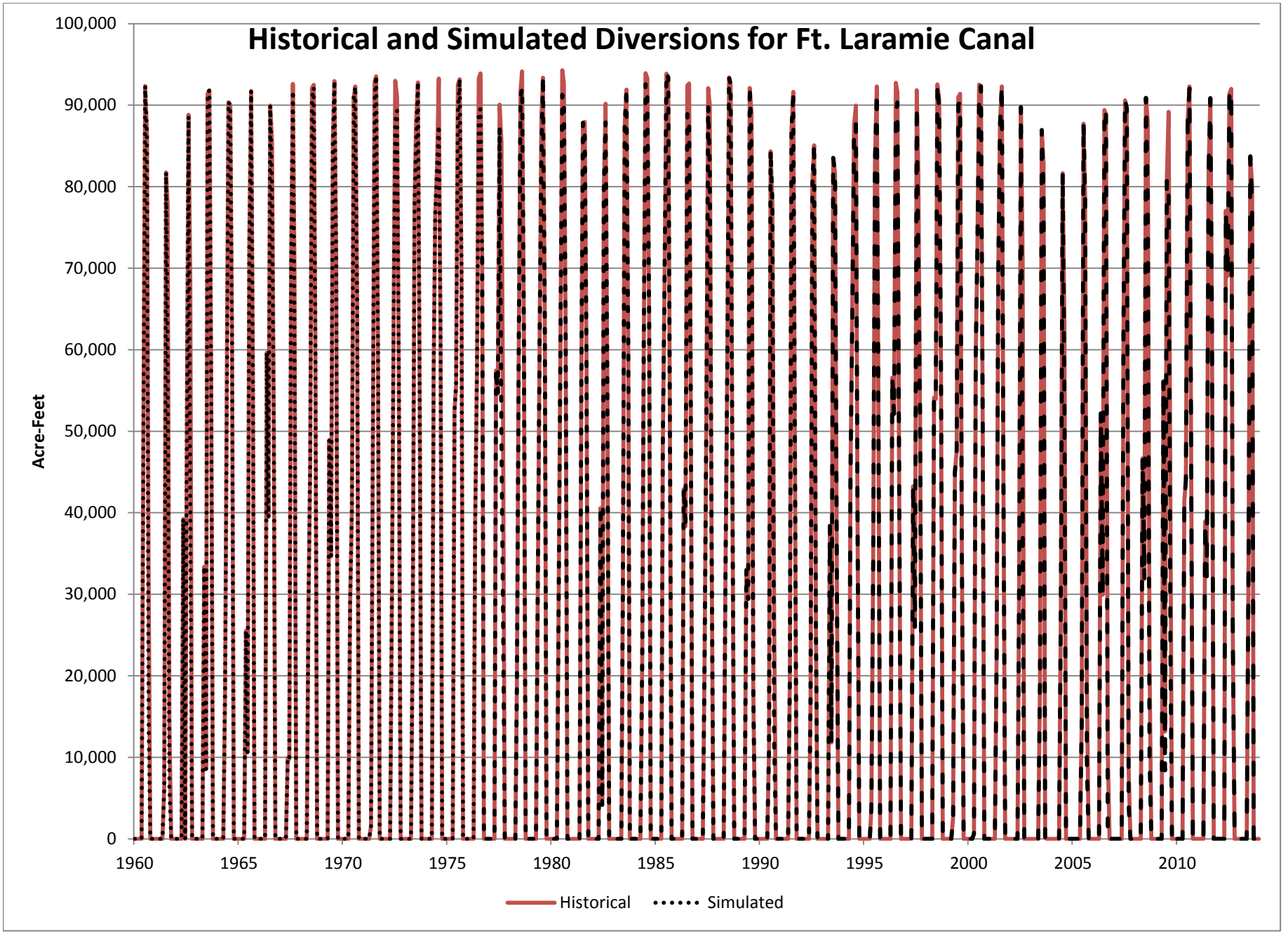

Historical and Simulated Diversions for Empire Canal
Empire Canal irrigation demand is modeled with Belmont Irrigation District - multiple headgates/carriers
Acre-Feet
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

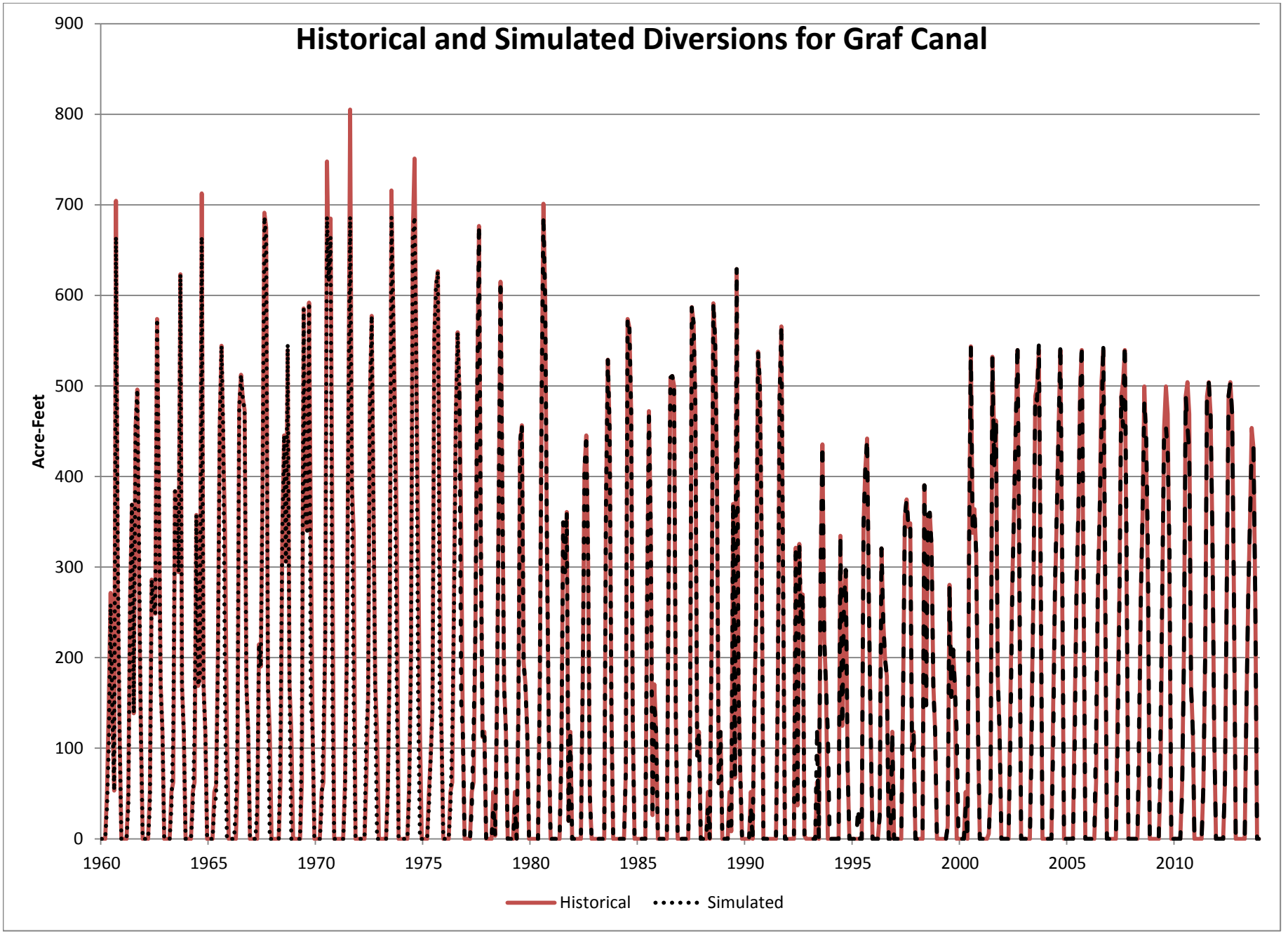

Historical and Simulated Diversions for Enterprise Canal
Acre-Feet
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated
Enterprise Canal diverts to meet entire demand, small carriers are included in the model but not simulated

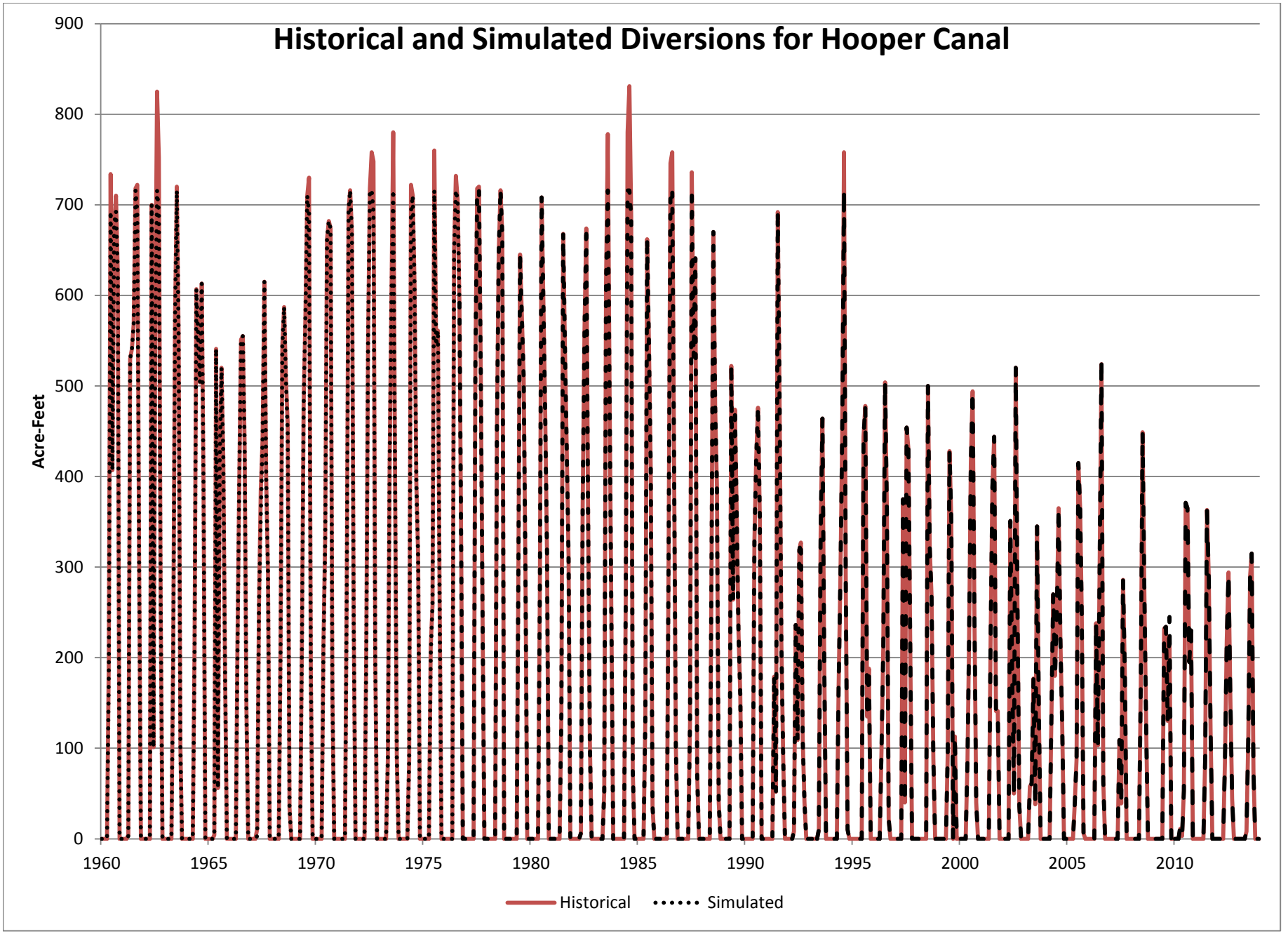

Historical and Simulated Diversions for Enterprise Canal - Morrill Drain Carrier
Enterprise Canal diverts to meet entire demand, small carriers are included in the model but not simulated
Acre-Feet
500
450
400
350
300
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

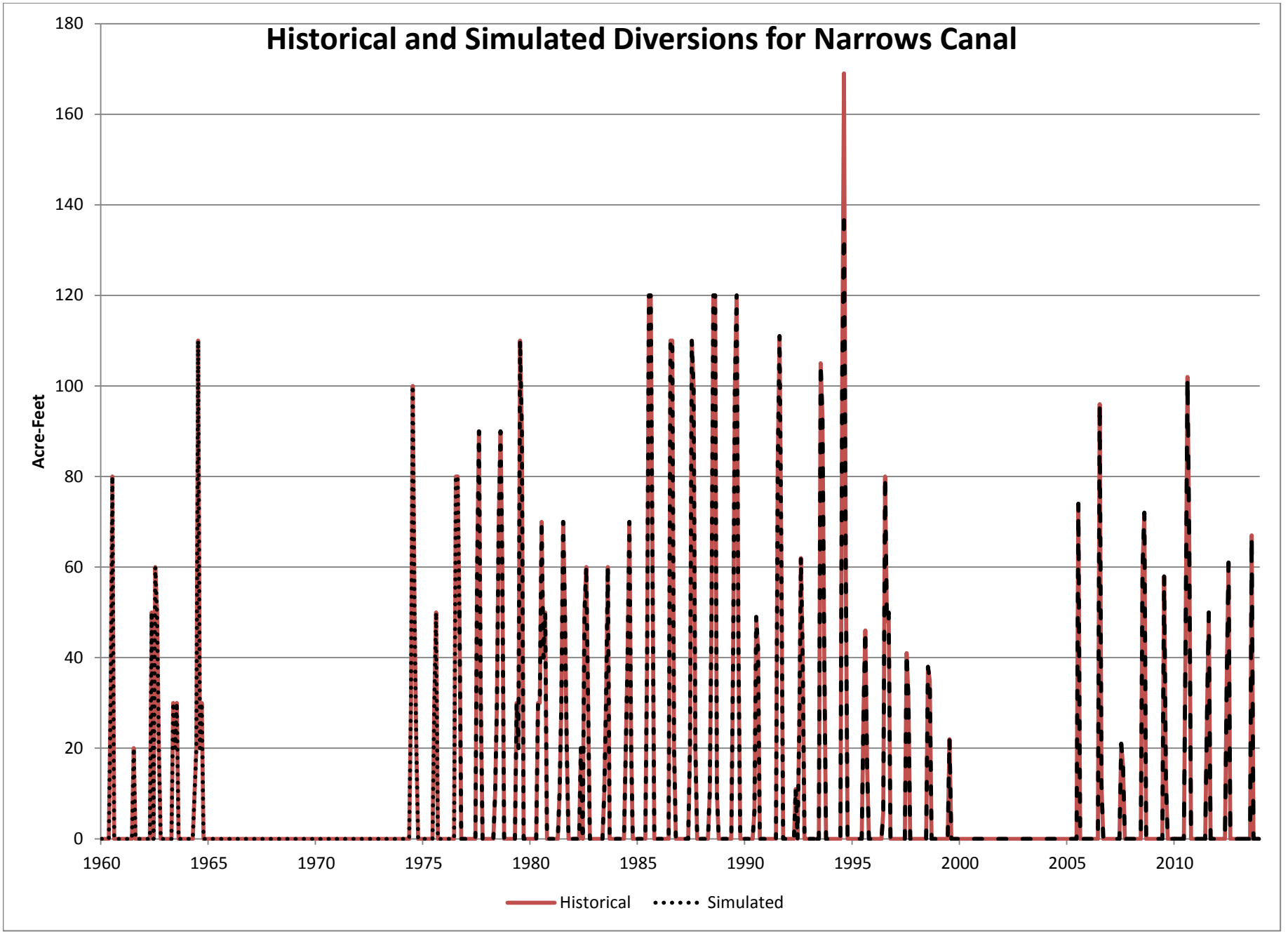

Historical and Simulated Diversions for
Enterprise Canal - Winters Creek Carrier
Enterprise Canal diverts to meet entire demand, small carriers are included in the model but not simulated
Acre-Feet
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

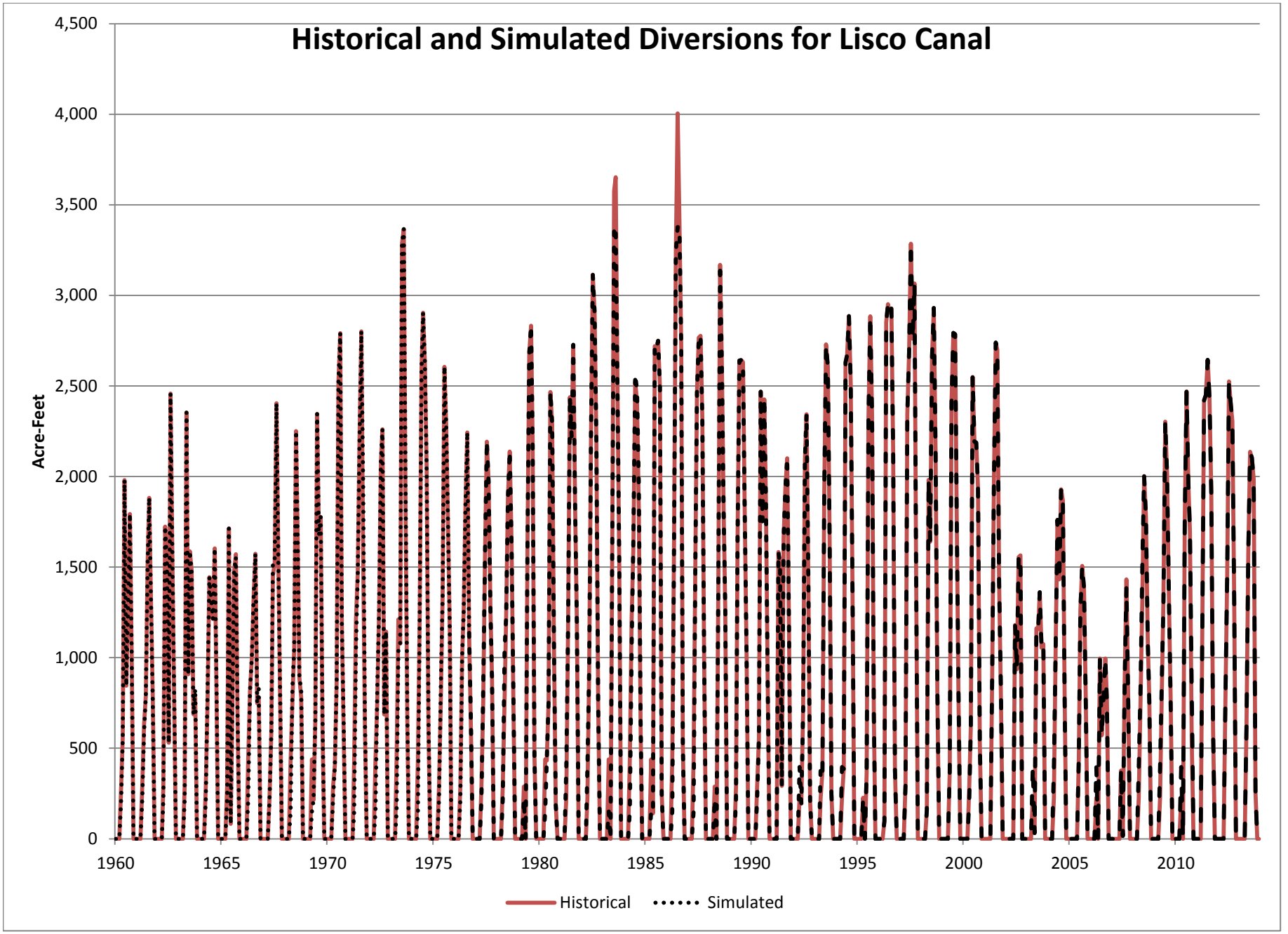

Historical and Simulated Diversions for Tri-State Canal
Acre-Feet
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated
Tri-State Canal diverts for Farmers Irrigation District and Northport Irrigation District; system includes multiple headgates/ carriers

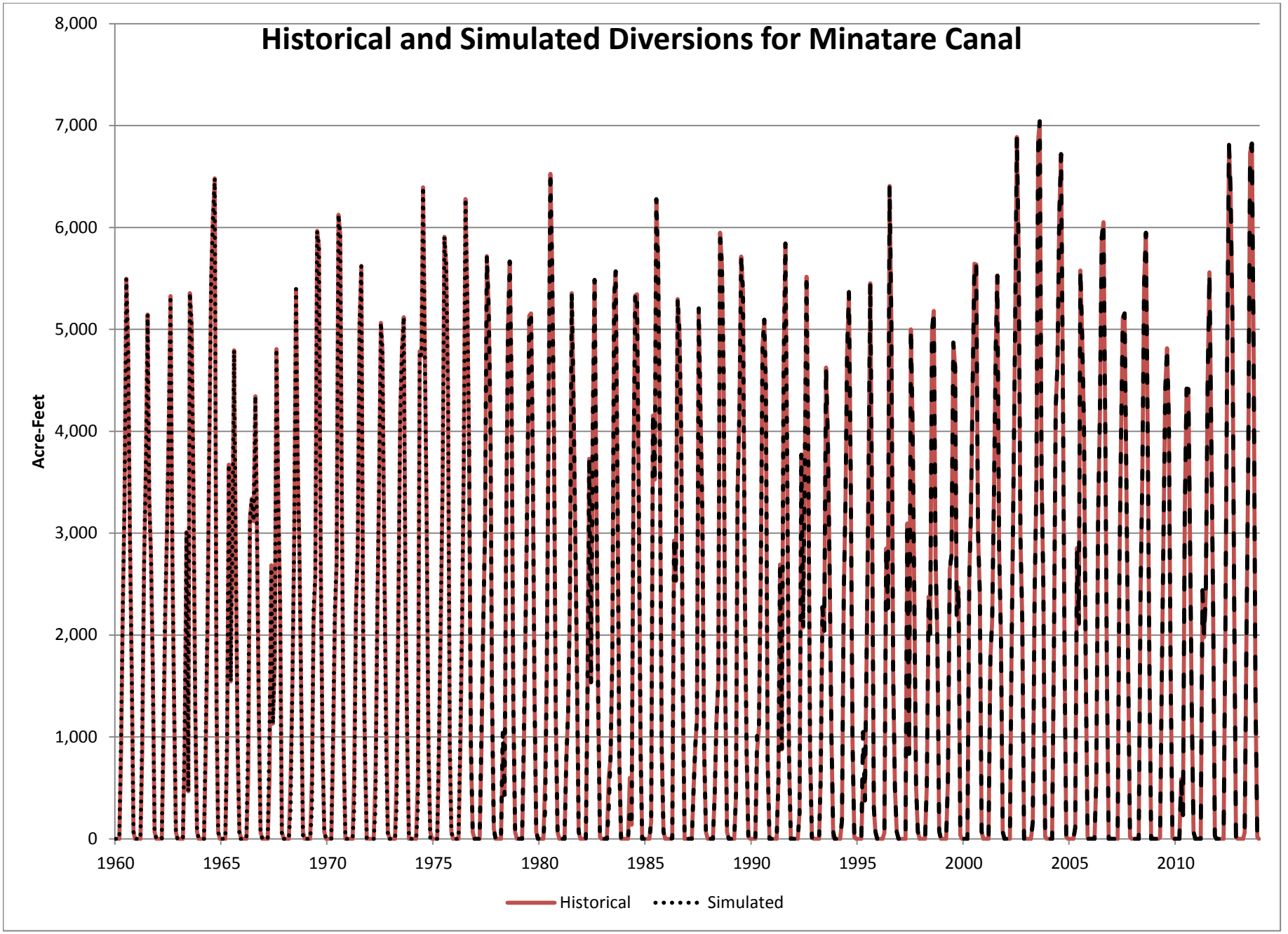

Historical and Simulated Diversions for Ft. Laramie Canal
Acre-Feet
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

