Chapter 3: Watershed Hydrology
Appendix 3.I: 06-Upper St. Johns River Calibration

6A Fort Drum Watershed

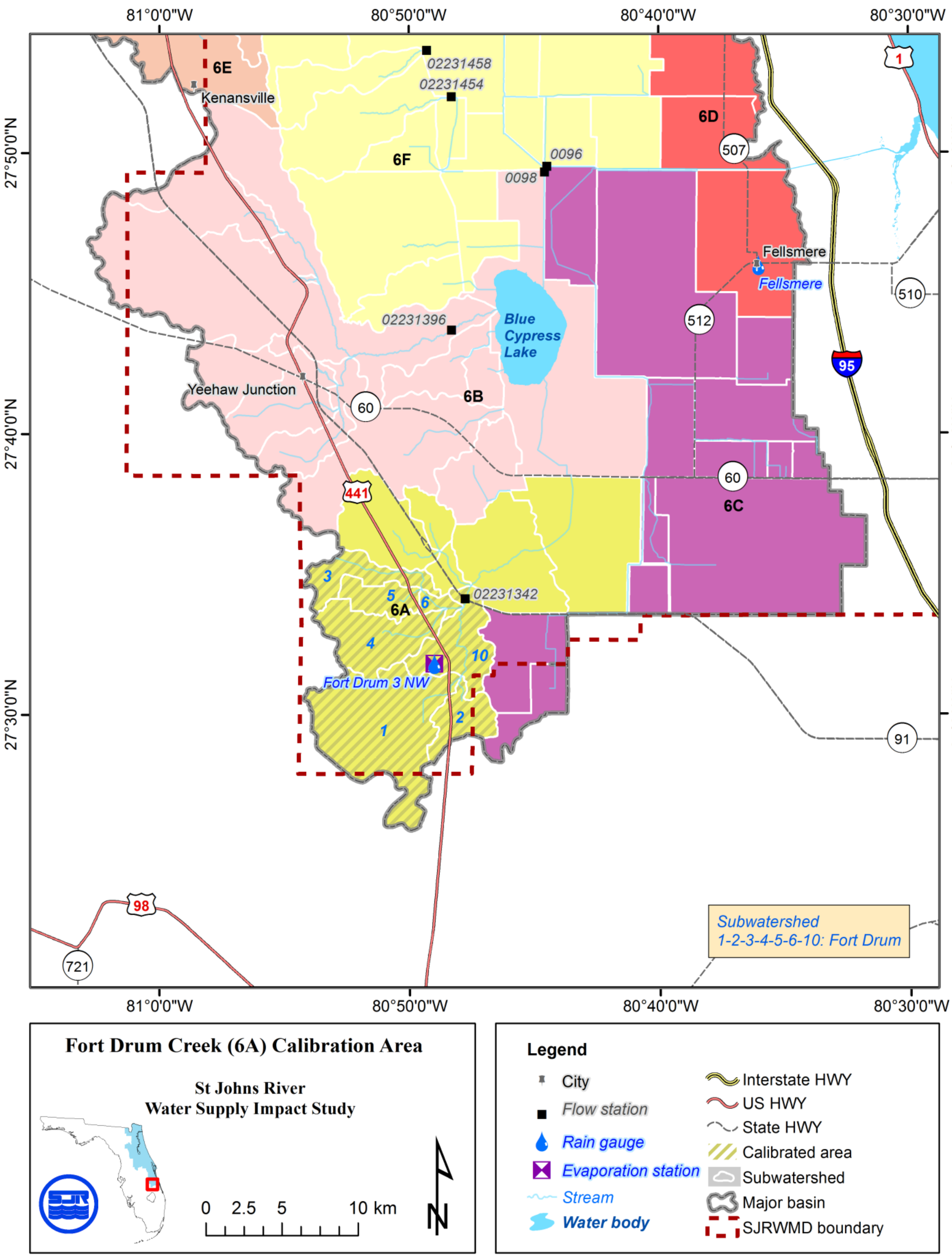

Figure 3.I. 1: 6A Fort Drum Watershed calibration areas

6A Fort Drum Watershed. Fort Drum Creek Subwatersheds

Fort Drum Creek is effectively the headwater at the southern end of the St. Johns River Basin, lying in the southwest corner of the basin, even though there is not a continuous channel but a mix of channels, marshes, and canals until many miles further downstream.

The overall modeled area comprises most of Planning Unit 6A. It covers 45,980 acres, of which 36,064 contribute to the USGS gauge 02231342 (Fort Drum Creek near Fort Drum). An additional 9,916 acres is drained by Jim Green Creek downstream of the gauge. Below this confluence, the creek spreads out into marshland in the Fort Drum Marsh Conservation Area (Fort Drum MCA), which is more similar to the area downstream in the Blue Cypress March Conservation Area (Blue Cypress MCA).