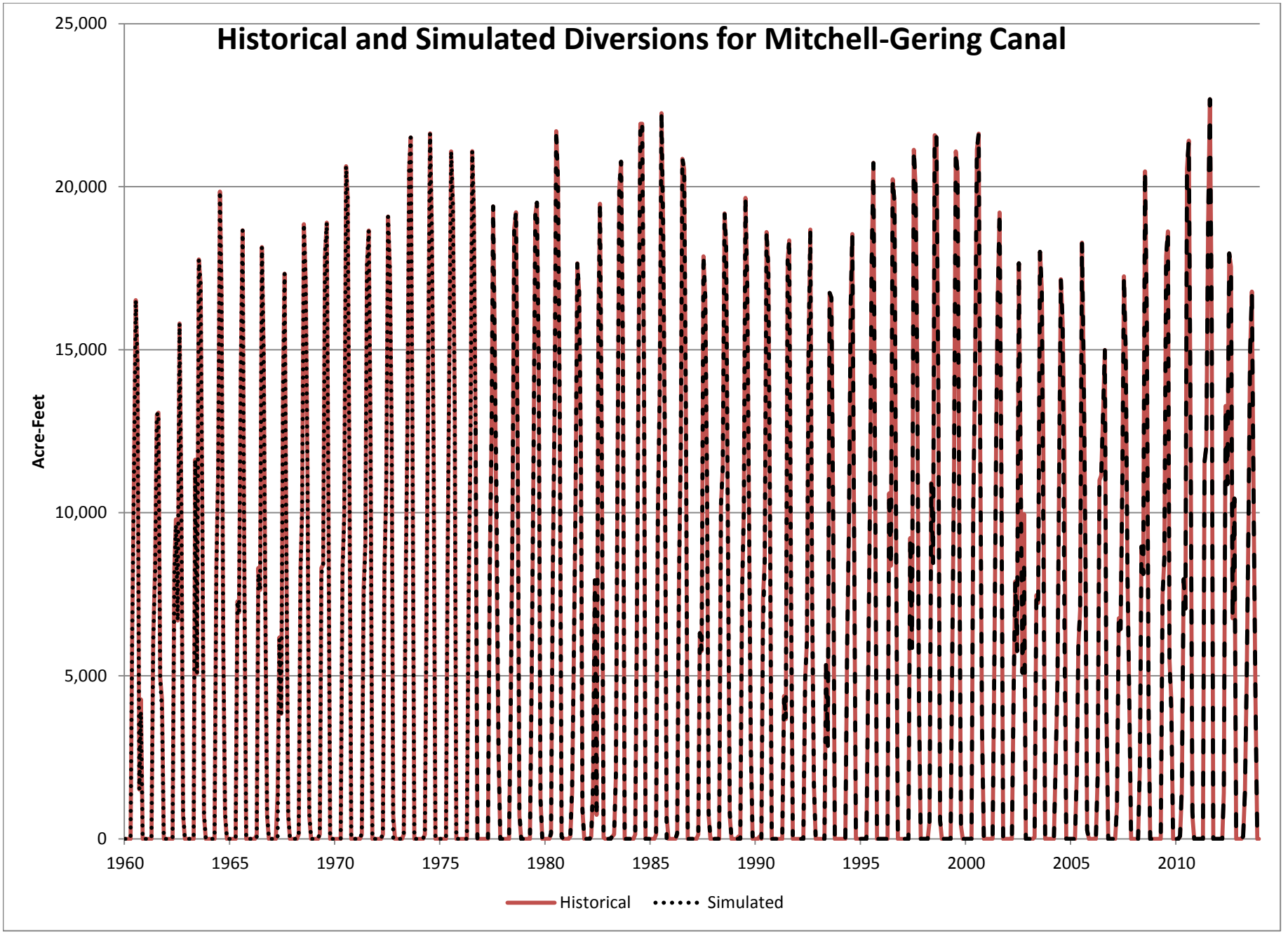

Historical and Simulated Diversions for Graf Canal
Acre-Feet
900
800
700
600
500
400
300
200
100
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

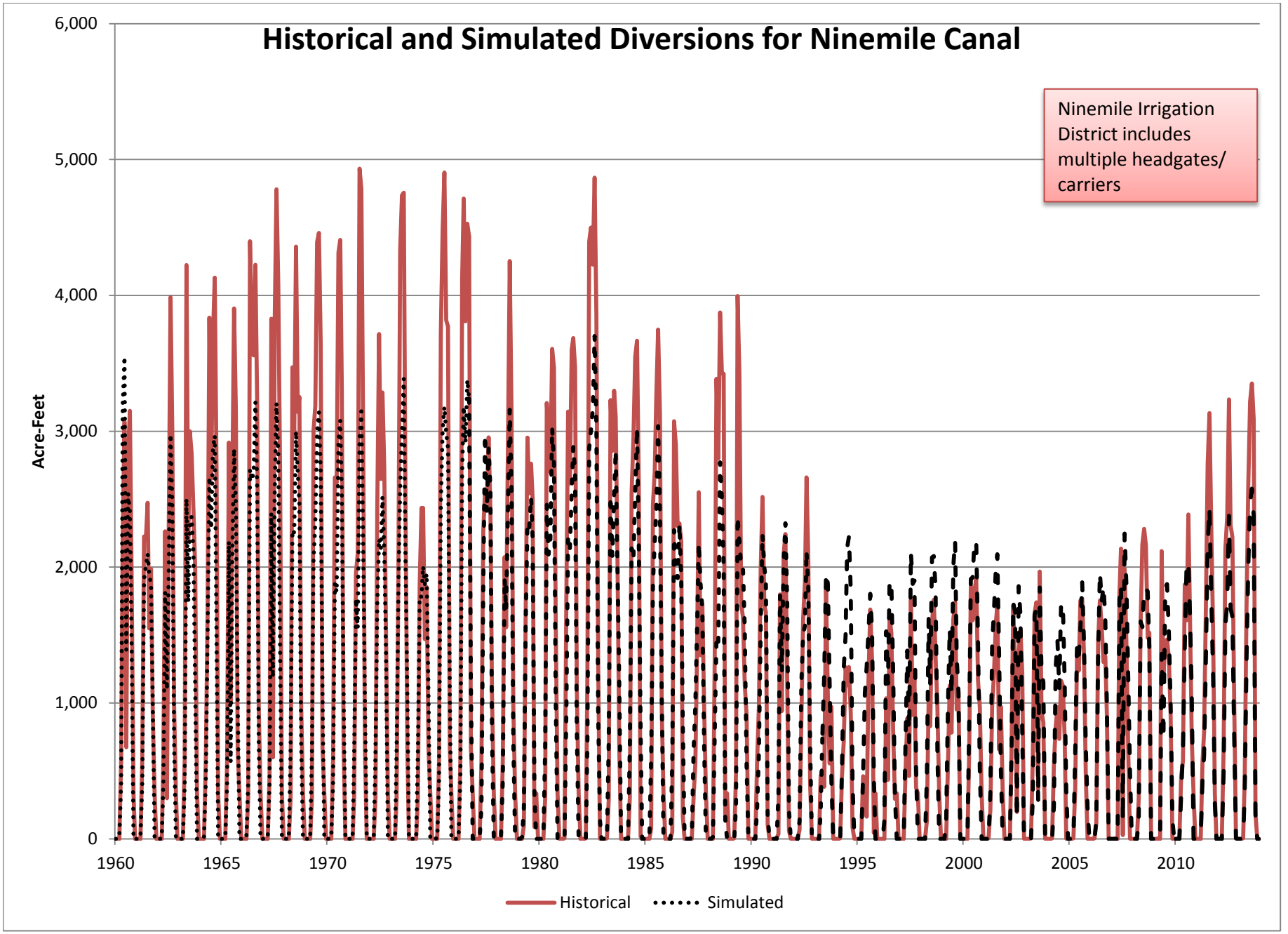

Historical and Simulated Diversions for Hooper Canal
Acre-Feet
900
800
700
600
500
400
300
200
100
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

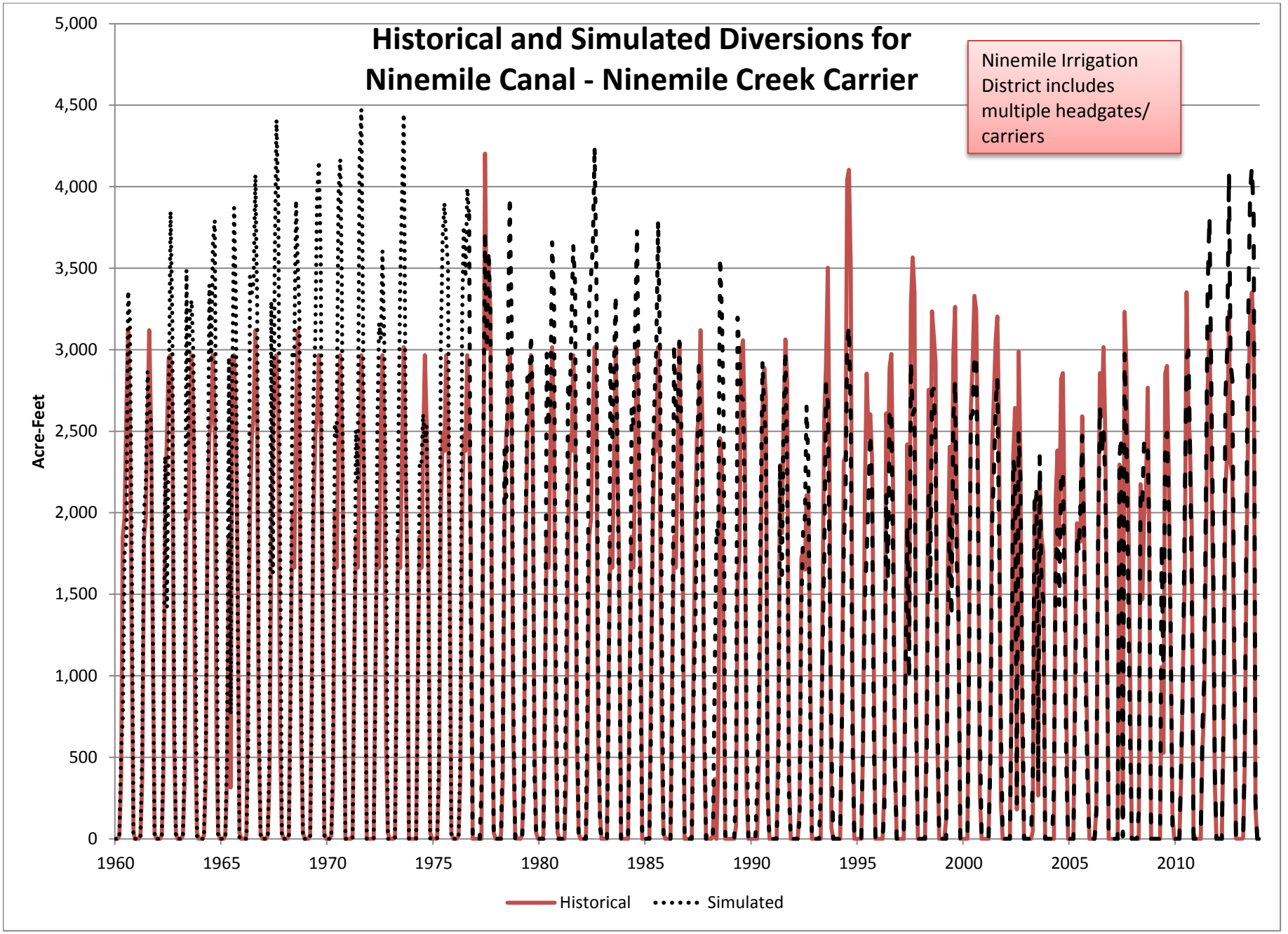

Historical and Simulated Diversions for Narrows Canal
Acre-Feet
180
160
140
120
100
80
60
40
20
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

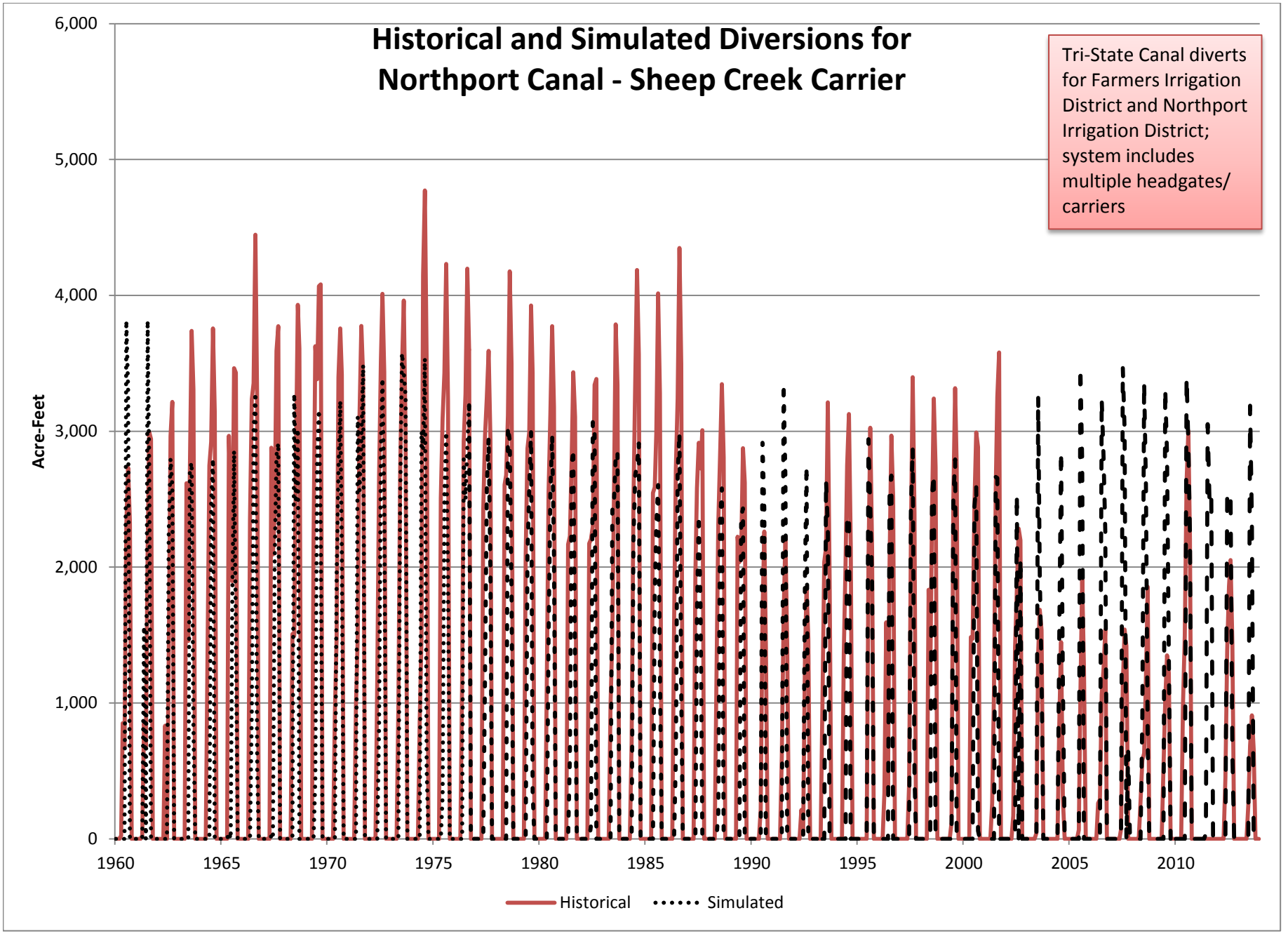

Historical and Simulated Diversions for Lisco Canal
Acre-Feet
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

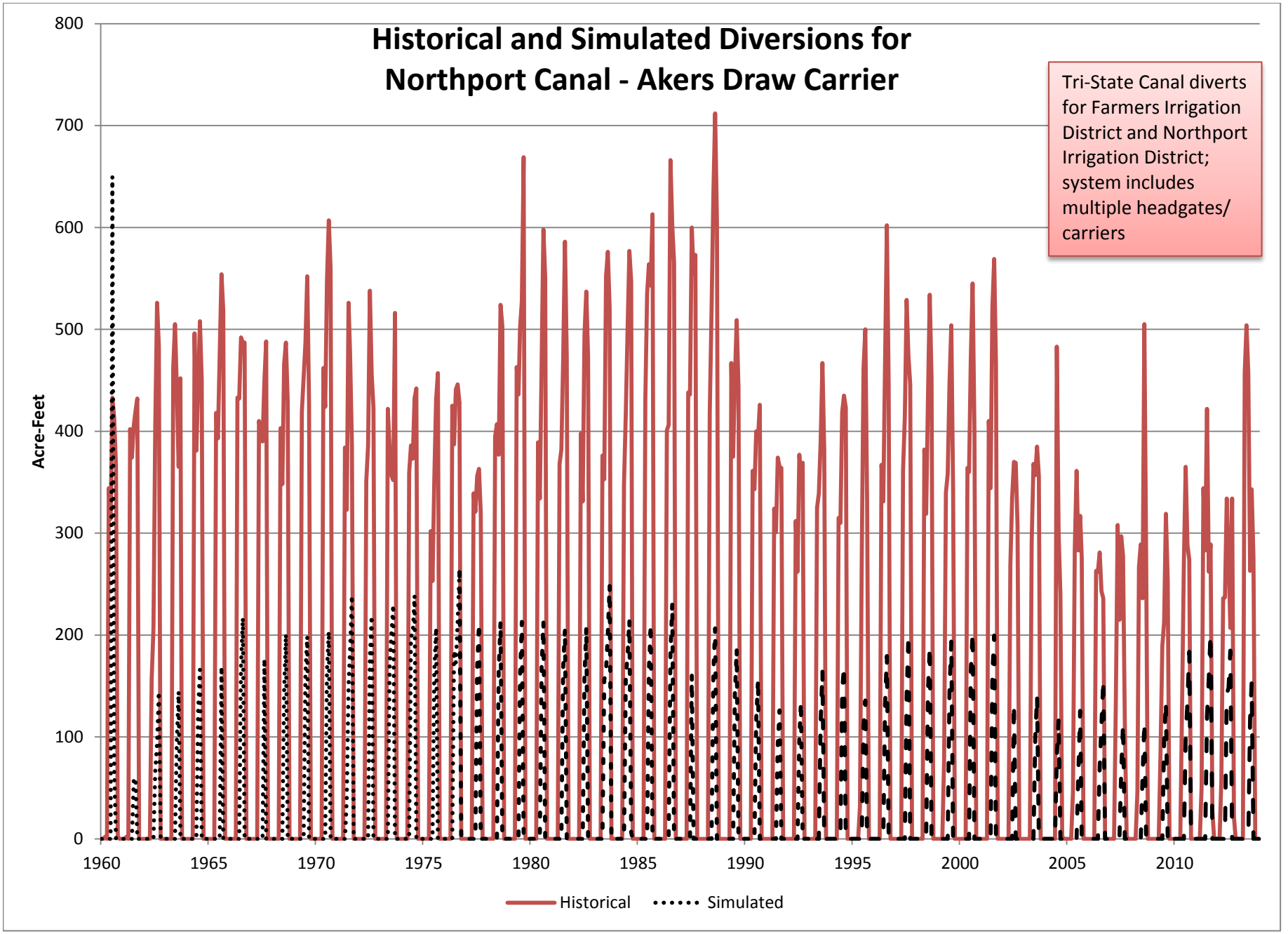

Historical and Simulated Diversions for Minatare Canal
Acre-Feet
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

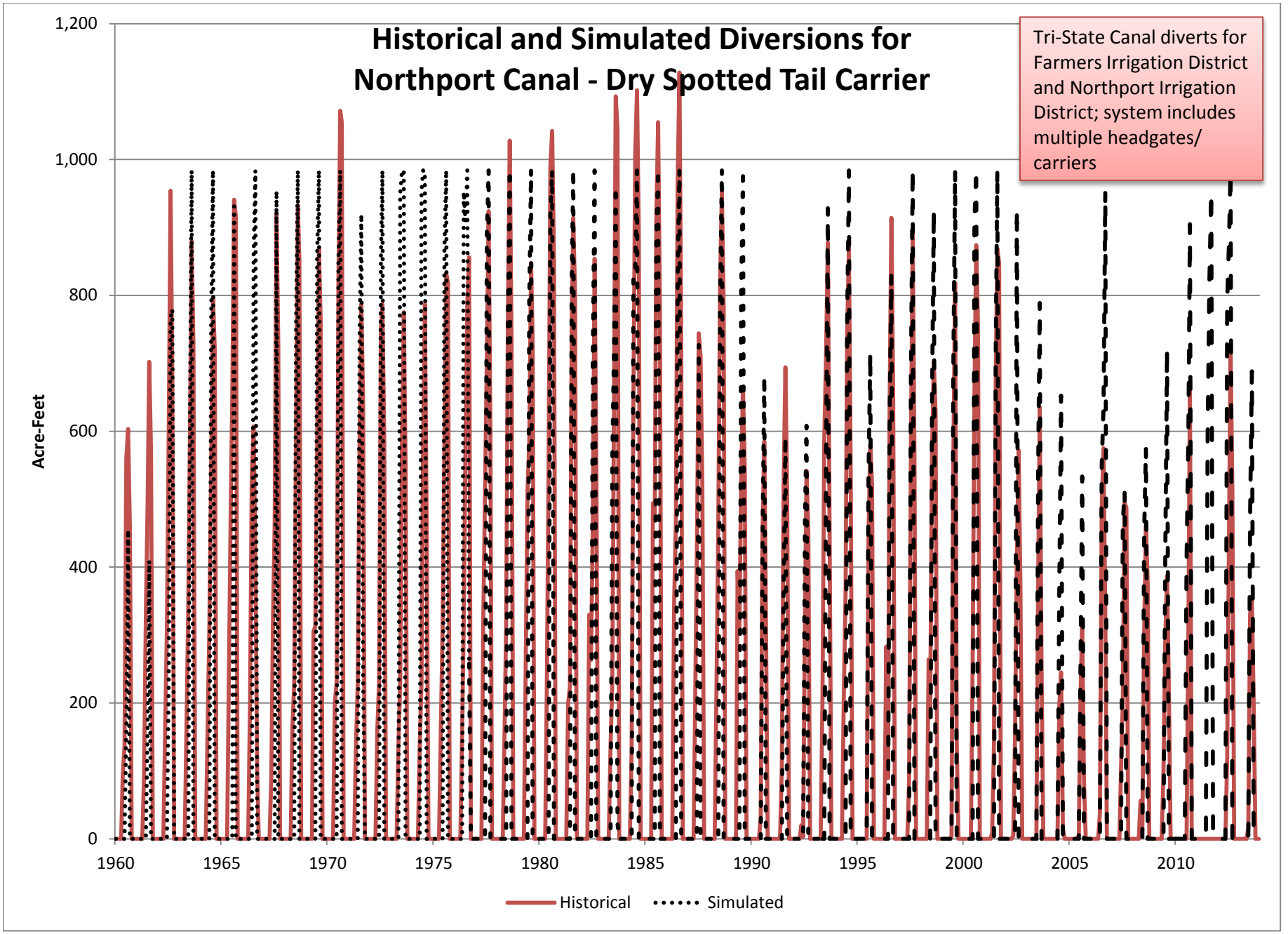

Historical and Simulated Diversions for Mitchell-Gering Canal
25,000
20,000
15,000
10,000
5,000
0
Acre-Feet
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

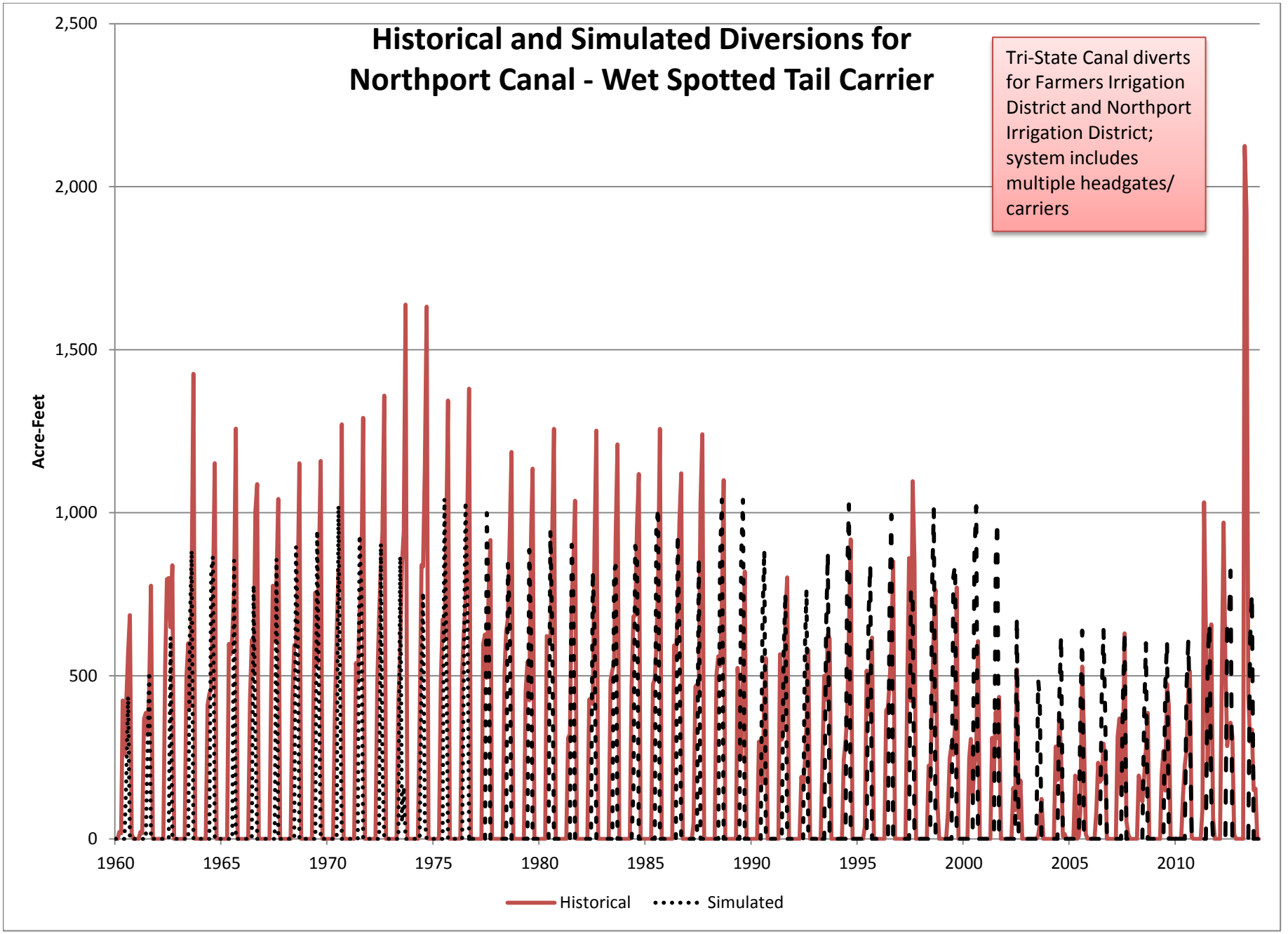

Historical and Simulated Diversions for Ninemile Canal
Ninemile Irrigation District includes multiple headgates/ carriers
Acre-Feet
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

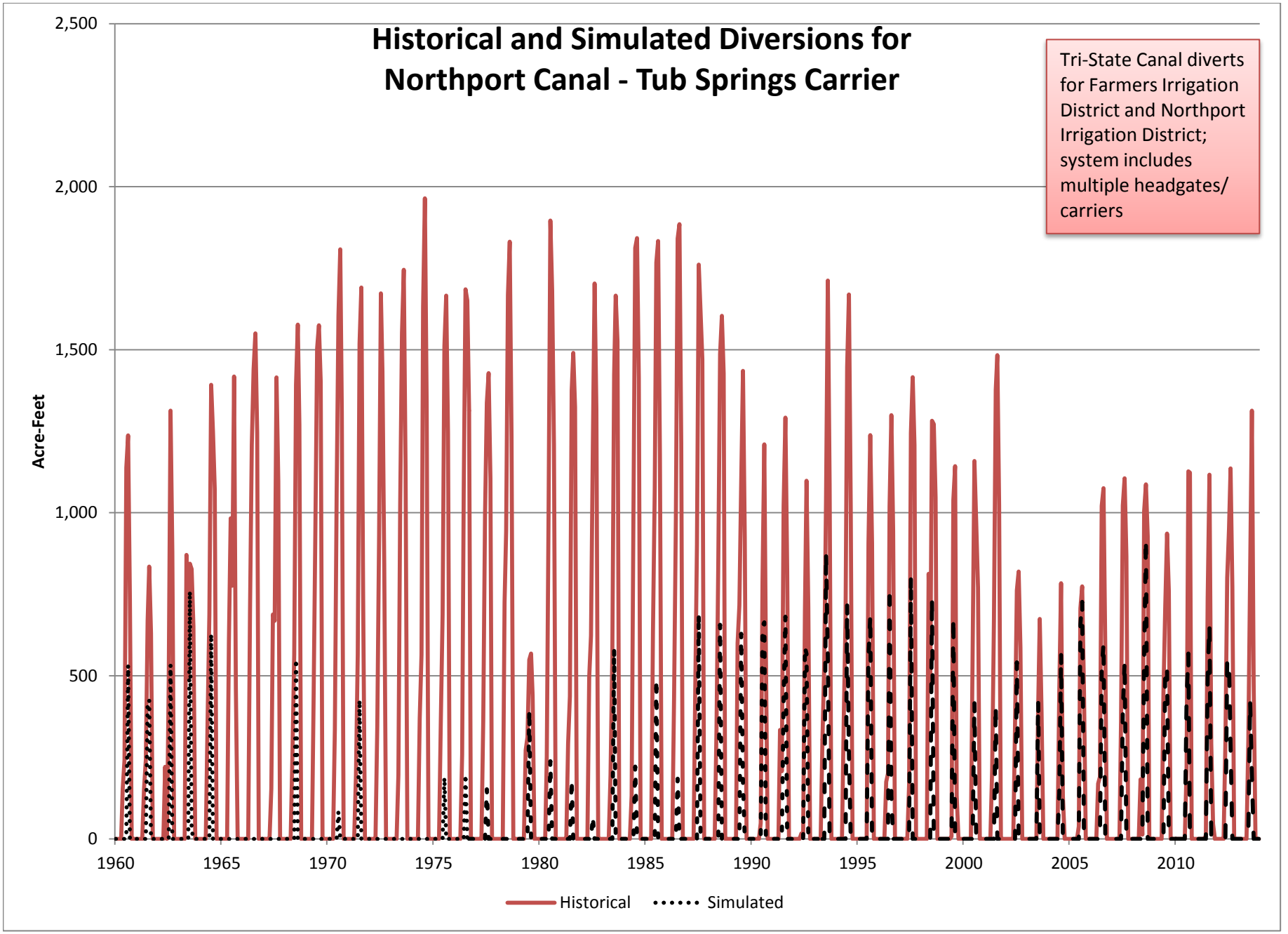

Historical and Simulated Diversions for Ninemile Canal - Ninemile Creek Carrier
Ninemile Irrigation District includes multiple headgates/ carriers
Acre-Feet
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

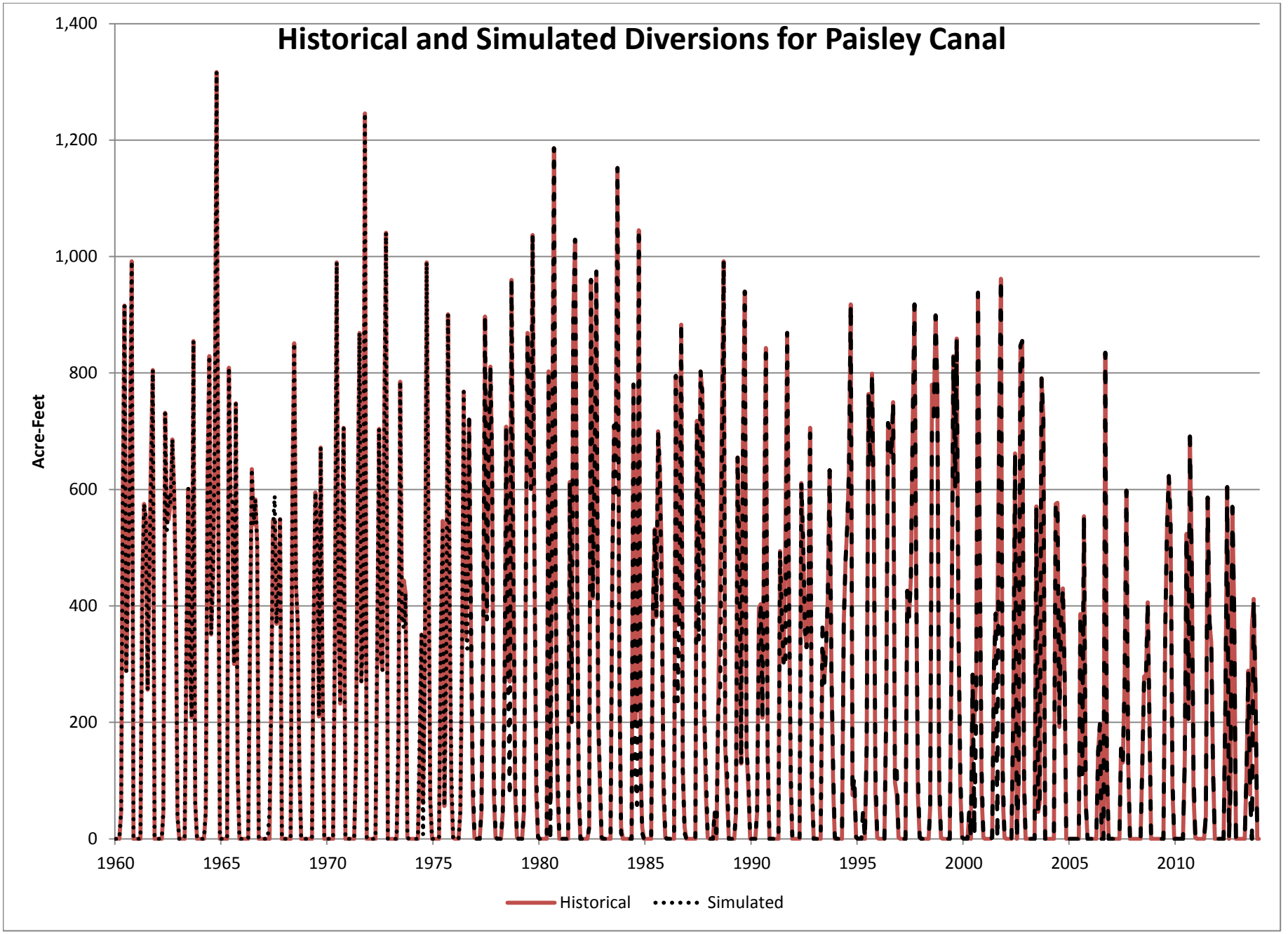

Historical and Simulated Diversions for Northport Canal - Sheep Creek Carrier
Tri-State Canal diverts for Farmers Irrigation District and Northport Irrigation District; system includes multiple headgates/ carriers
Acre-Feet
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

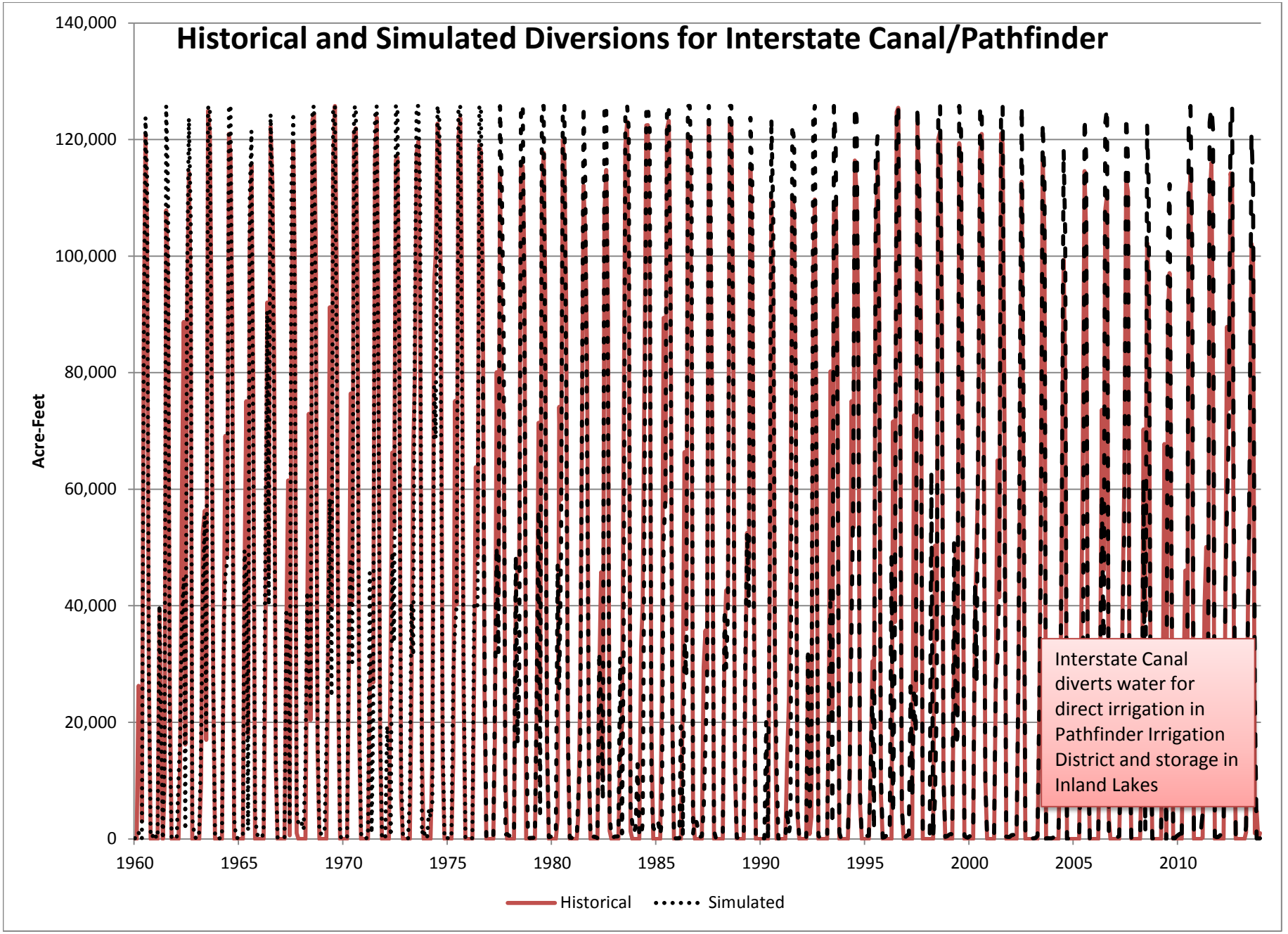

Historical and Simulated Diversions for Northport Canal - Akers Draw Carrier
Tri-State Canal diverts for Farmers Irrigation District and Northport Irrigation District; system includes multiple headgates/ carriers
Acre-Feet
800
700
600
500
400
300
200
100
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

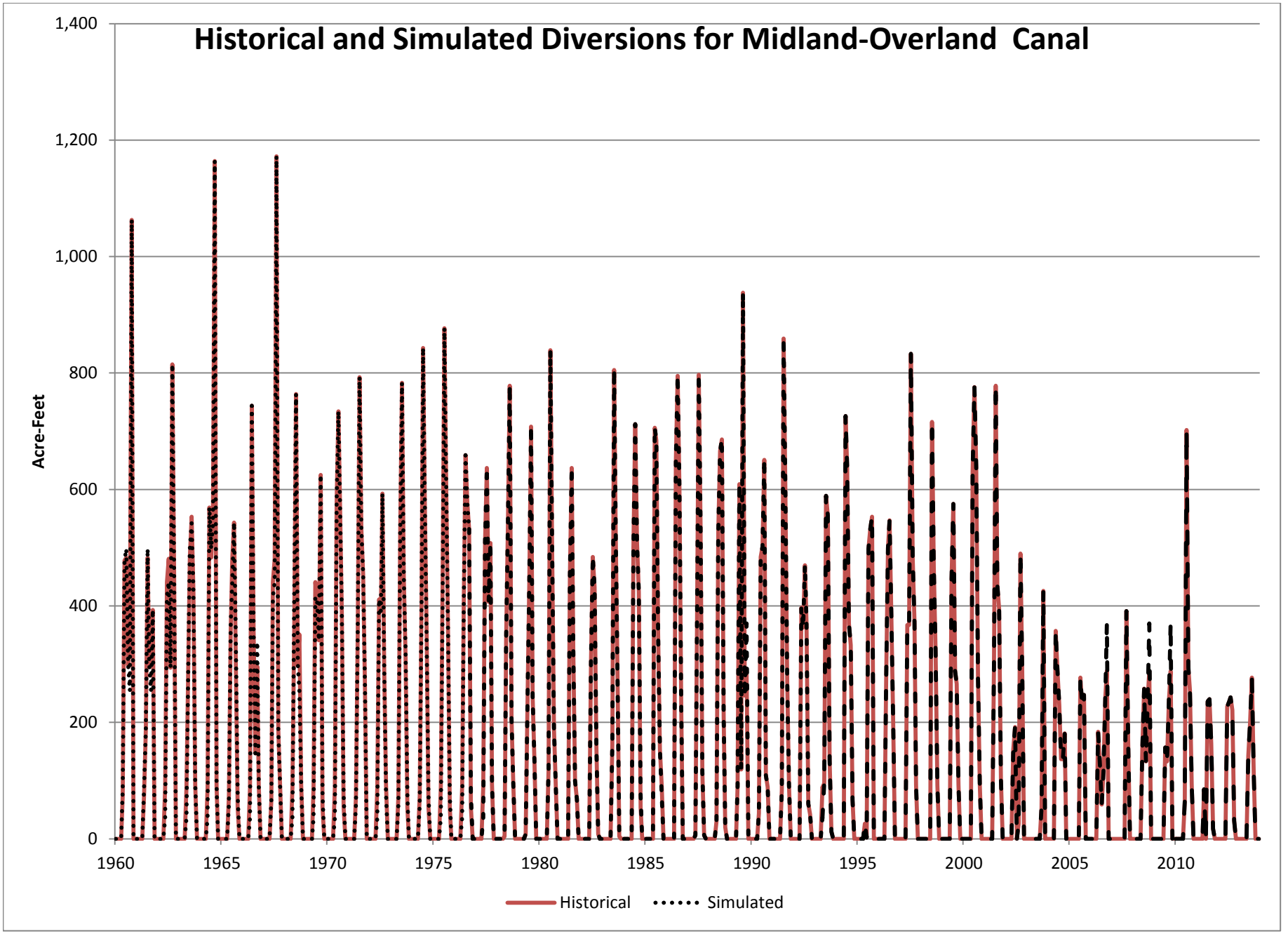

Historical and Simulated Diversions for Northport Canal - Dry Spotted Tail Carrier
Tri-State Canal diverts for Farmers Irrigation District and Northport Irrigation District; system includes multiple headgates/ carriers
Acre-Feet
1,200
1,000
800
600
400
200
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

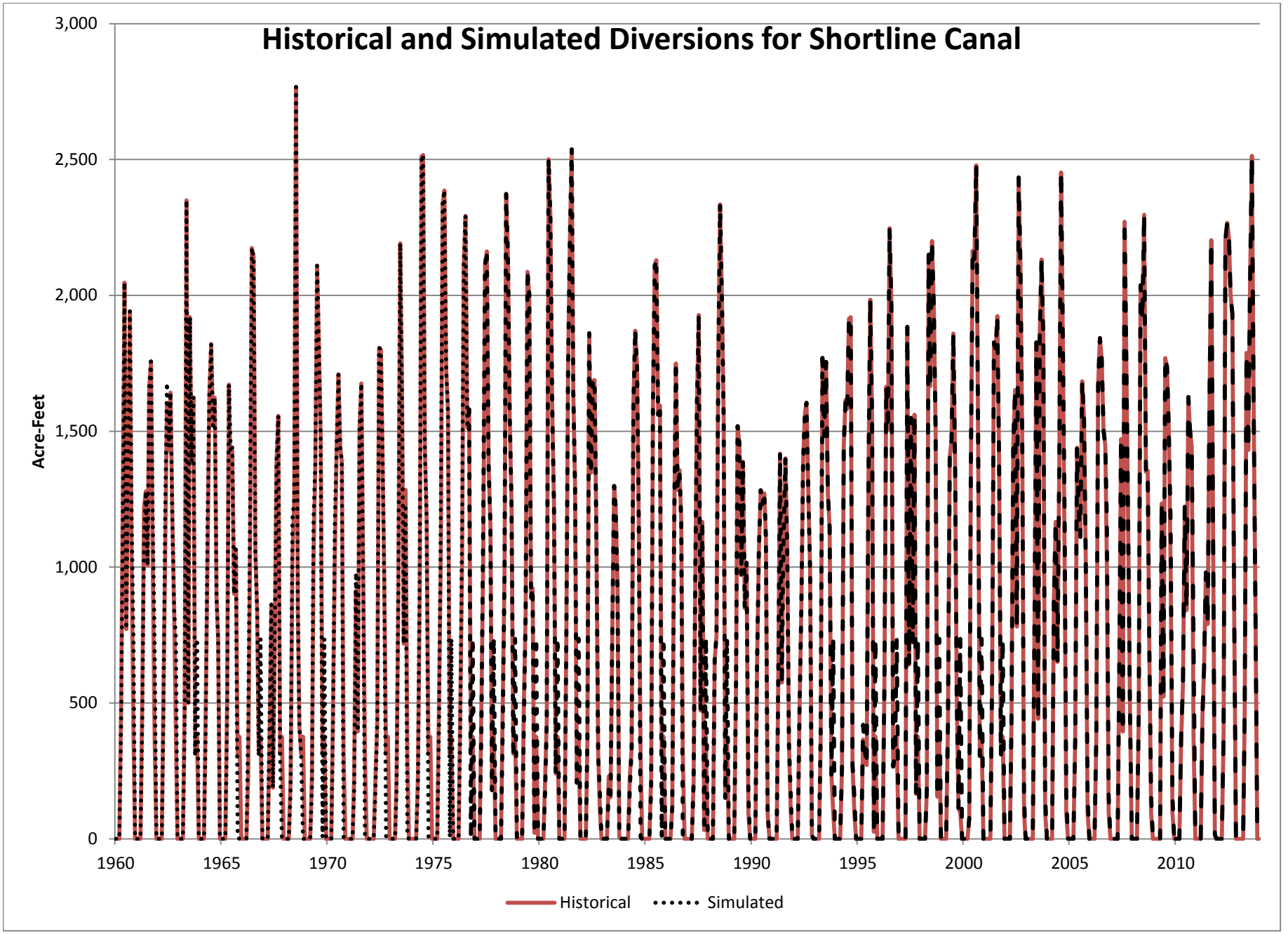

Historical and Simulated Diversions for Northport Canal - Wet Spotted Tail Carrier
Tri-State Canal diverts for Farmers Irrigation District and Northport Irrigation District; system includes multiple headgates/ carriers
Acre-Feet
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