The Fort Drum station was used for precipitation and potential evapotranspiration input time series data. The calibration period comprised calendar years 1995 to 2006.

The Parameter Estimation model (PEST model) was run comparing simulated flows from subwatersheds 1 to 6 and 10 against USGS-gauged flows using project-common logic as a starting point. Adjustments to objective function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory. The calibrated parameter set was extended to subwatersheds 7 to 9 because they are topographically similar. The downstream marsh areas, largely consisting of the Fort Drum MCA, were calibrated as part of the downstream subwatershed draining through structure S-96C.

The resulting overall simulated mean flow of 34.17 was within 1.5% of the observed value of 34.62, and the Nash–Sutcliffe statistic on monthly flow was 0.72, which shows good model fit efficiency. Other simulated statistics in the following table are in general agreement with the observed mean monthly flow.

The hydrographs for daily and monthly flow show a good fit. The average monthly flow shows that the model captures the seasonal variability of flows at the gauge. The flow duration plot shows a very good match of model performance on a frequency basis, with a slight undersimulation of the highest flows and a slight oversimulation of low flows. Overall, the calibration is very good.

Table 3.I.1: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.72	-1.31

Table 3.I.2: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02231342)	Simulated
Average	34.62	34.17
Median	9.69	9.81
Variance	5217.99	4707.64
Standard Deviation	72.24	68.61
Skew	4.90	4.49
Kurtosis	33.I.4	29.55
Minimum	-0.00	0.00
Maximum	907.18	972.44
Range	907.18	972.44