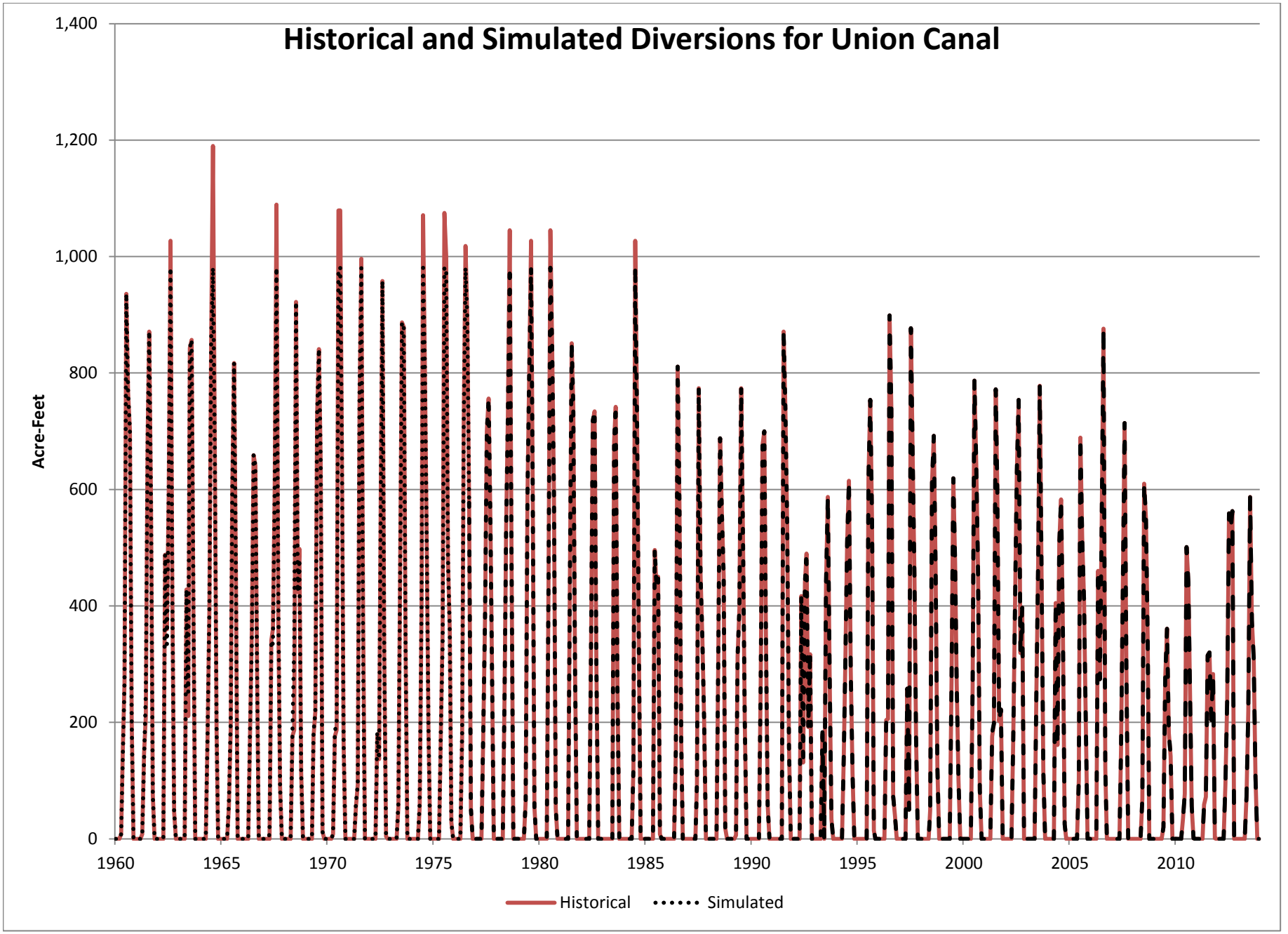

Historical and Simulated Diversions for Northport Canal - Tub Springs Carrier
Tri-State Canal diverts for Farmers Irrigation District and Northport Irrigation District; system includes multiple headgates/ carriers
Acre-Feet
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

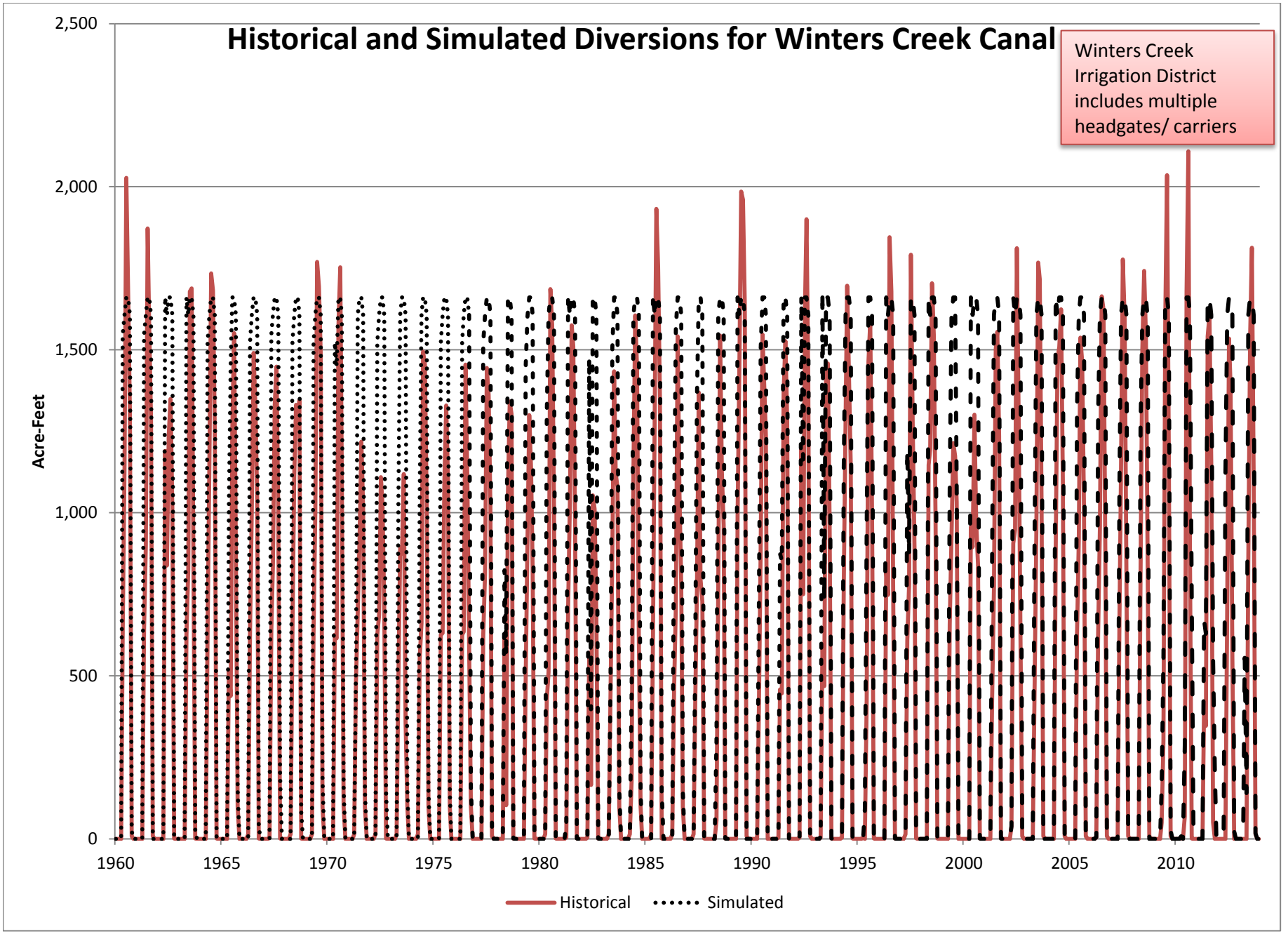

Historical and Simulated Diversions for Paisley Canal
Acre-Feet
1,400
1,200
1,000
800
600
400
200
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

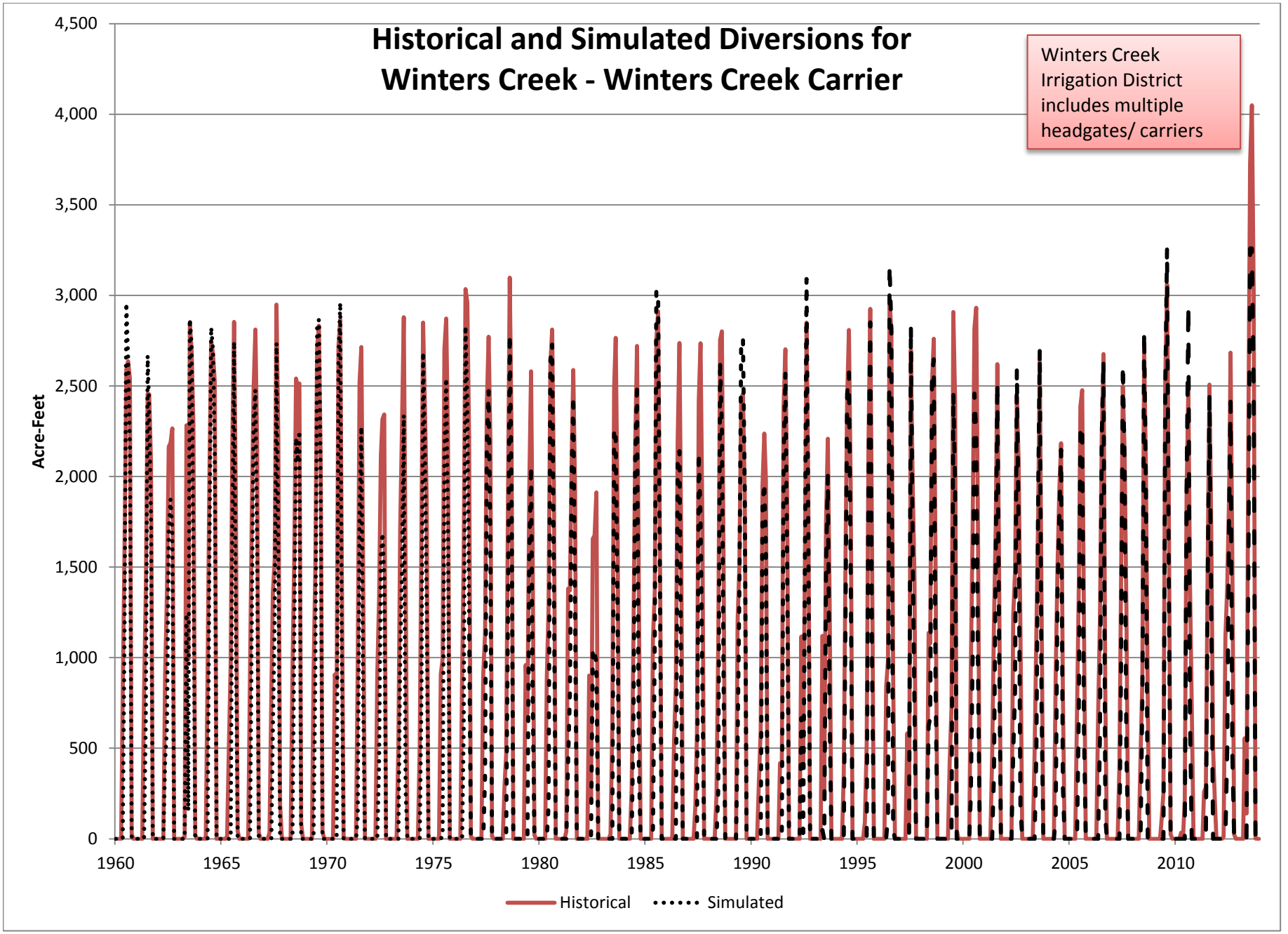

Historical and Simulated Diversions for Interstate Canal/Pathfinder
Acre-Feet
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated
Interstate Canal diverts water for direct irrigation in Pathfinder Irrigation District and storage in Inland Lakes

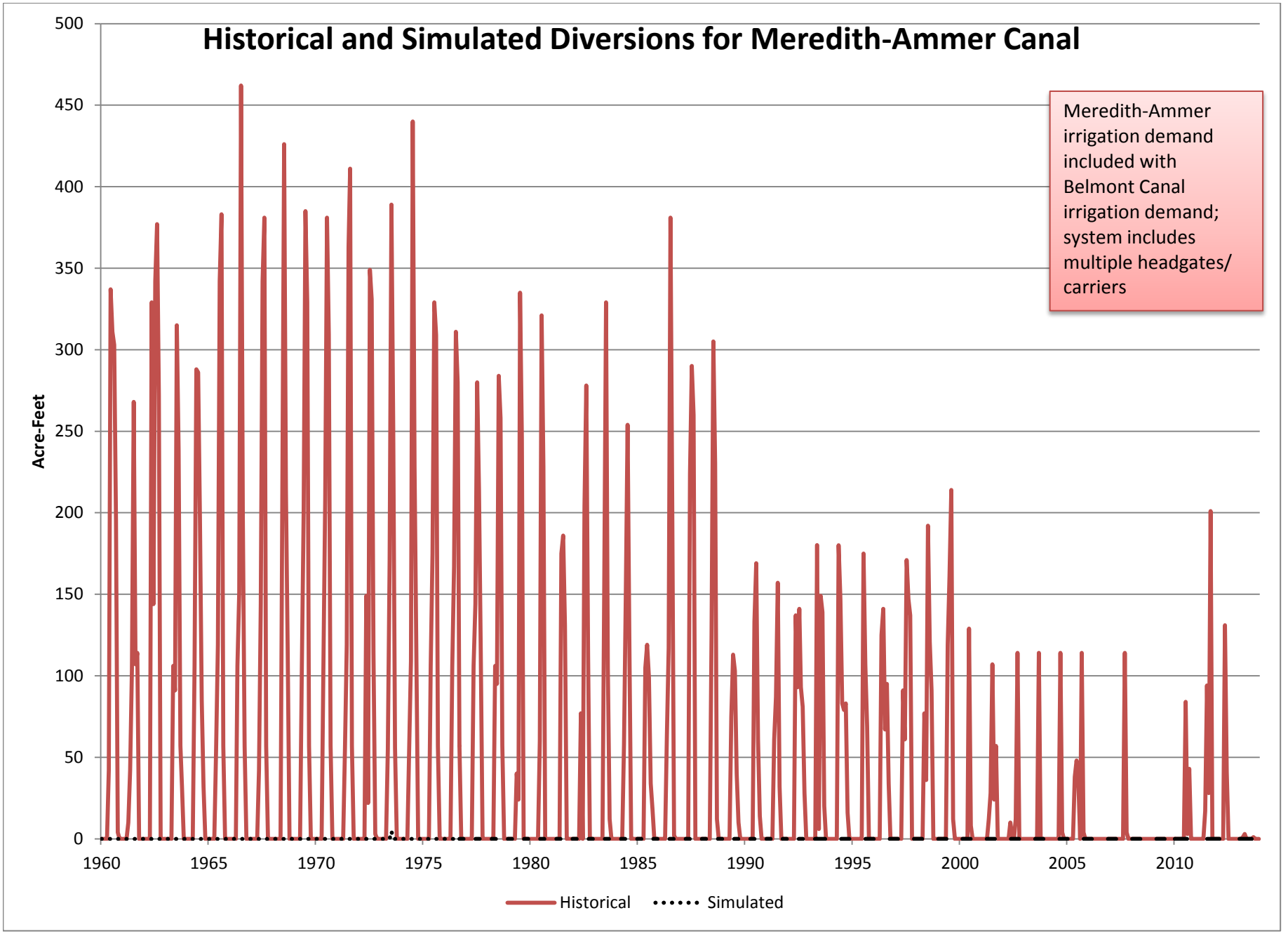

Historical and Simulated Diversions for Midland-Overland Canal
Acre-Feet
1,400
1,200
1,000
800
600
400
200
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

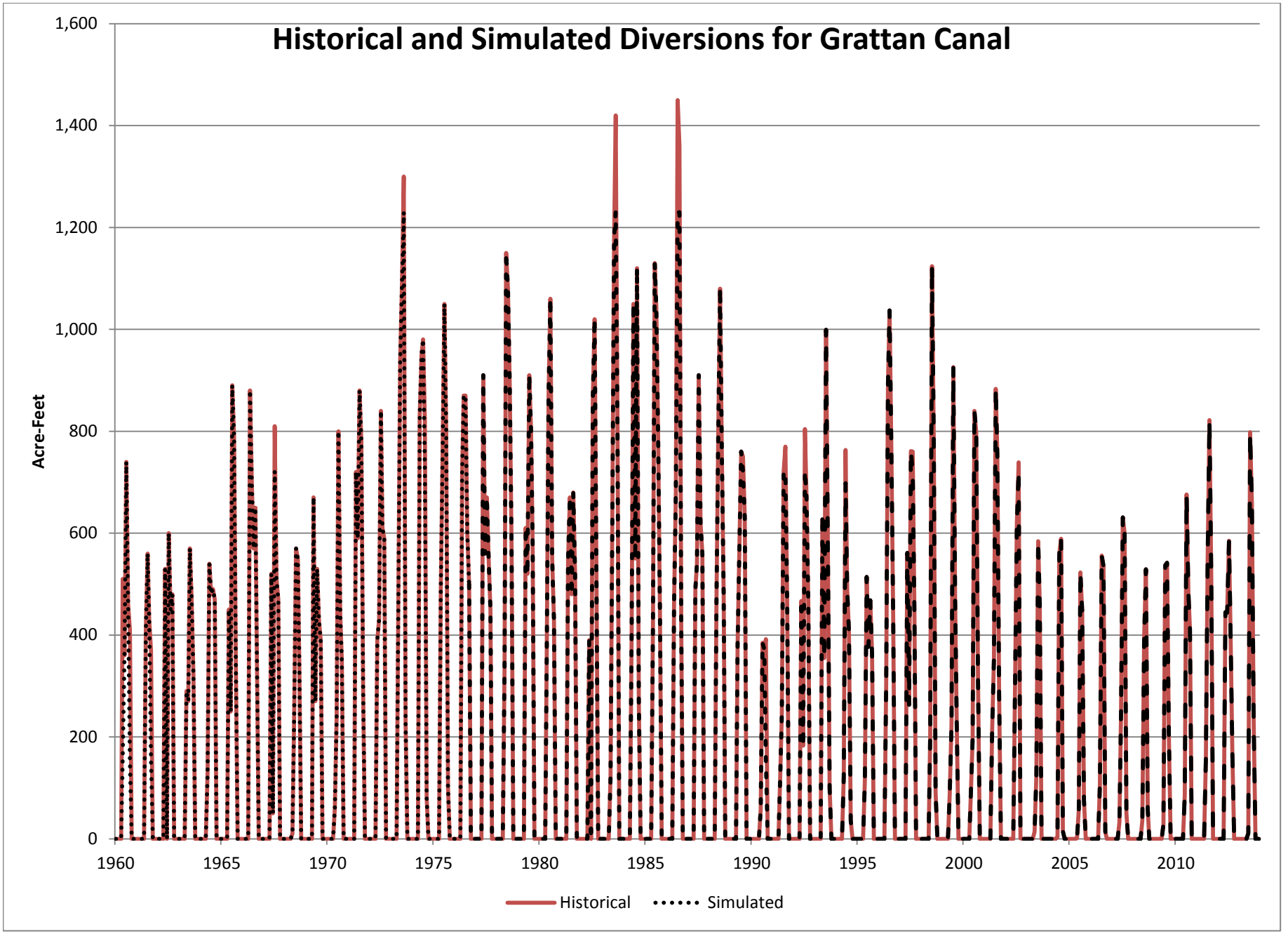

Historical and Simulated Diversions for Shortline Canal
Acre-Feet
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

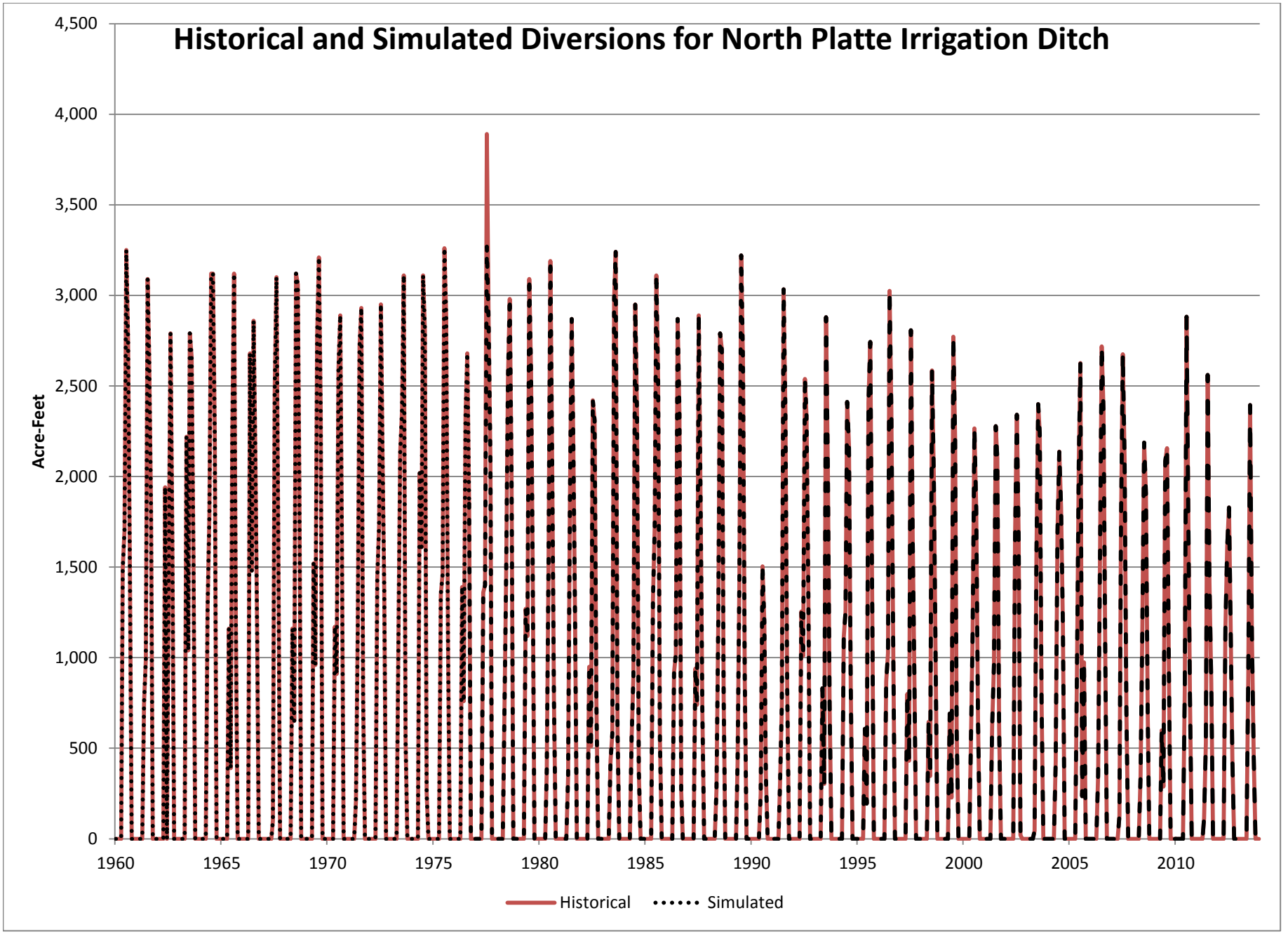

Historical and Simulated Diversions for Union Canal
Acre-Feet
1,400
1,200
1,000
800
600
400
200
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

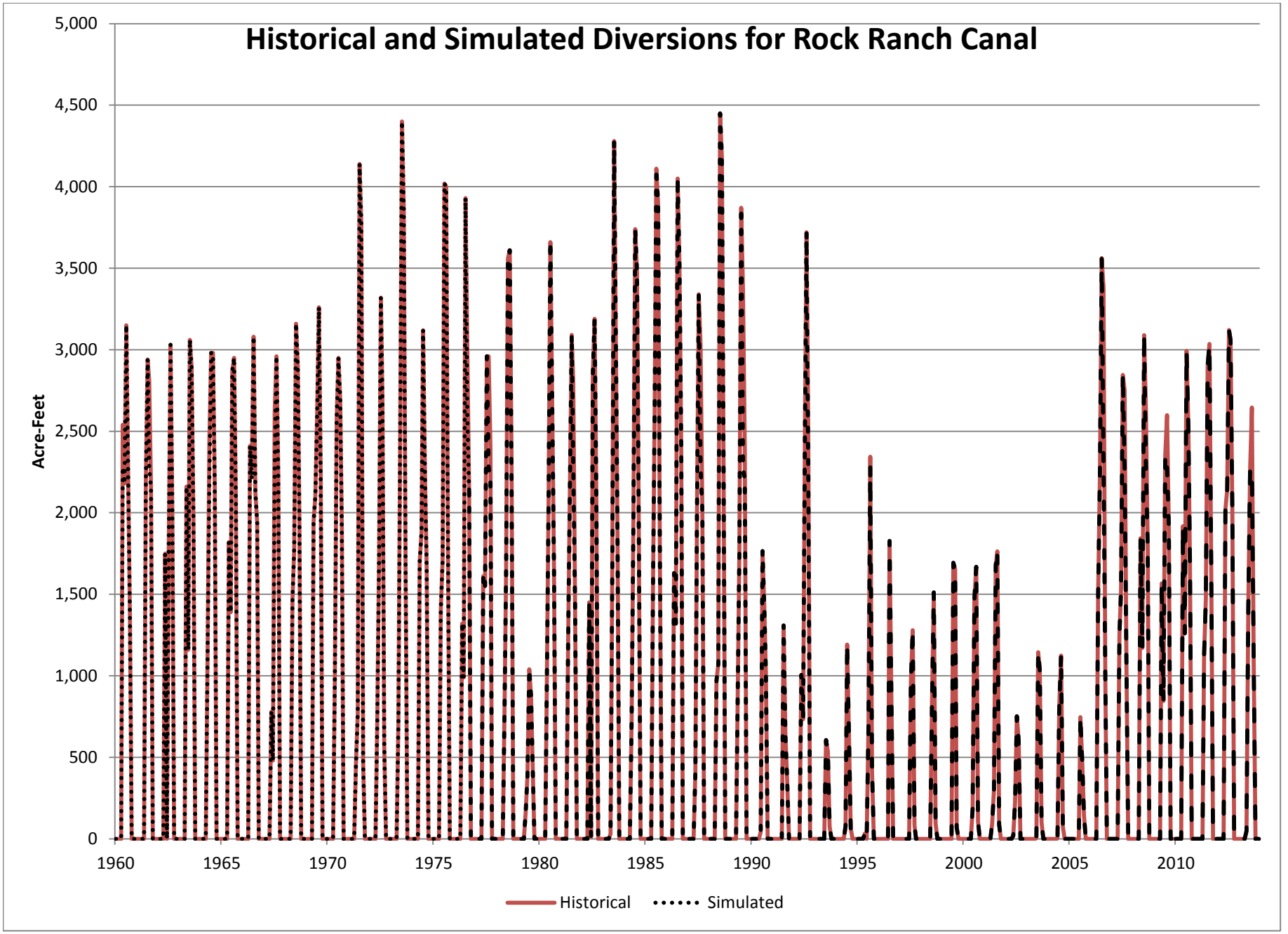

Historical and Simulated Diversions for Winters Creek Canal
Winters Creek Irrigation District includes multiple headgates/ carriers
Acre-Feet
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

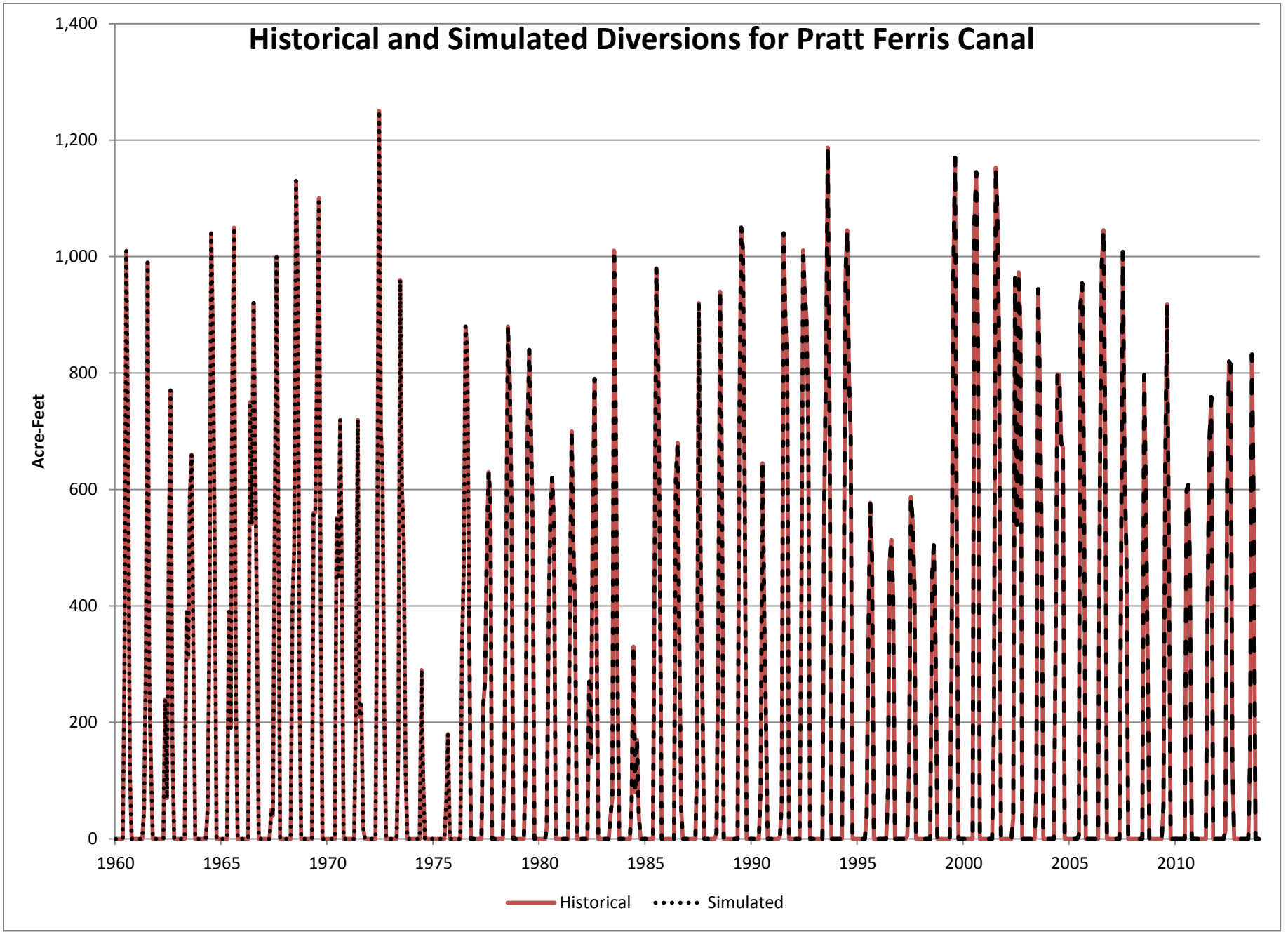

Historical and Simulated Diversions for
Winters Creek - Winters Creek Carrier
Winters Creek Irrigation District includes multiple headgates/ carriers
Acre-Feet
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

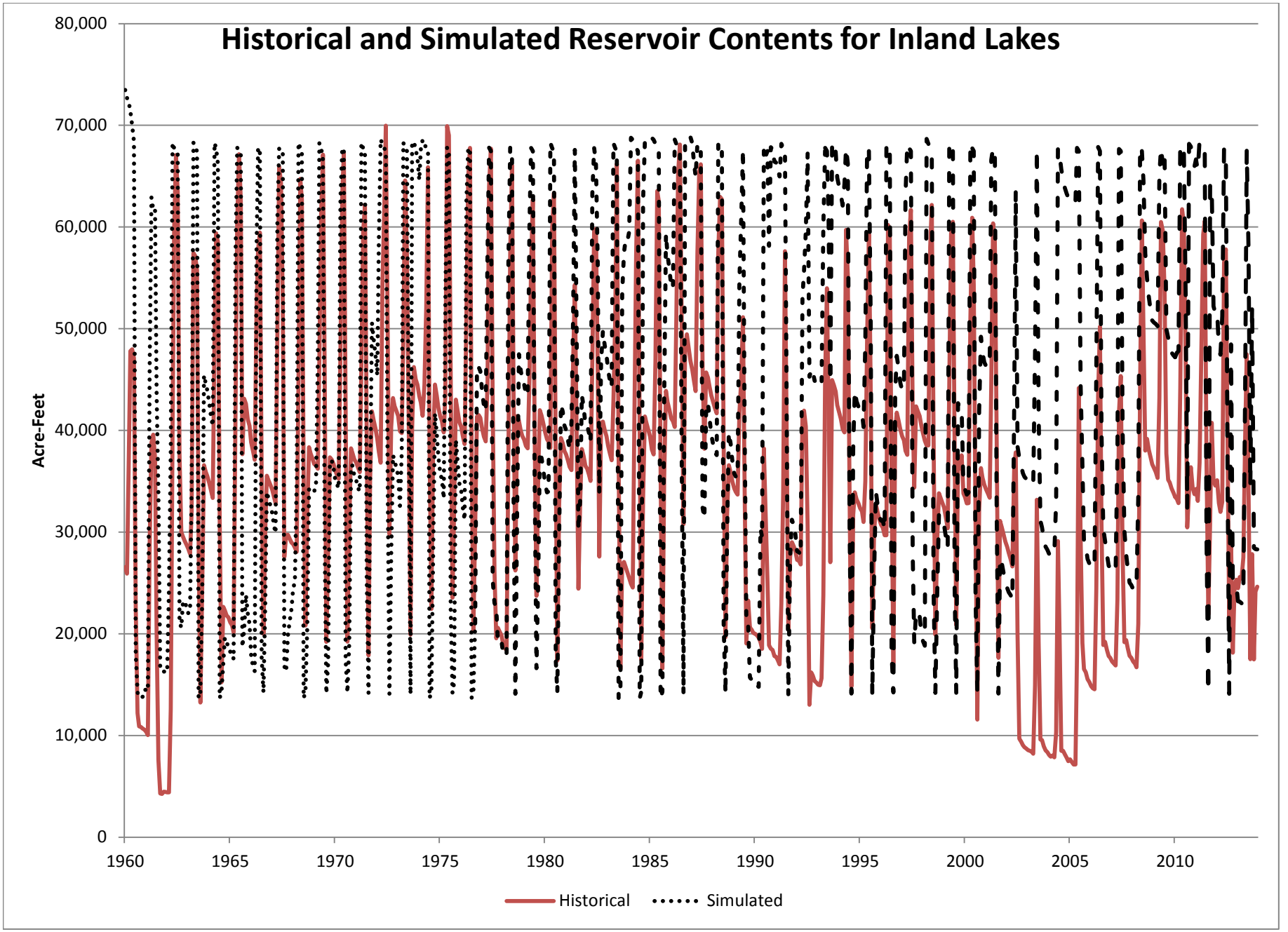

Historical and Simulated Diversions for Meredith-Ammer Canal
Meredith-Ammer irrigation demand included with Belmont Canal irrigation demand; system includes multiple headgates/ carriers
Acre-Feet
500
450
400
350
300
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

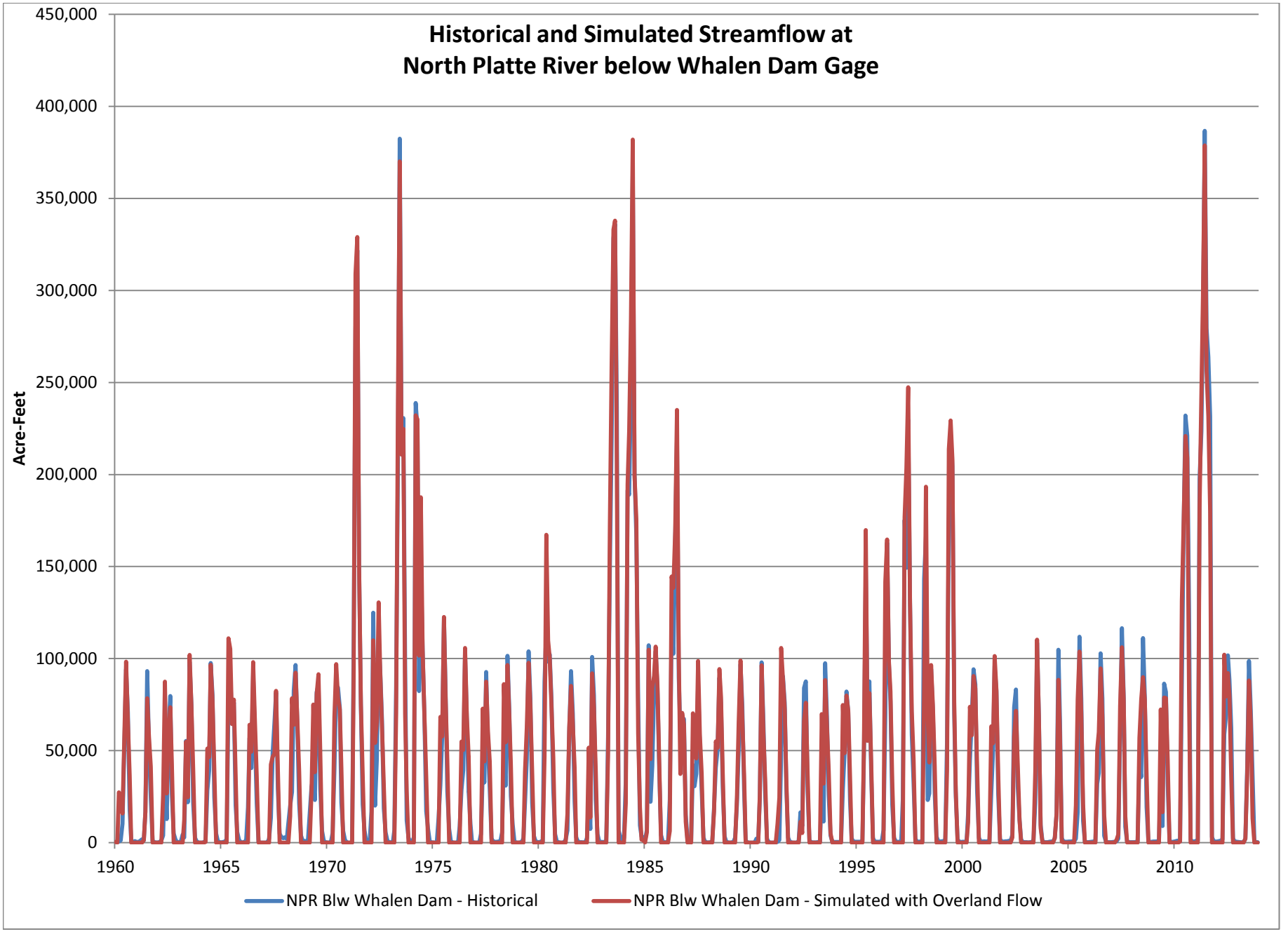

Historical and Simulated Diversions for Grattan Canal
Acre-Feet
1,600
1,400
1,200
1,000
800
600
400
200
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

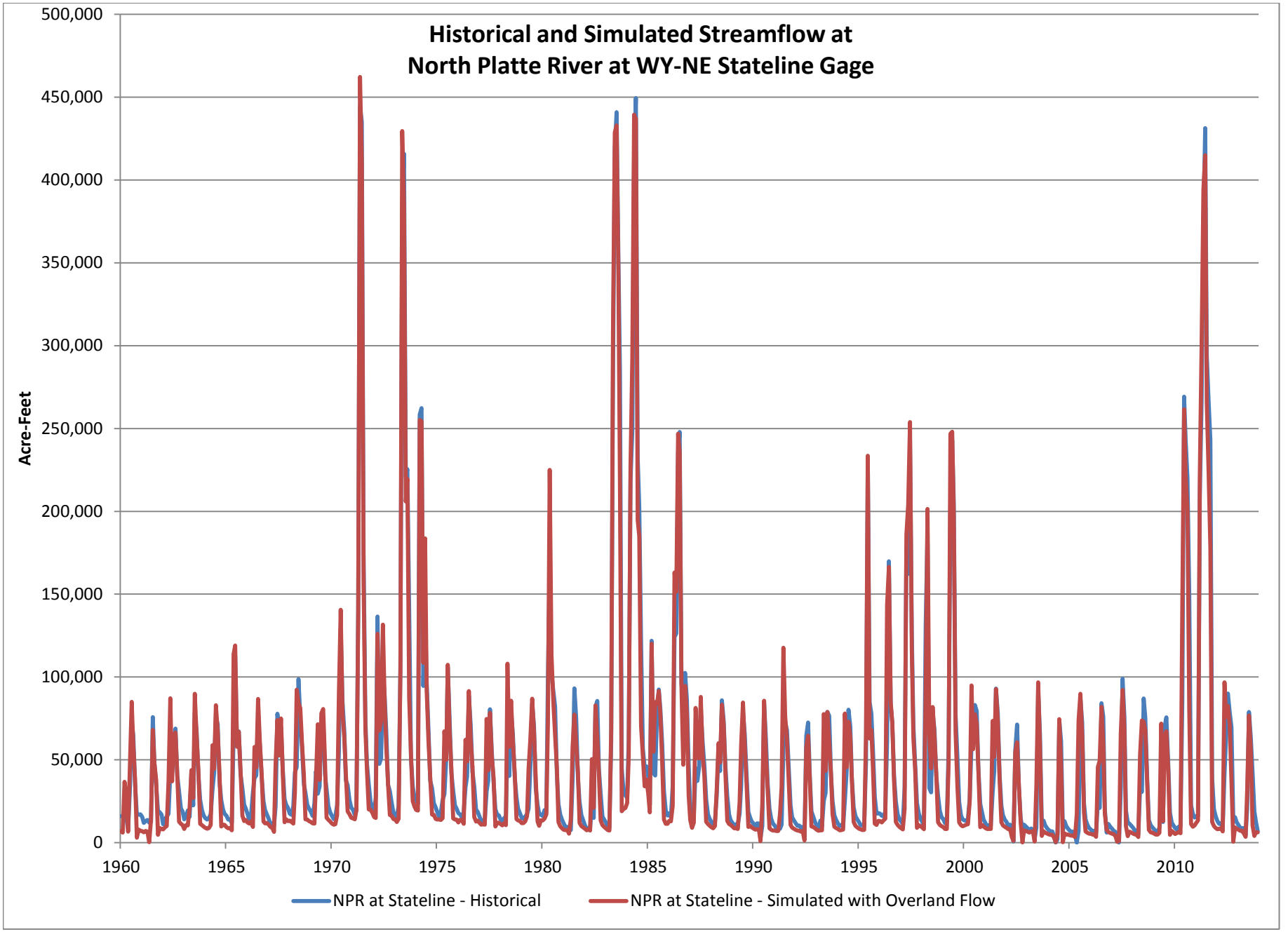

Historical and Simulated Diversions for North Platte Irrigation Ditch
Acre-Feet
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

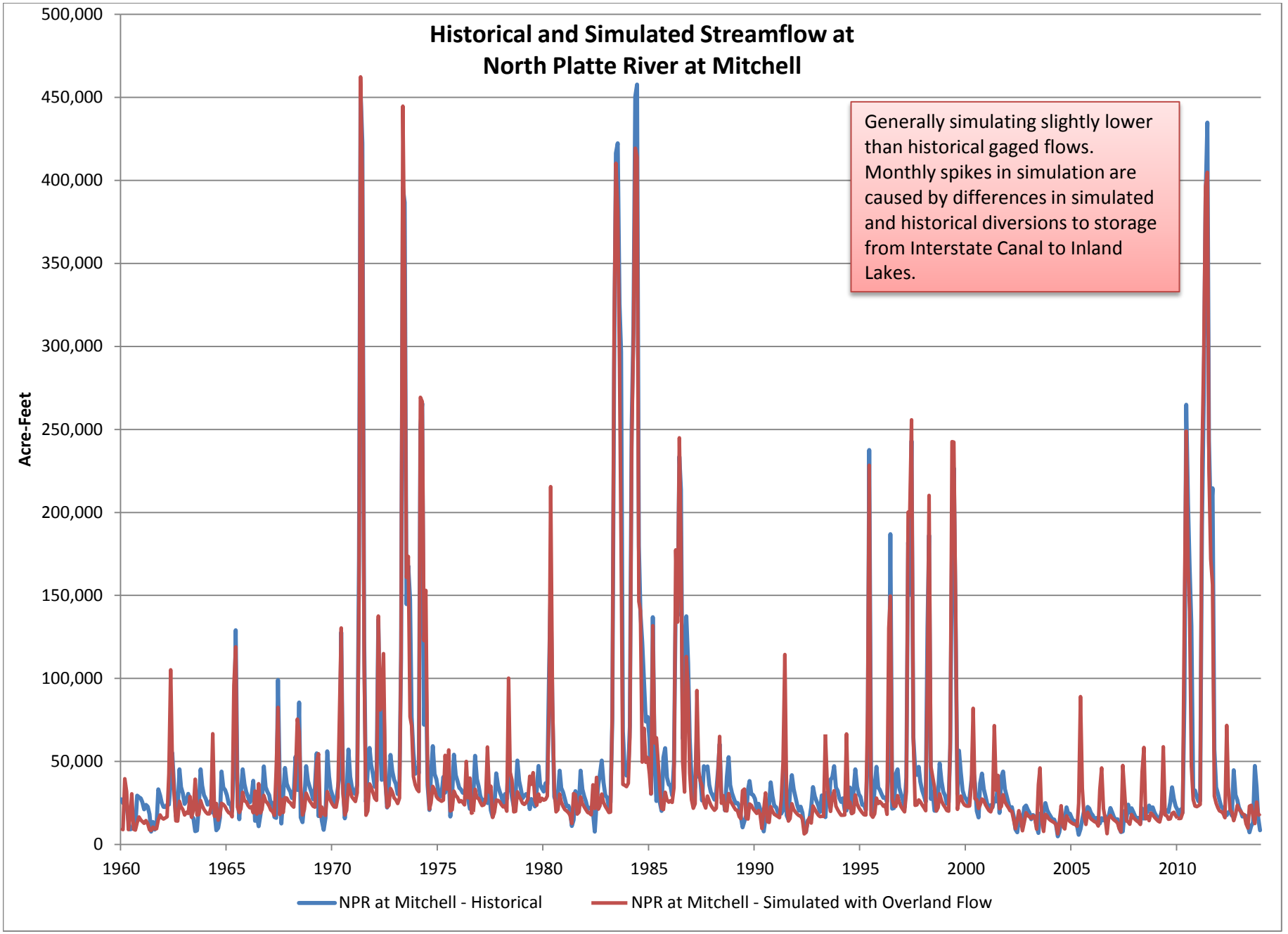

Historical and Simulated Diversions for Rock Ranch Canal
Acre-Feet
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