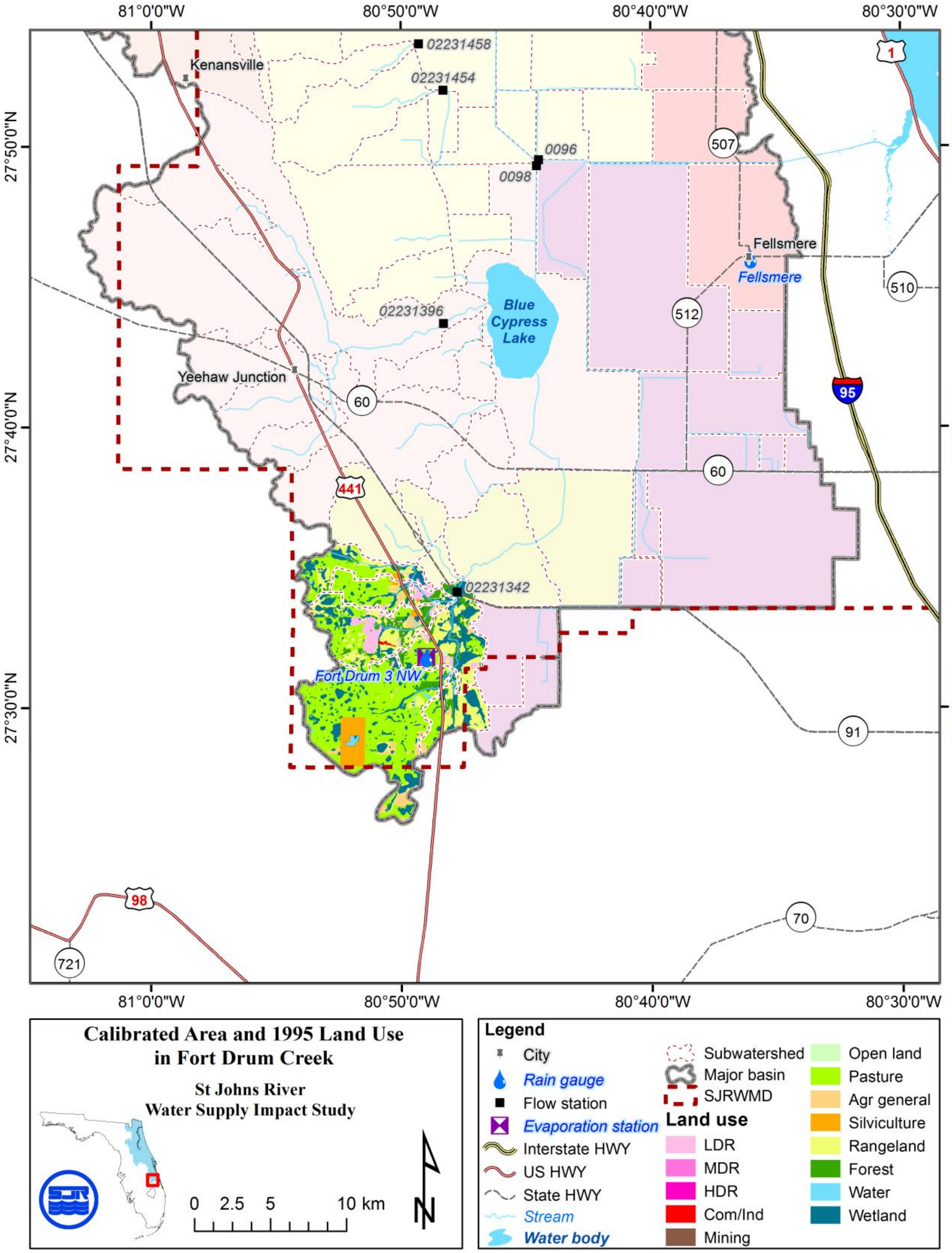

Figure 3.I. 2: Fort Drum Creek land use map

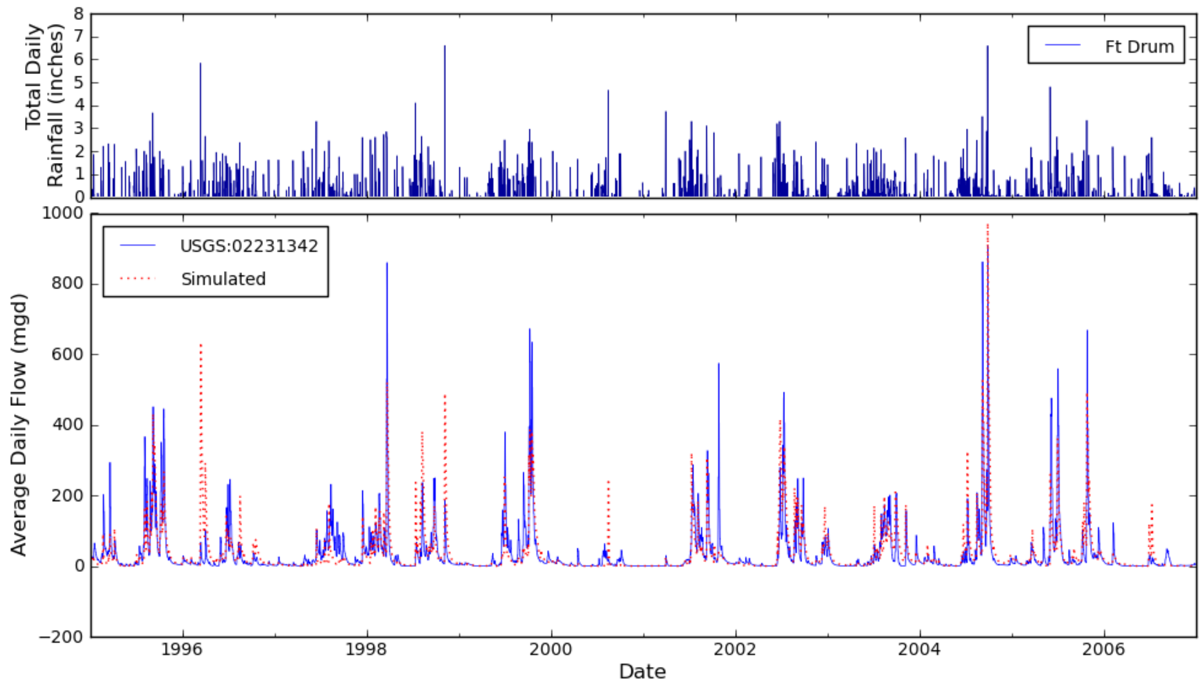

Figure 3.I. 3: Fort Drum Creek daily hydrograph

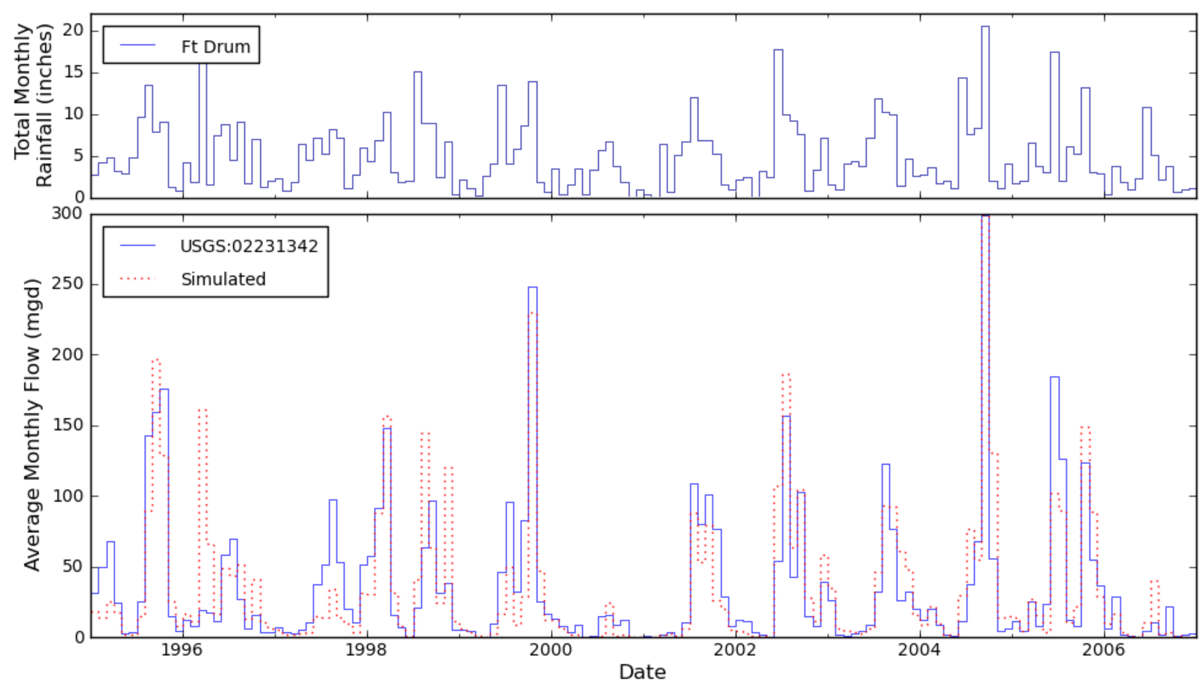

Figure 3. I.4: Fort Drum Creek monthly hydrograph

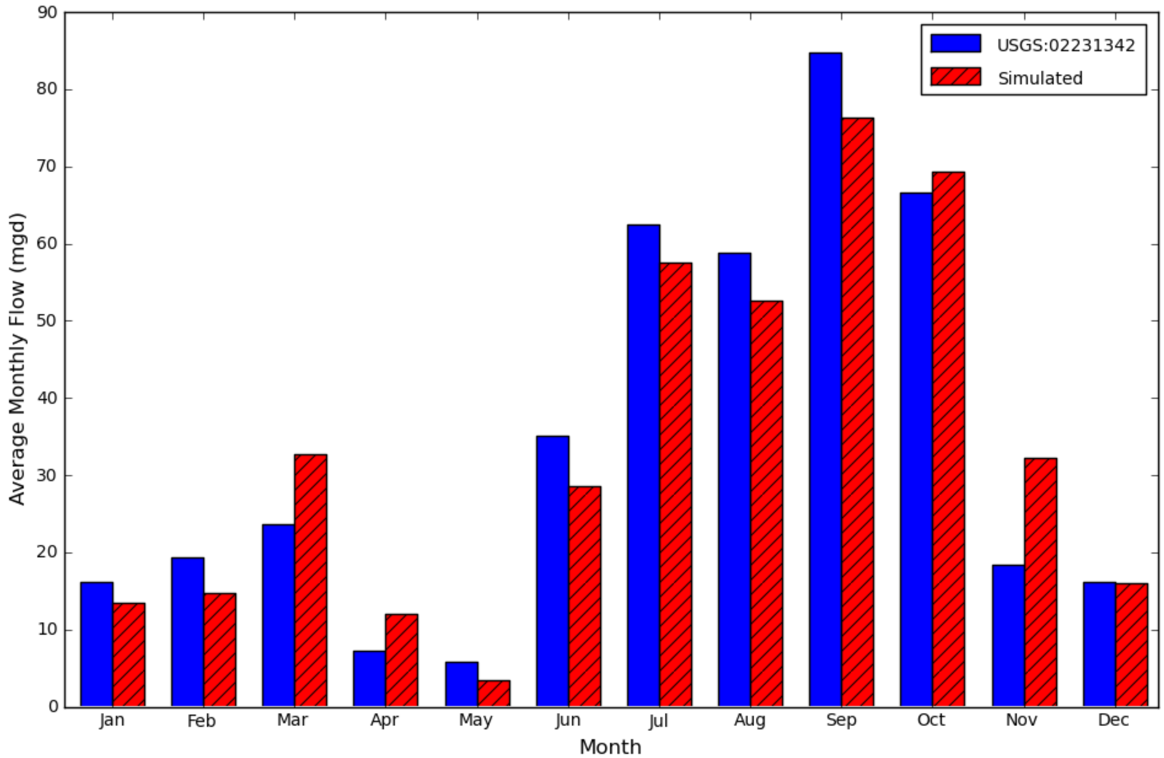

Figure 3.I. 5: Fort Drum Creek average monthly flow

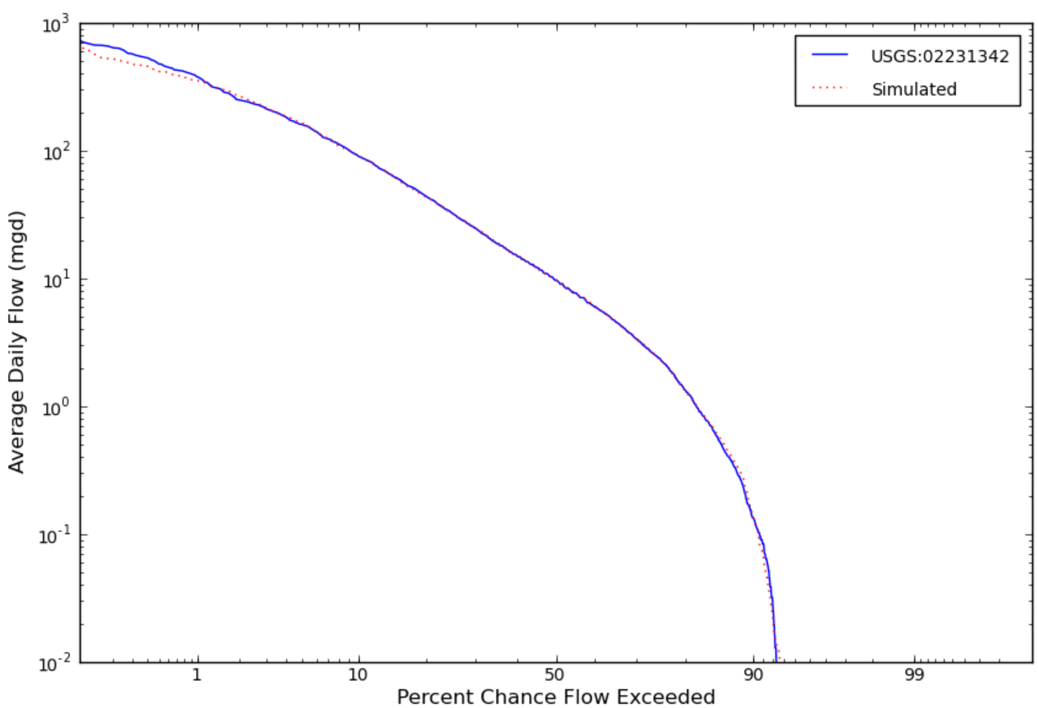

Figure 3.I. 6: Fort Drum Creek exceedance probability curve

6B Blue Cypress Watershed

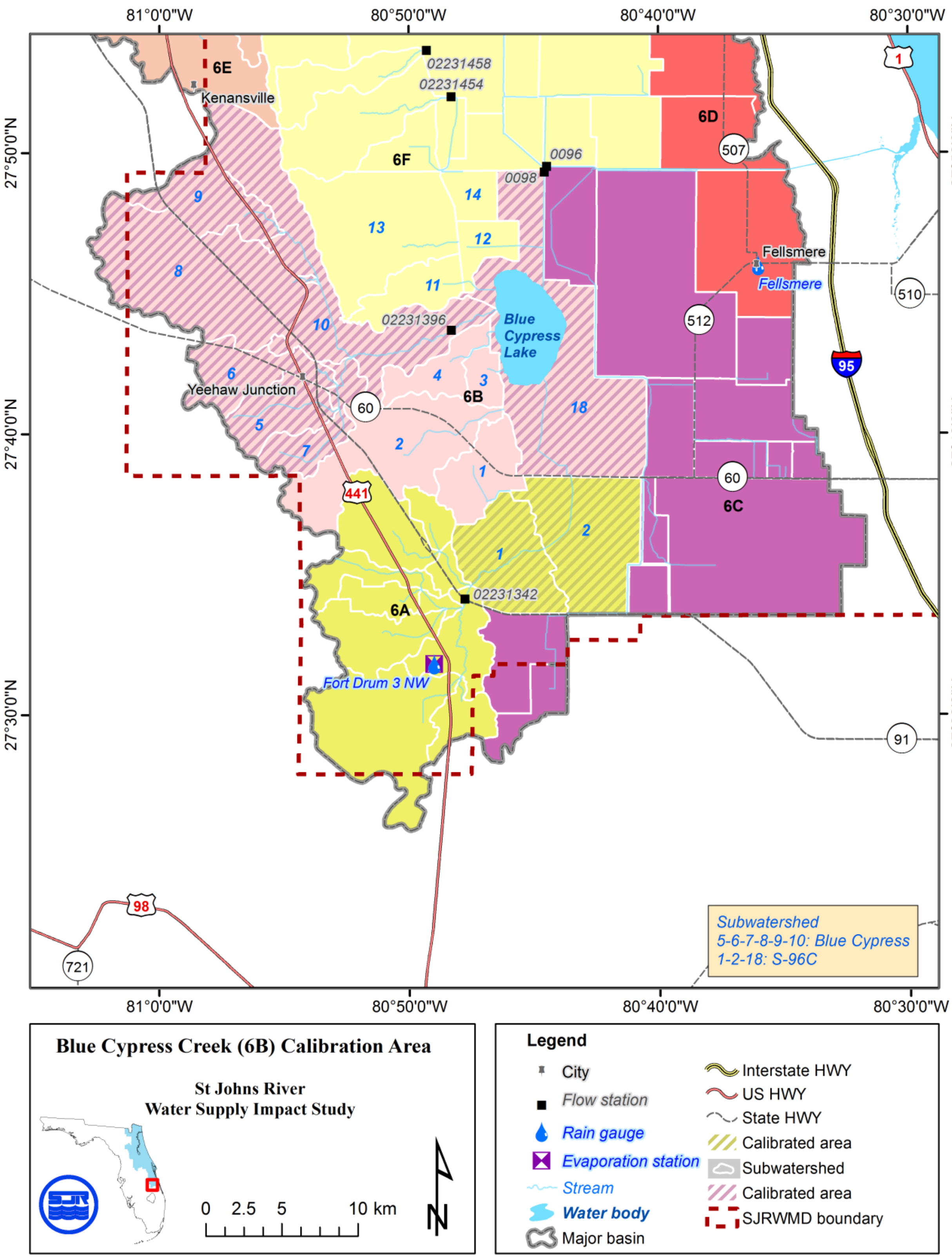

Figure 3.I. 7: 6B Blue Cypress Watershed calibration areas

6B BLUE CYPRESS WATERSHED. BLUE CYPRESS CREEK SUBWATERSHEDS

The Blue Cypress Creek model watershed is located on the west side of the upper basin just north of Fort Drum. The creek has a generally well-defined channel