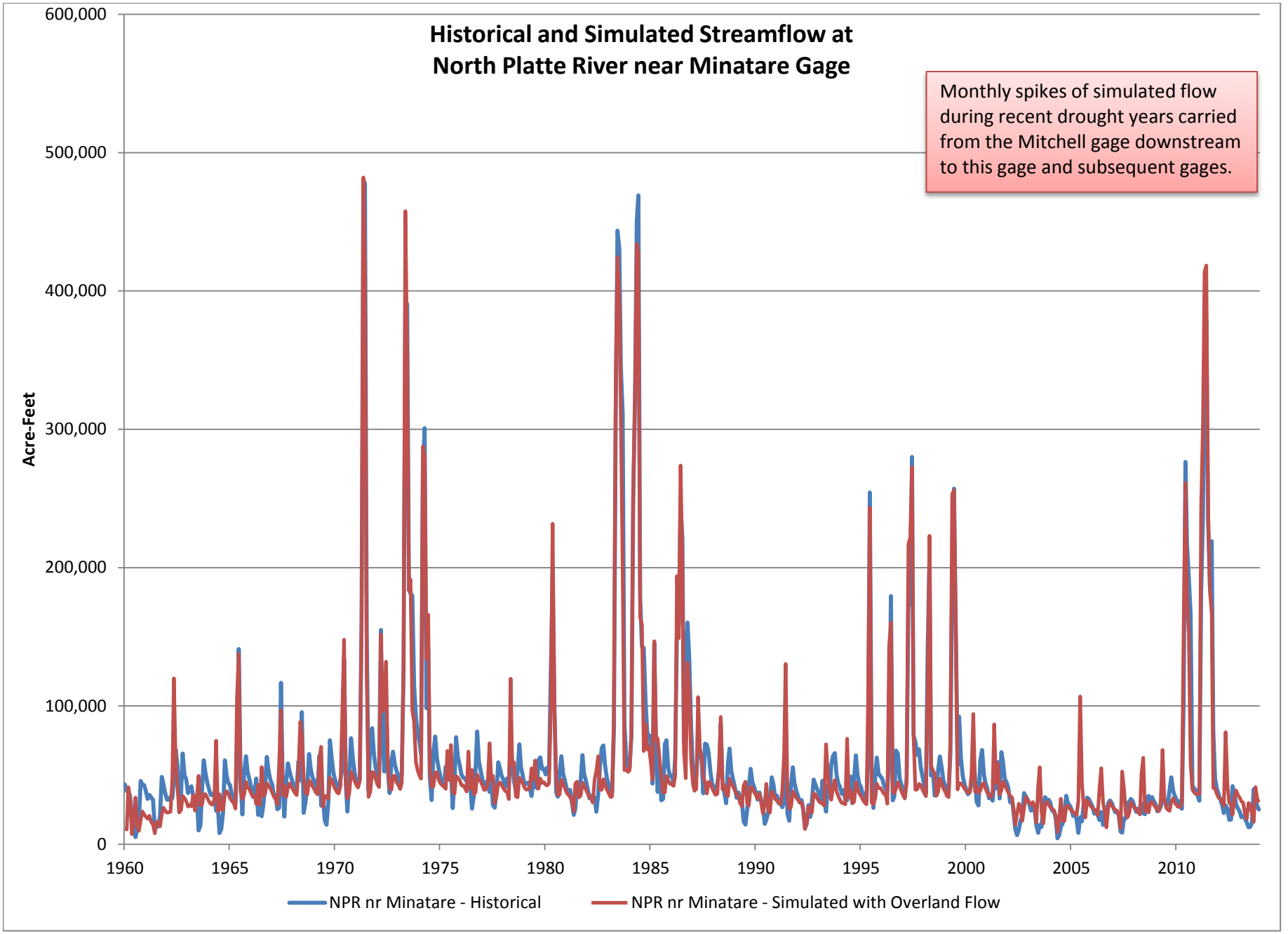

Historical and Simulated Diversions for Pratt Ferris Canal
Acre-Feet
1,400
1,200
1,000
800
600
400
200
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

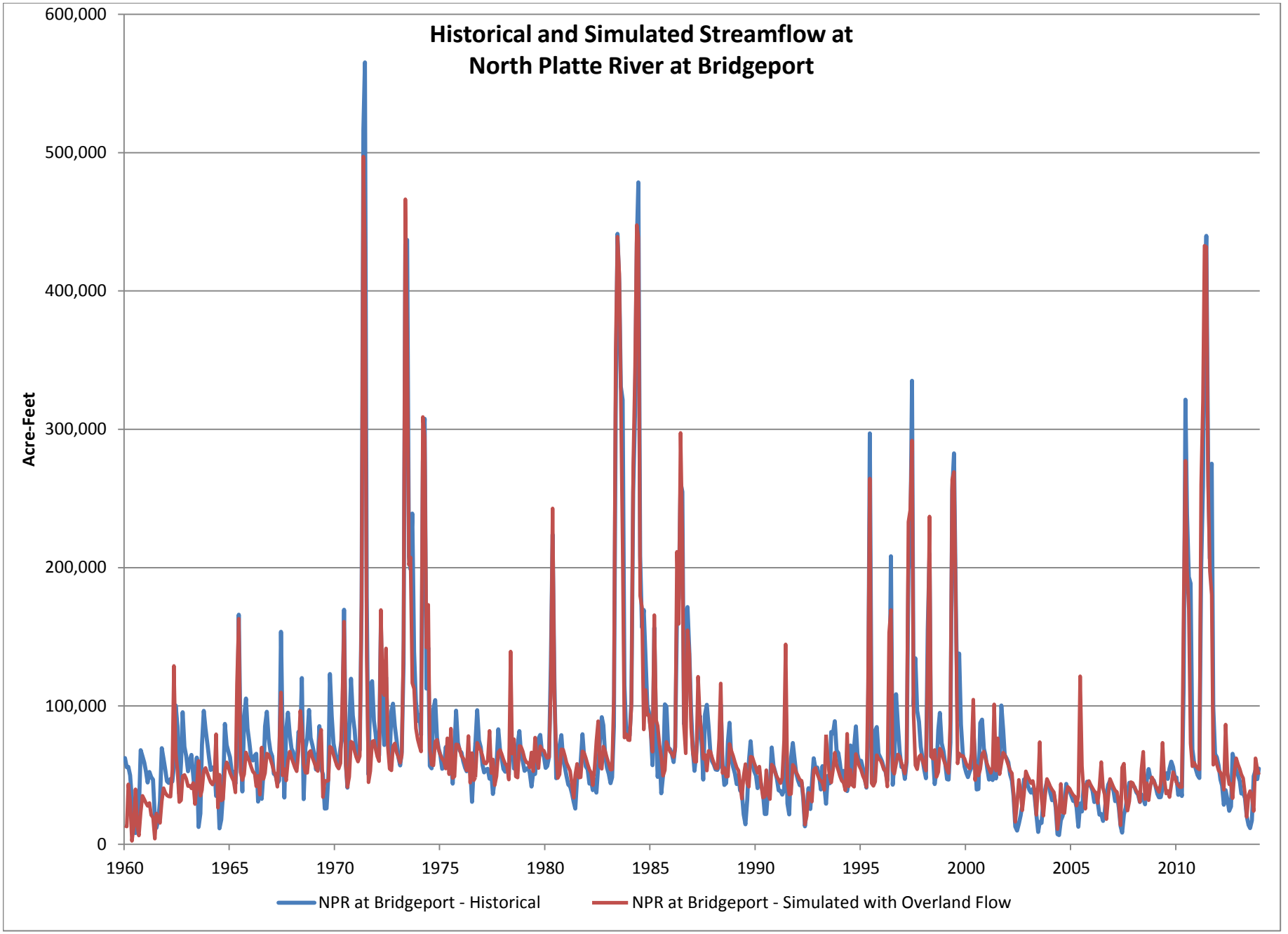

Historical and Simulated Reservoir Contents for Inland Lakes
Acre-Feet
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Historical
Simulated

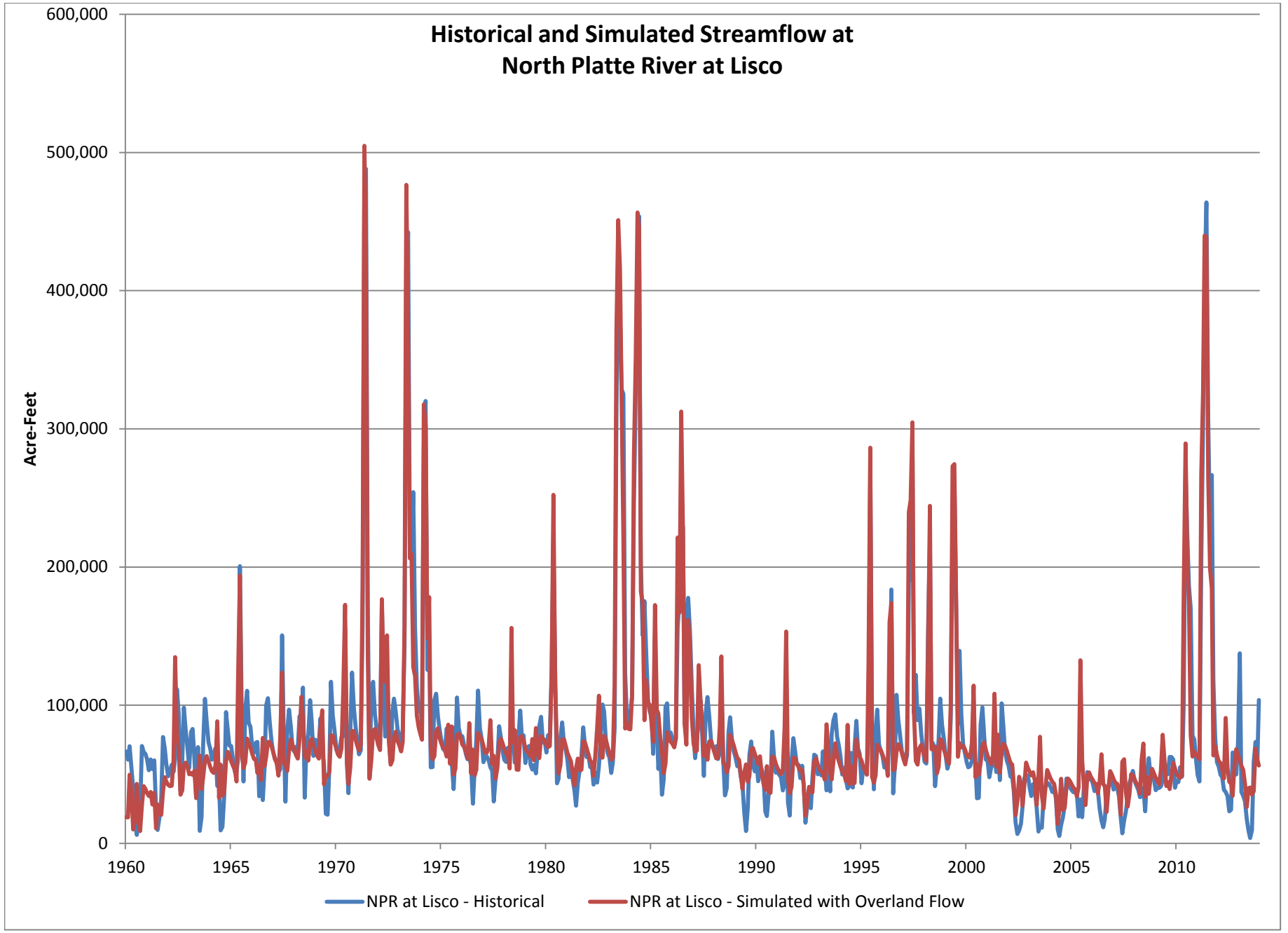

Historical and Simulated Streamflow at
North Platte River below Whalen Dam Gage
Acre-Feet
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
NPR Blw Whalen Dam - Historical
NPR Blw Whalen Dam - Simulated with Overland Flow

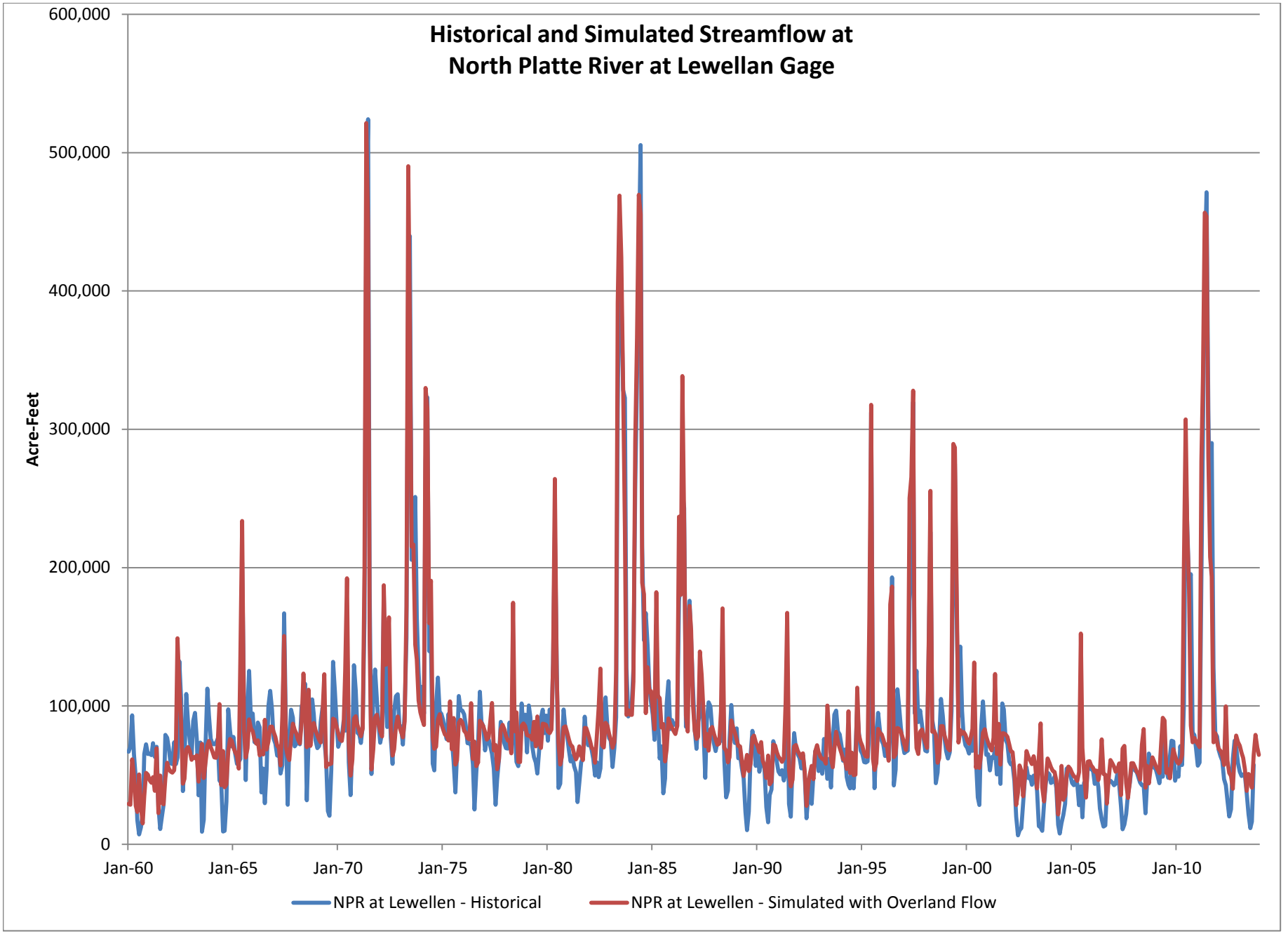

Historical and Simulated Streamflow at
North Platte River at WY-NE Stateline Gage
Acre-Feet
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
NPR at Stateline - Historical
NPR at Stateline - Simulated with Overland Flow

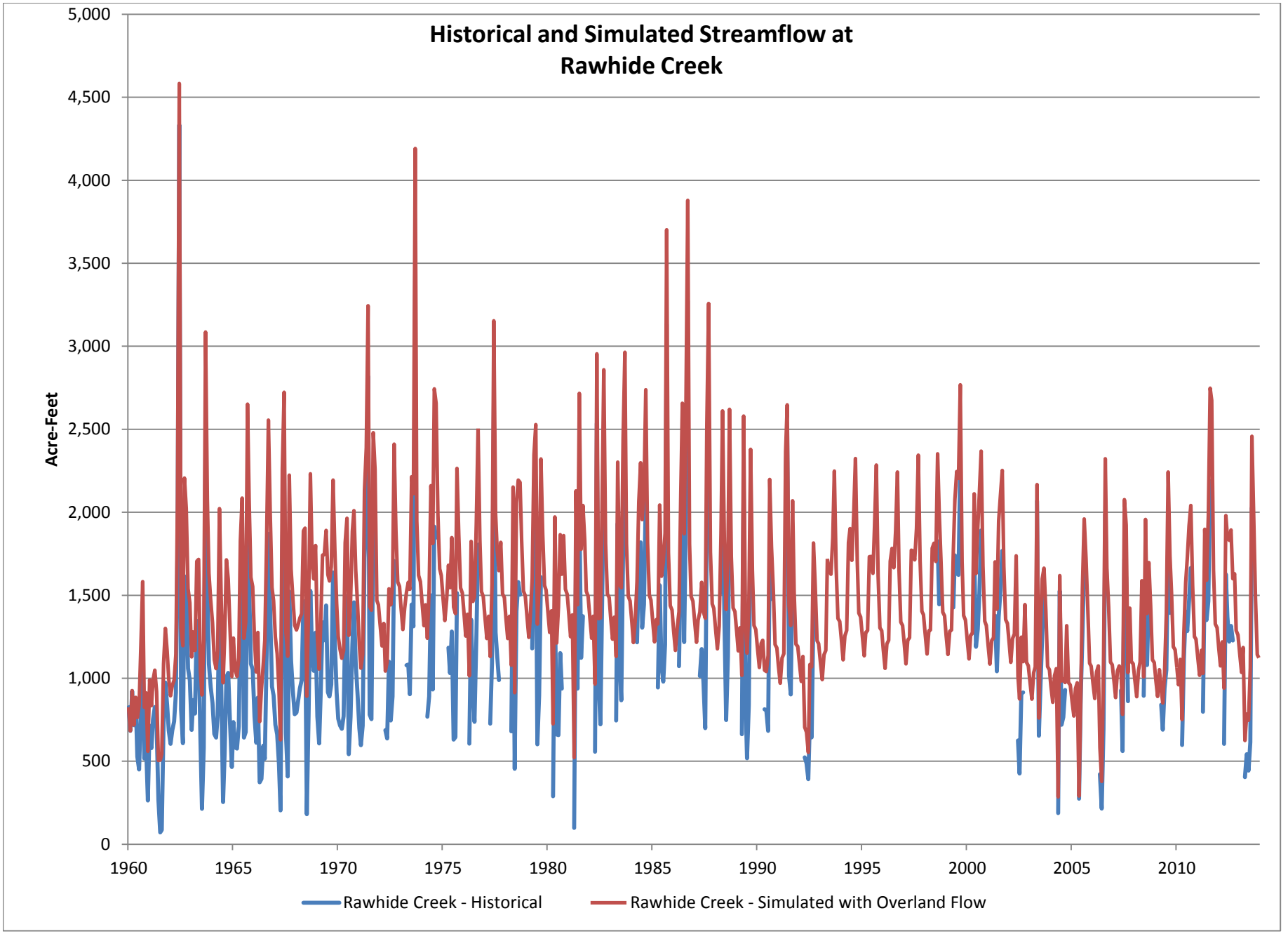

Historical and Simulated Streamflow at
North Platte River at Mitchell
Generally simulating slightly lower than historical gaged flows. Monthly spikes in simulation are caused by differences in simulated and historical diversions to storage from Interstate Canal to Inland Lakes.
Acre-Feet
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
NPR at Mitchell - Historical
NPR at Mitchell - Simulated with Overland Flow

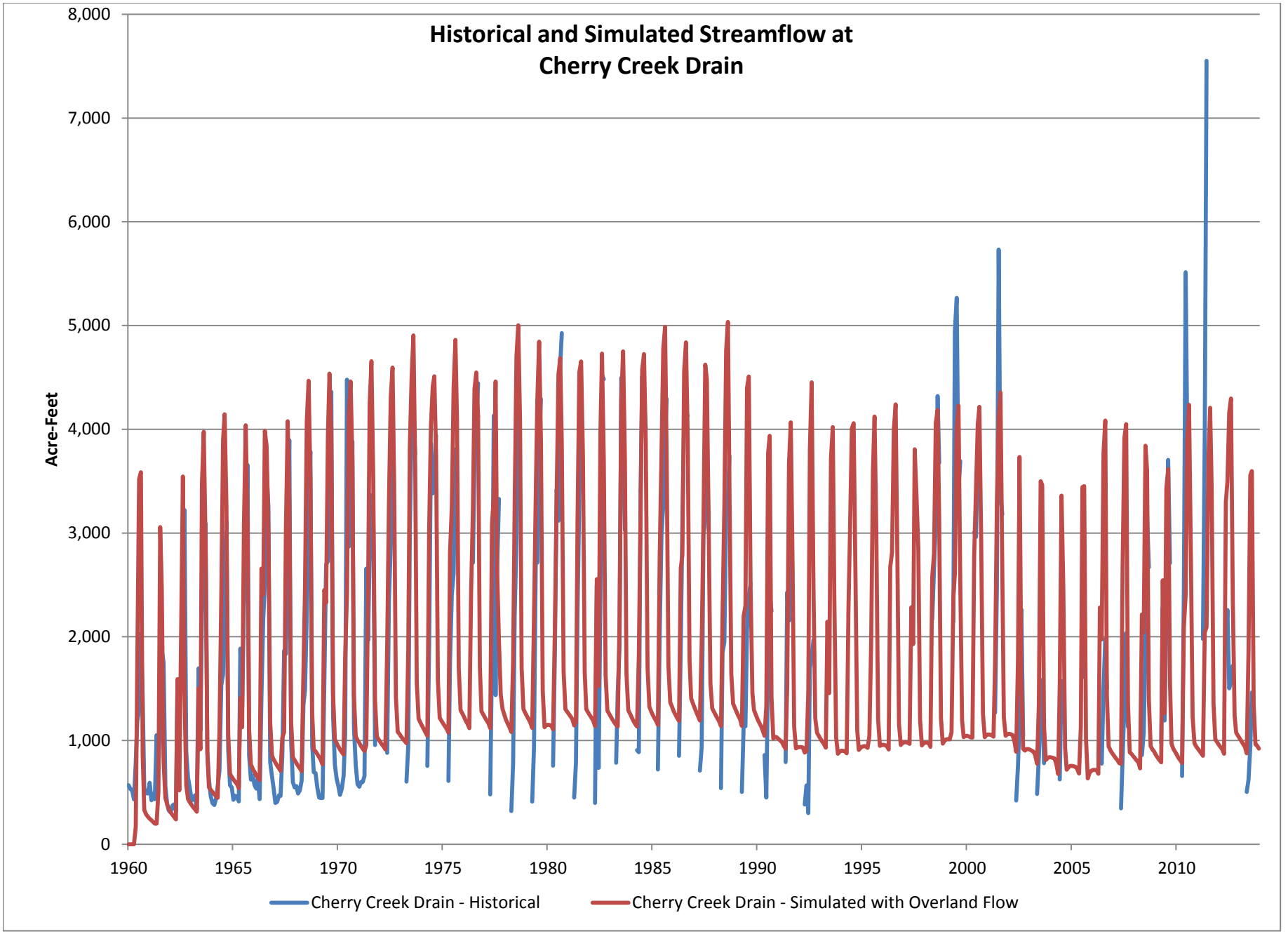

Historical and Simulated Streamflow at North Platte River near Minatare Gage
Monthly spikes of simulated flow during recent drought years carried from the Mitchell gage downstream to this gage and subsequent gages.
Acre-Feet
600,000
500,000
400,000
300,000
200,000
100,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
NPR nr Minatare - Historical
NPR nr Minatare - Simulated with Overland Flow

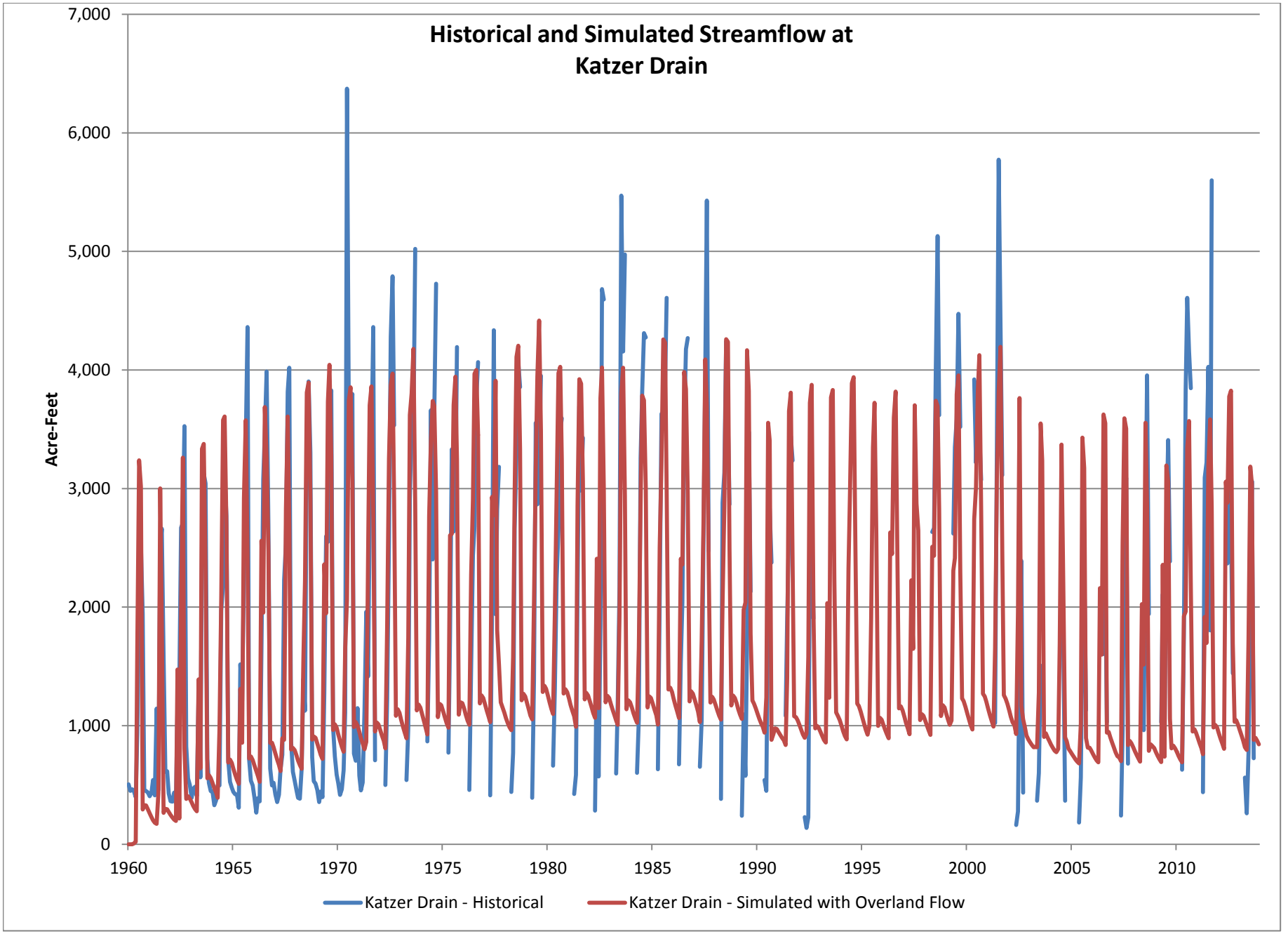

Historical and Simulated Streamflow at
North Platte River at Bridgeport
Acre-Feet
600,000
500,000
400,000
300,000
200,000
100,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
NPR at Bridgeport - Historical
NPR at Bridgeport - Simulated with Overland Flow

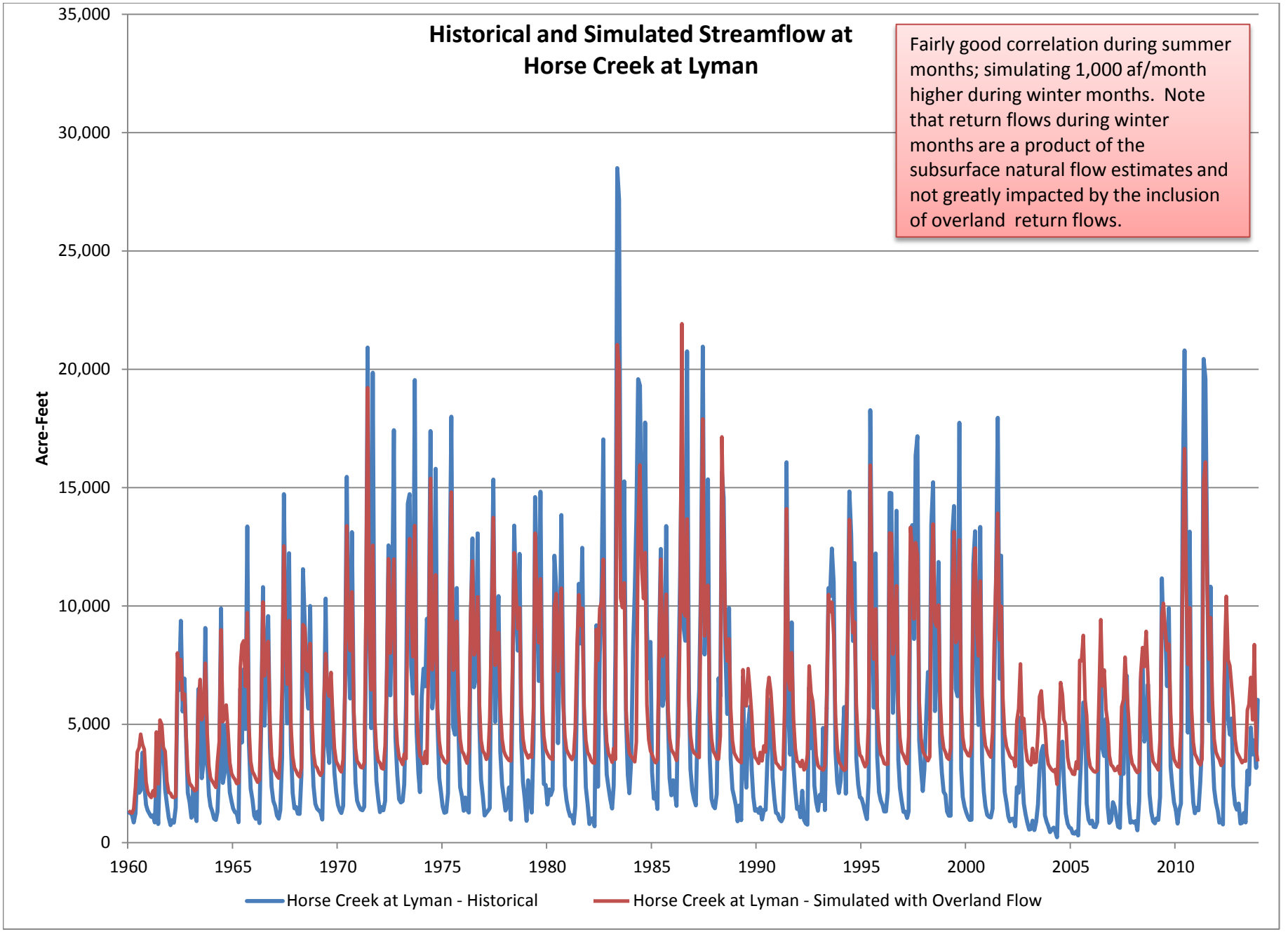

Historical and Simulated Streamflow at
North Platte River at Lisco
Acre-Feet
600,000
500,000
400,000
300,000
200,000
100,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
NPR at Lisco - Historical
NPR at Lisco - Simulated with Overland Flow

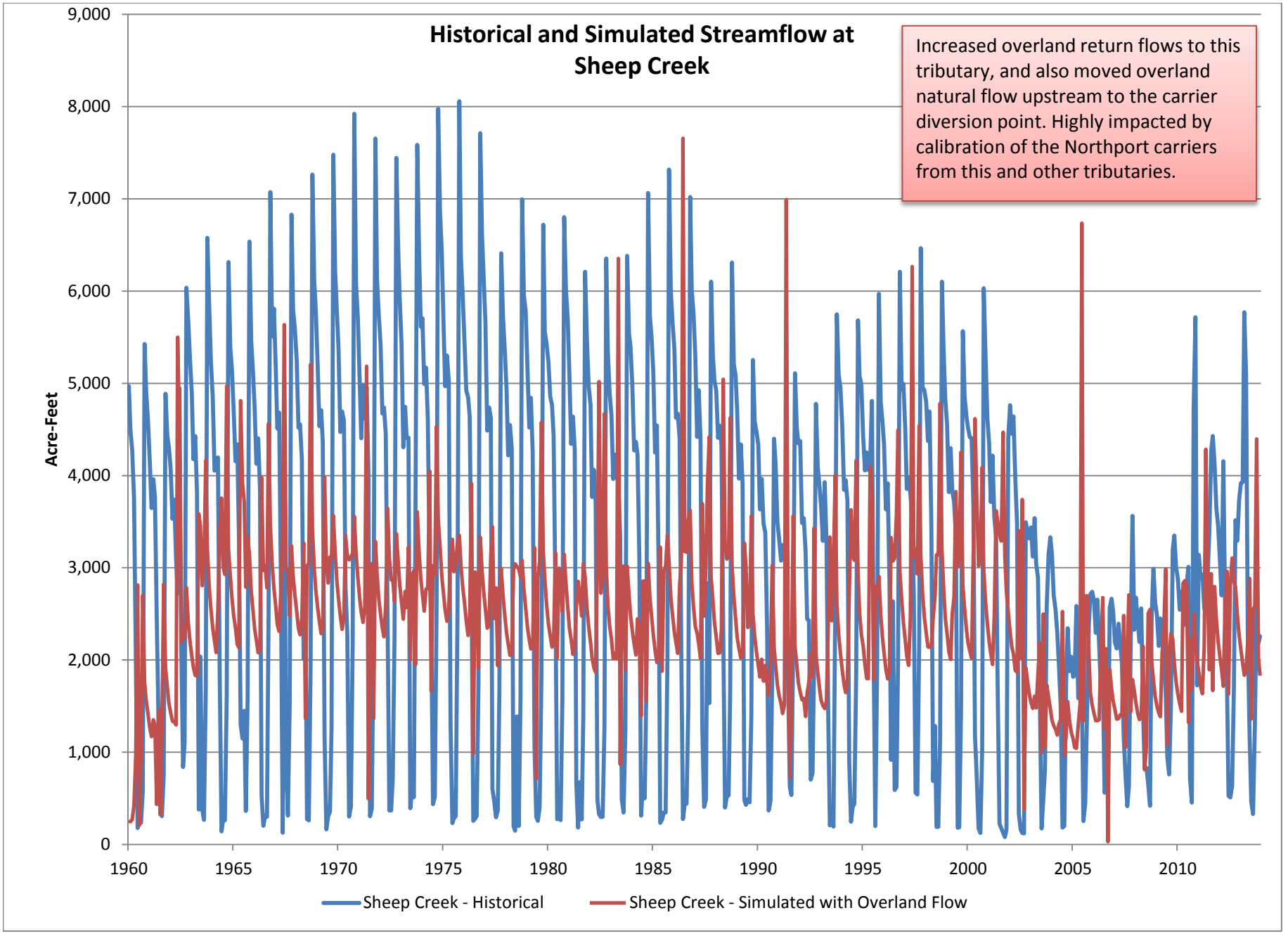

Historical and Simulated Streamflow at
North Platte River at Lewellan Gage
Acre-Feet
600,000
500,000
400,000
300,000
200,000
100,000
0
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
NPR at Lewellen - Historical
NPR at Lewellen - Simulated with Overland Flow

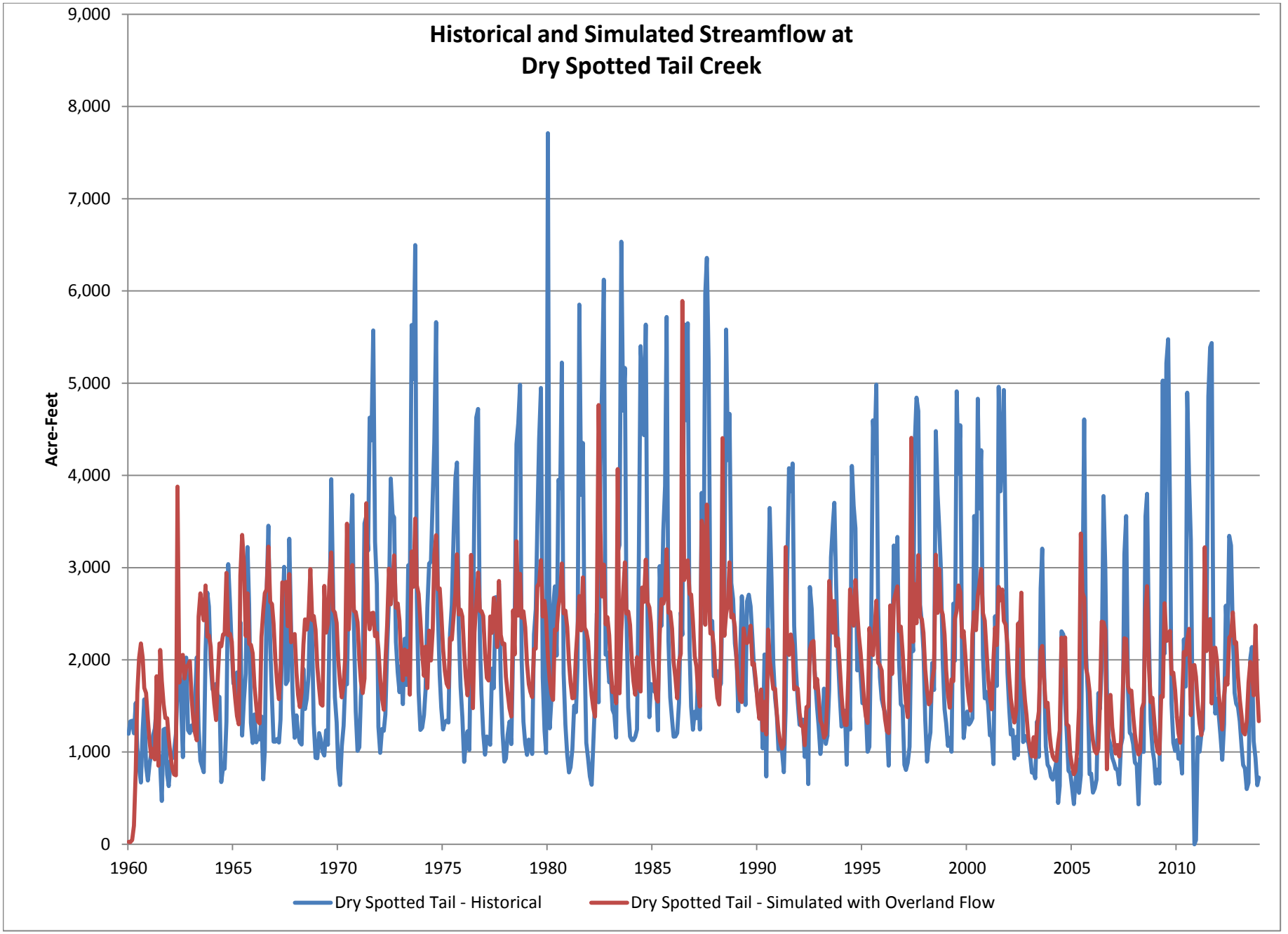

Historical and Simulated Streamflow at Rawhide Creek
Acre-Feet
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Rawhide Creek - Historical
Rawhide Creek - Simulated with Overland Flow

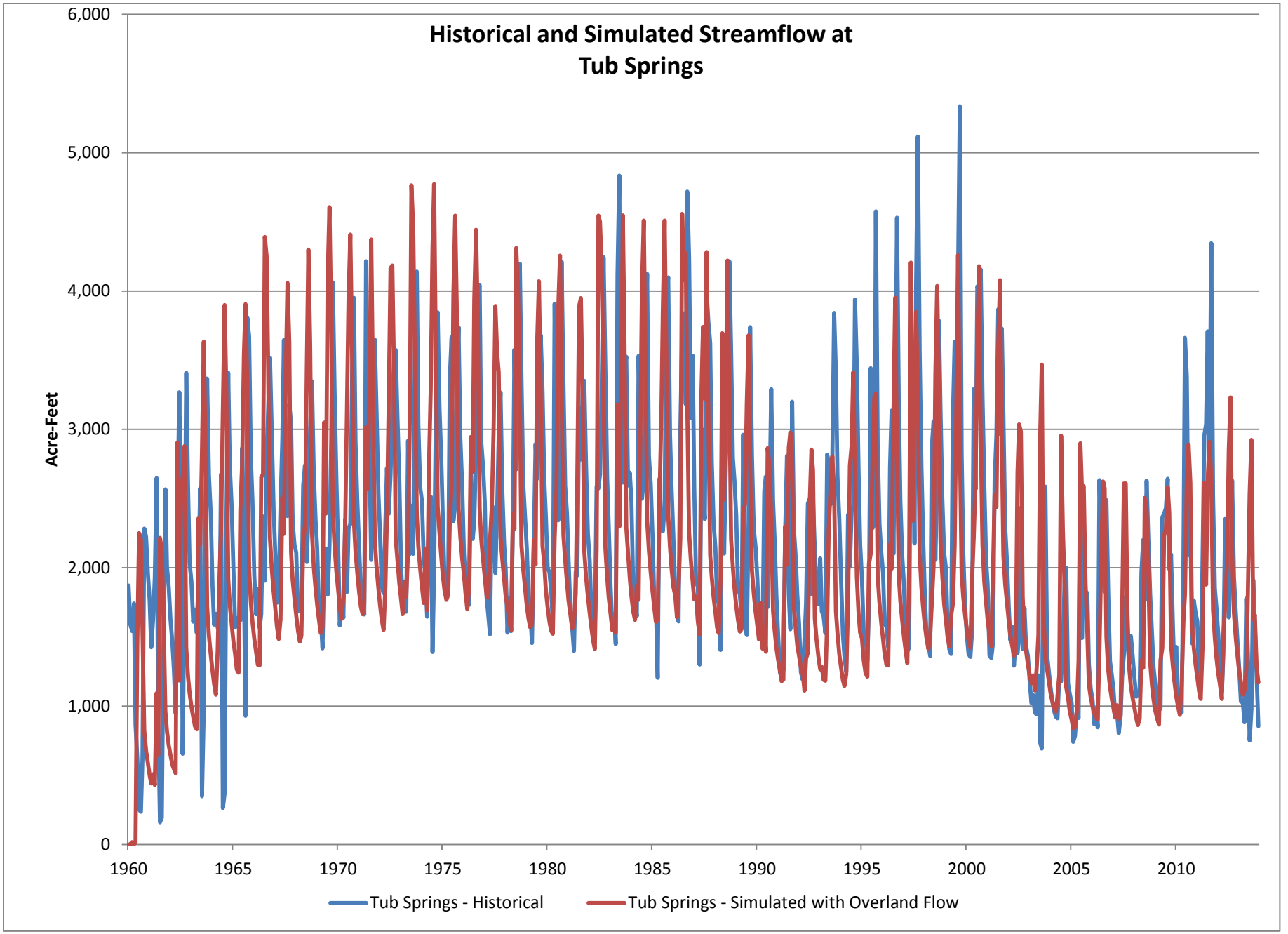

Historical and Simulated Streamflow at
Cherry Creek Drain
Acre-Feet
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Cherry Creek Drain - Historical
Cherry Creek Drain - Simulated with Overland Flow