down to the gauge location before spreading out into a marsh that drains into Blue Cypress Lake in the Blue Cypress MCA. The dominant land uses are wetland and agriculture, predominantly pasture with some rangeland and crops.

The overall modeled area covers much of Planning Unit 6B. The gauged watershed itself is 66,903 acres, consisting of subwatersheds 5 to 10. In addition, the calibrated parameters were extended to subwatersheds 1 to 4 to the south covering 27,188 acres and 26,636 acres of Planning Unit 6F that extends south of Fellsmere Grade in subwatersheds 11 to 14. These areas are considered physically and hydrologically similar to Blue Cypress Creek. The total modeled area is 120,726 acres. USGS gauge 02231396 lies just upstream of the outlet of subwatershed 10, but the incremental area is small so it is not segmented separately.

Three rainfall stations were used to cover the modeled area. The Fort Drum station was used for subwatersheds 1 to 7 and 11, covering most of the area including the entire calibrated watershed. Fellsmere station was applied to subwatersheds 12 to 14, while Kenansville station was applied to subwatersheds 8 and 9. The Fort Drum potential evapotranspiration station was used throughout. The calibration period was calendar year 1996 because observed data for the full 1995 calendar year was not recorded.

The PEST model was run comparing simulated flows from subwatersheds 5 to 10 against USGS-gauged flows using project-common logic as a starting point. Adjustments to objective function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory. The calibrated parameter set was extended to subwatersheds 1 to 4 and 11 to 14.

The resulting overall simulated mean flow of 70.74 was within 1% of the observed value of 71.23, and the Nash–Sutcliffe statistic on monthly flow was 0.52, which shows satisfactory model fit efficiency. Other simulated statistics in the following table are in general agreement with observed.

The hydrographs for daily and monthly flow show a fair fit. The average monthly flow shows that the model generally does the job of capturing the seasonal variability in flows, with some undersimulation in winter and some oversimulation in spring. The flow duration plot shows a good match of model performance on a frequency basis with some oversimulation of the lowest flows below 1 cfs; however, these do not carry appreciable volume. Overall, the calibration is fair.