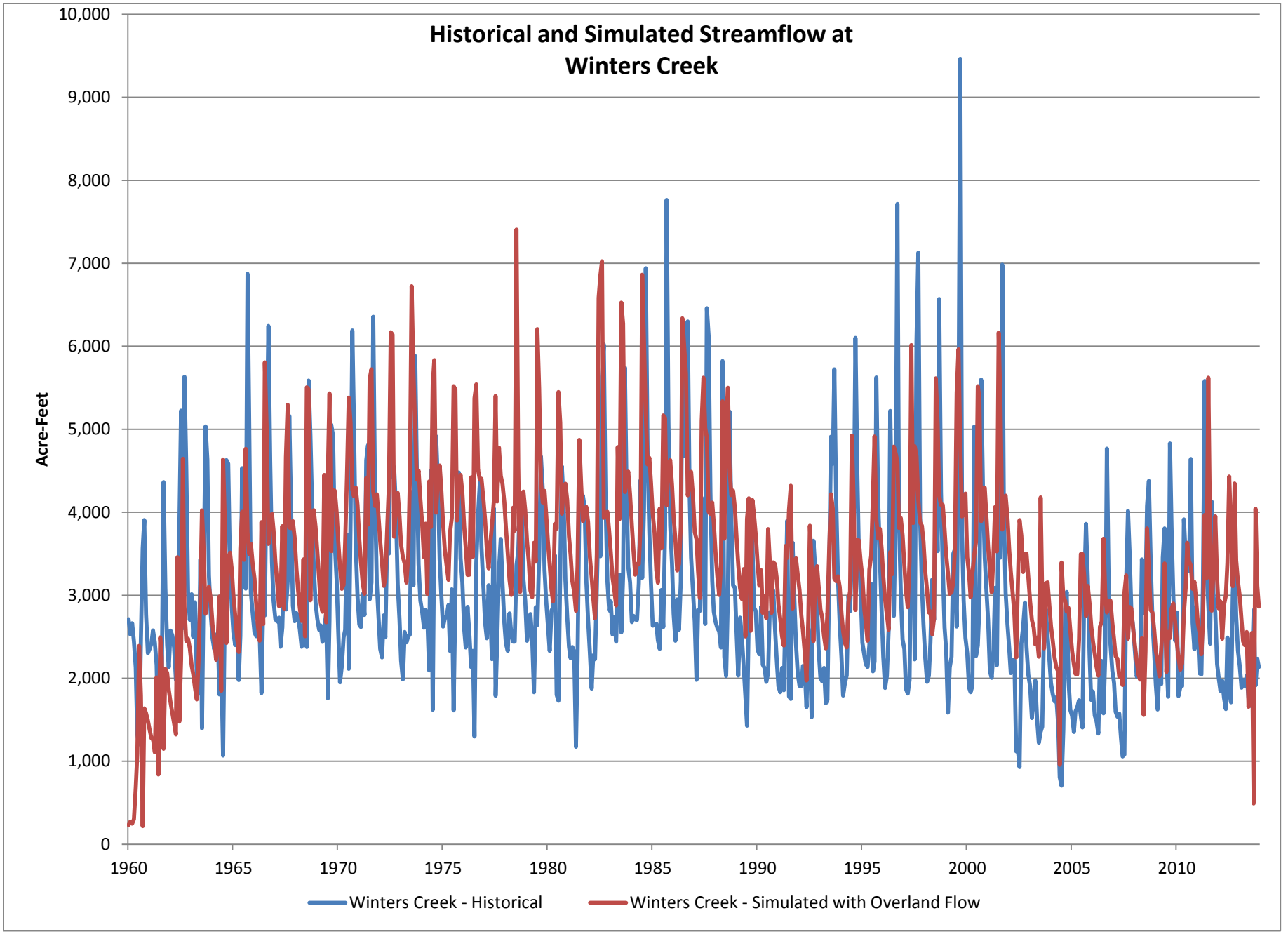

Historical and Simulated Streamflow at Katzer Drain
Acre-Feet
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Katzer Drain - Historical
Katzer Drain - Simulated with Overland Flow

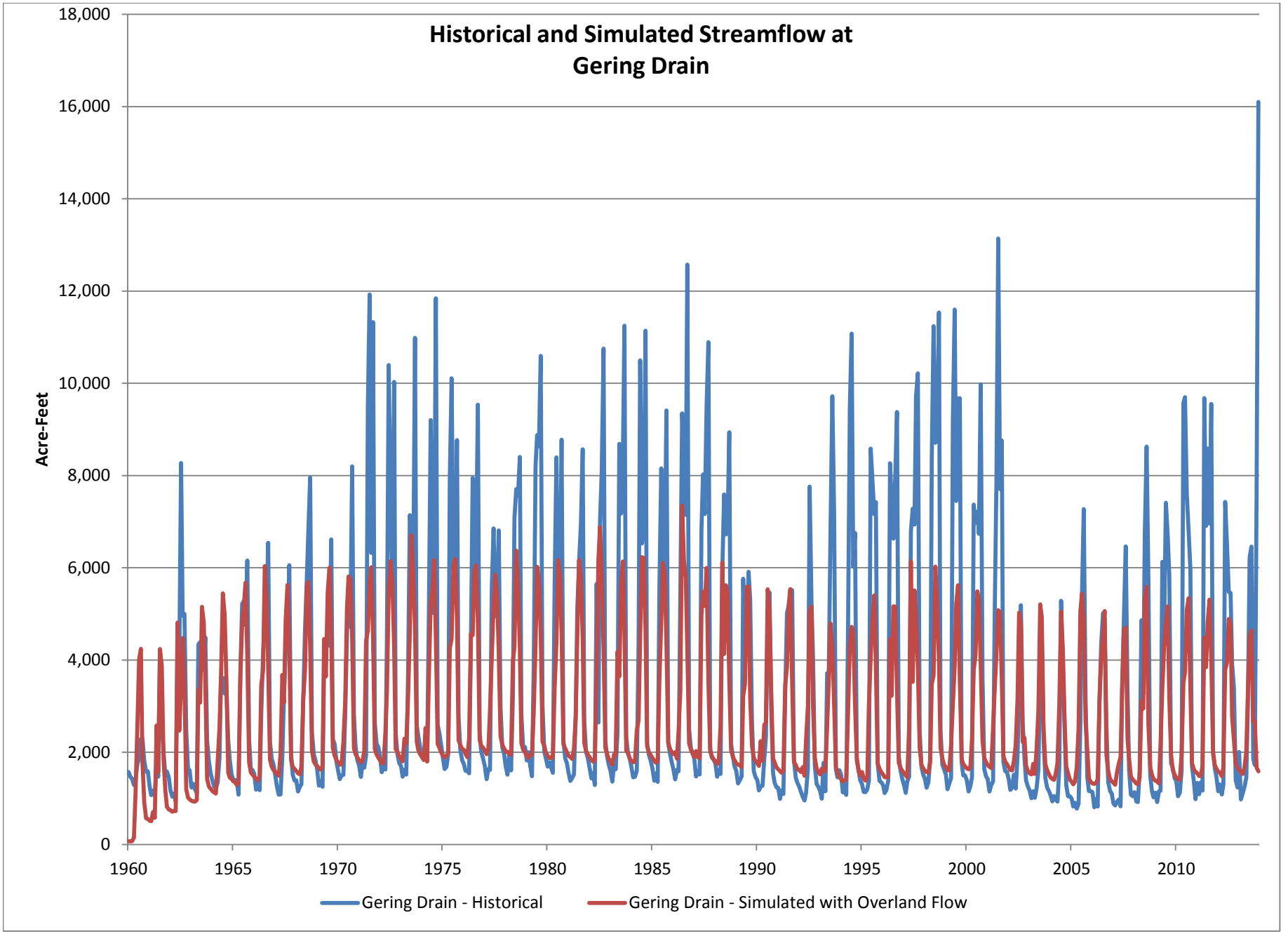

Historical and Simulated Streamflow at Horse Creek at Lyman
Fairly good correlation during summer months; simulating 1,000 af/month higher during winter months. Note that return flows during winter months are a product of the subsurface natural flow estimates and not greatly impacted by the inclusion of overland return flows.
Acre-Feet
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Horse Creek at Lyman - Historical
Horse Creek at Lyman - Simulated with Overland Flow

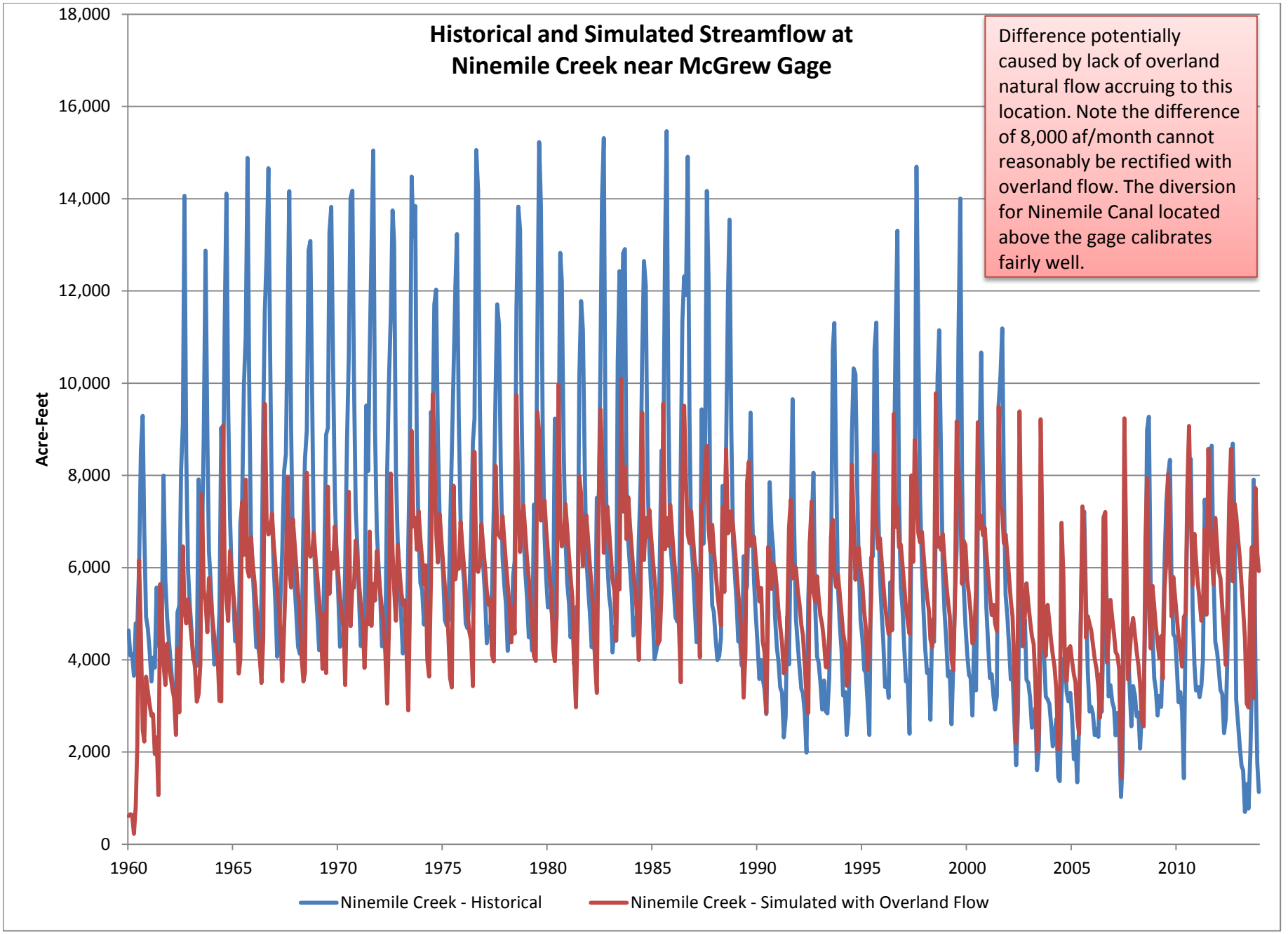

Historical and Simulated Streamflow at Sheep Creek
Increased overland return flows to this tributary, and also moved overland natural flow upstream to the carrier diversion point. Highly impacted by calibration of the Northport carriers from this and other tributaries.
Acre-Feet
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Sheep Creek - Historical
Sheep Creek - Simulated with Overland Flow

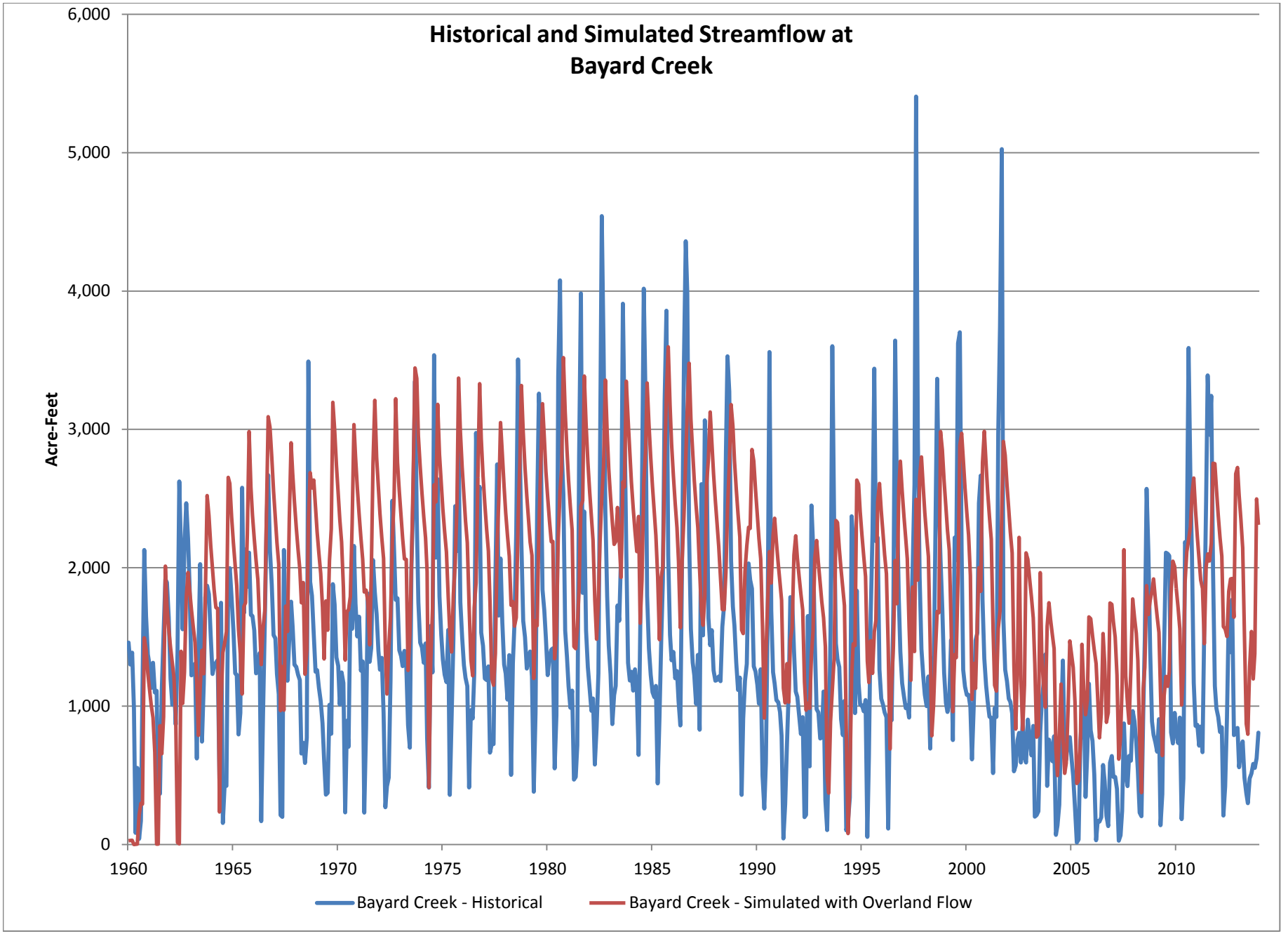

Historical and Simulated Streamflow at
Dry Spotted Tail Creek
Acre-Feet
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Dry Spotted Tail - Historical
Dry Spotted Tail - Simulated with Overland Flow

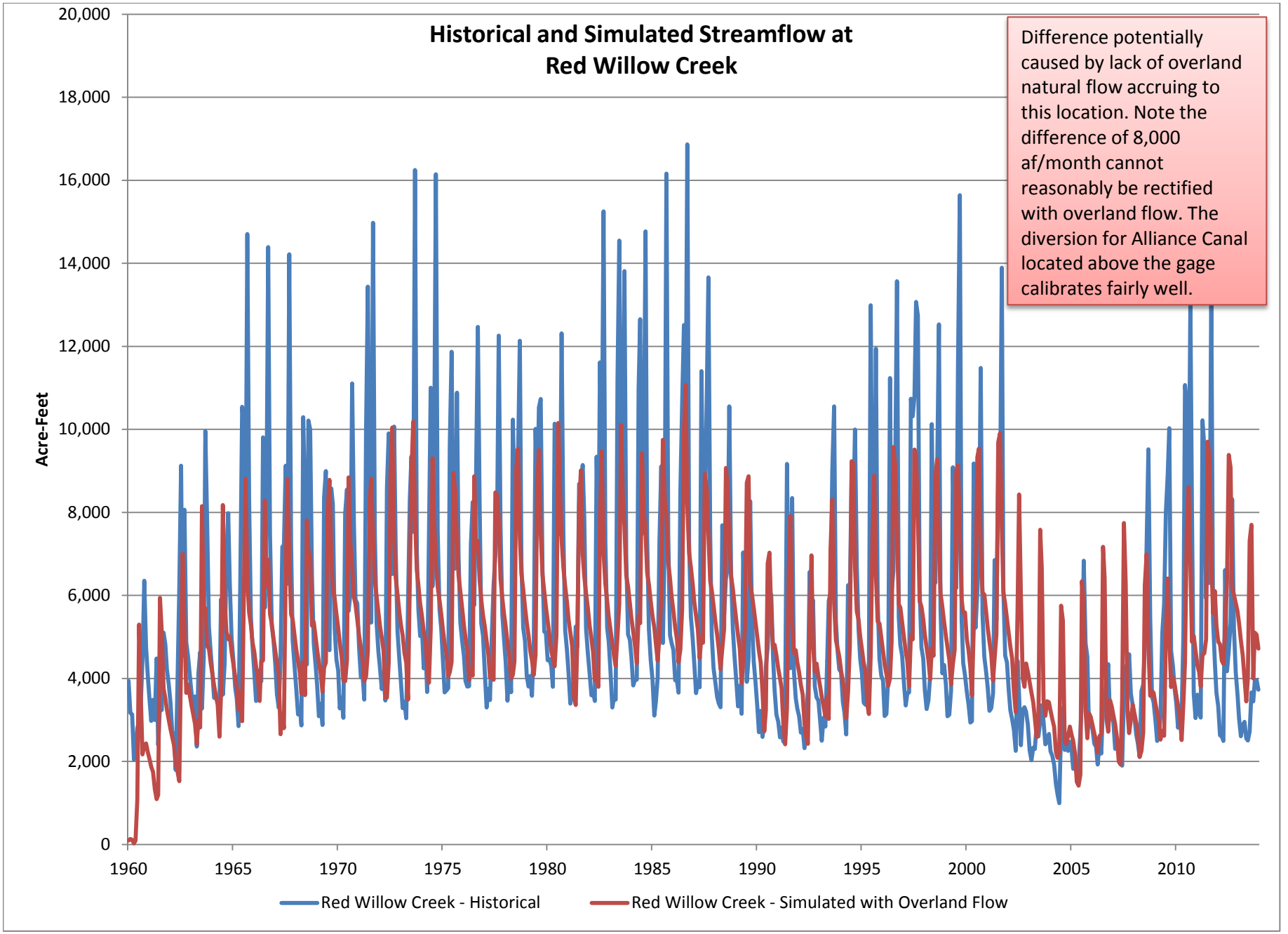

Historical and Simulated Streamflow at Tub Springs
Acre-Feet
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Tub Springs - Historical
Tub Springs - Simulated with Overland Flow

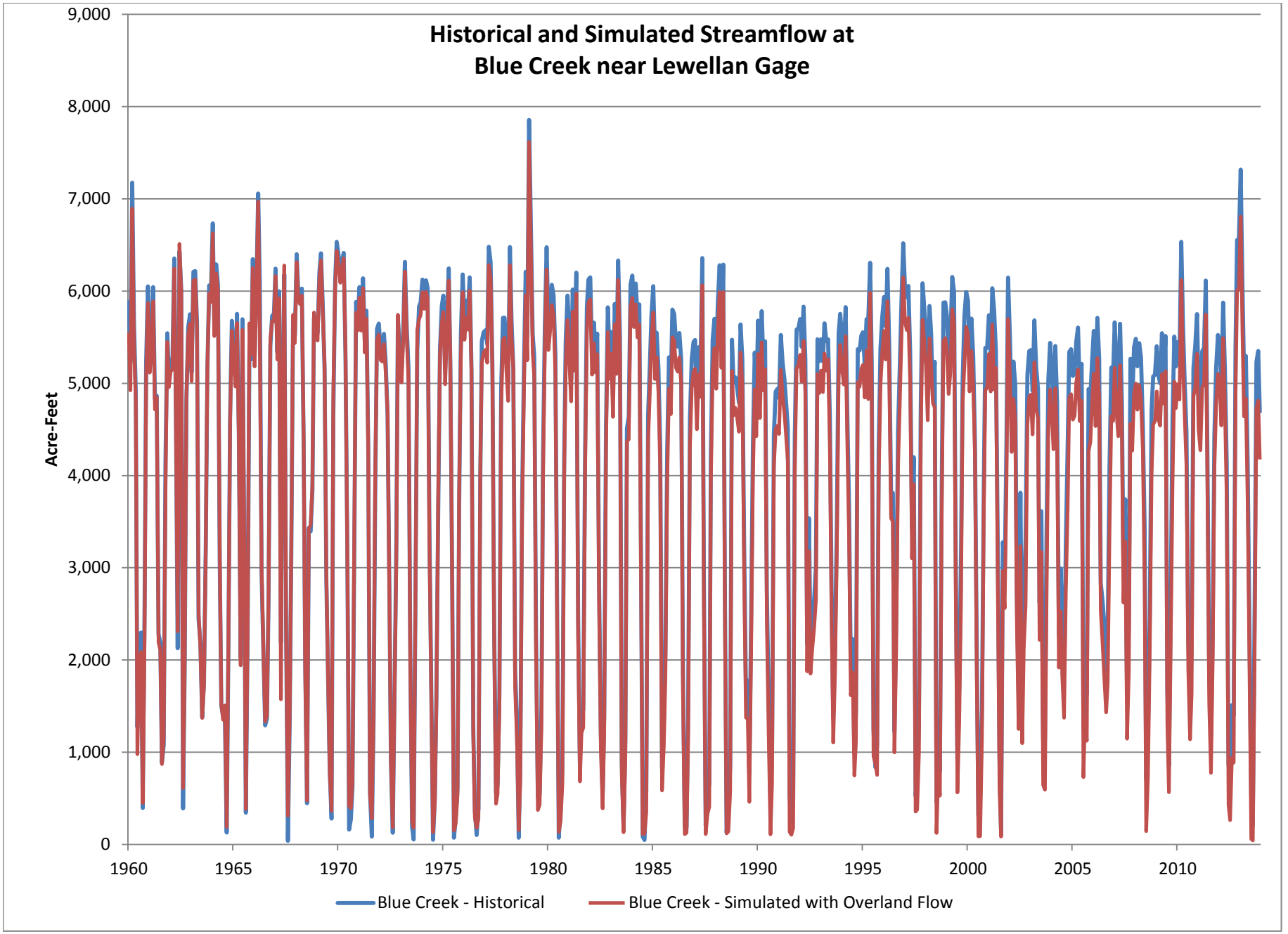

Historical and Simulated Streamflow at Winters Creek
Acre-Feet
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Winters Creek - Historical
Winters Creek - Simulated with Overland Flow


Historical and Simulated Streamflow at Gering Drain
Acre-Feet
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Gering Drain - Historical
Gering Drain - Simulated with Overland Flow


Historical and Simulated Streamflow at Ninemile Creek near McGrew Gage
Difference potentially caused by lack of overland natural flow accruing to this location. Note the difference of 8,000 af/month cannot reasonably be rectified with overland flow. The diversion for Ninemile Canal located above the gage calibrates fairly well.
Acre-Feet
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Ninemile Creek - Historical
Ninemile Creek - Simulated with Overland Flow


Historical and Simulated Streamflow at Bayard Creek
Acre-Feet
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Bayard Creek - Historical
Bayard Creek - Simulated with Overland Flow


Historical and Simulated Streamflow at Red Willow Creek
Difference potentially caused by lack of overland natural flow accruing to this location. Note the difference of 8,000 af/month cannot reasonably be rectified with overland flow. The diversion for Alliance Canal located above the gage calibrates fairly well.
Acre-Feet
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Red Willow Creek - Historical
Red Willow Creek - Simulated with Overland Flow


Historical and Simulated Streamflow at
Blue Creek near Lewellan Gage
Acre-Feet
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Blue Creek - Historical
Blue Creek - Simulated with Overland Flow