Table 3.I.3: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.52	-0.69

Table 3.I.4: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02231396)	Simulated
Average	71.23	70.74
Median	13.I.7	13.I.0
Variance	26252.26	28158.60
Standard Deviation	162.03	167.81
Skew	5.36	6.36
Kurtosis	40.75	59.63
Minimum	0.00	0.00
Maximum	2106.99	2549.15
Range	2106.99	2549.15

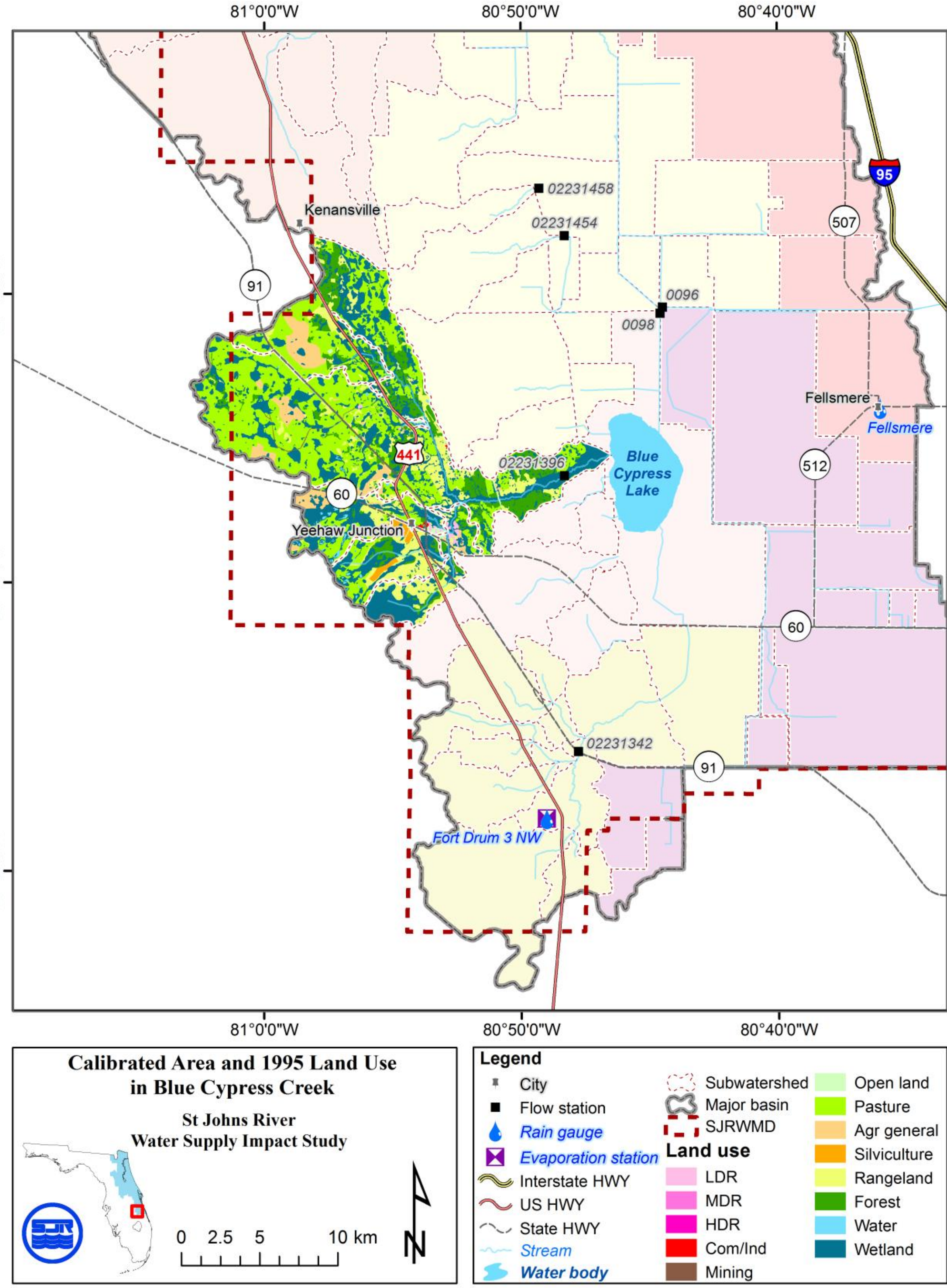

Figure 3I.8: Blue Cypress Creek land use map

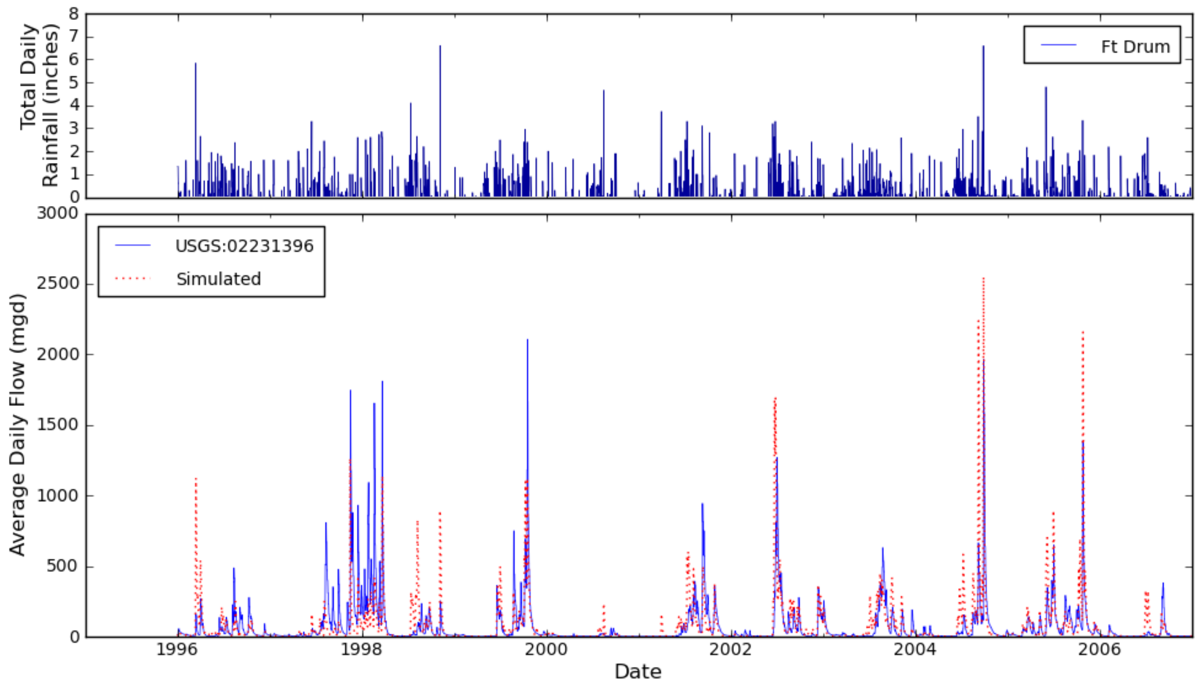

Figure 3. I.9: Blue Cypress Creek daily hydrograph

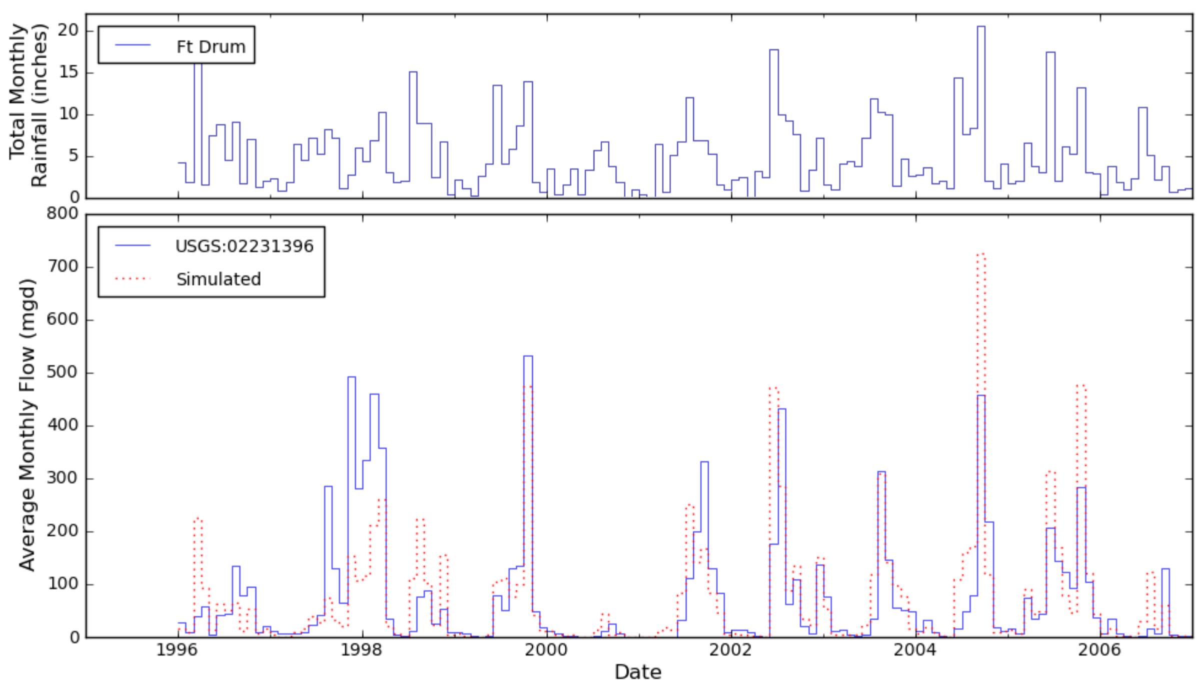

Figure 3. I.10: Blue Cypress Creek monthly hydrograph

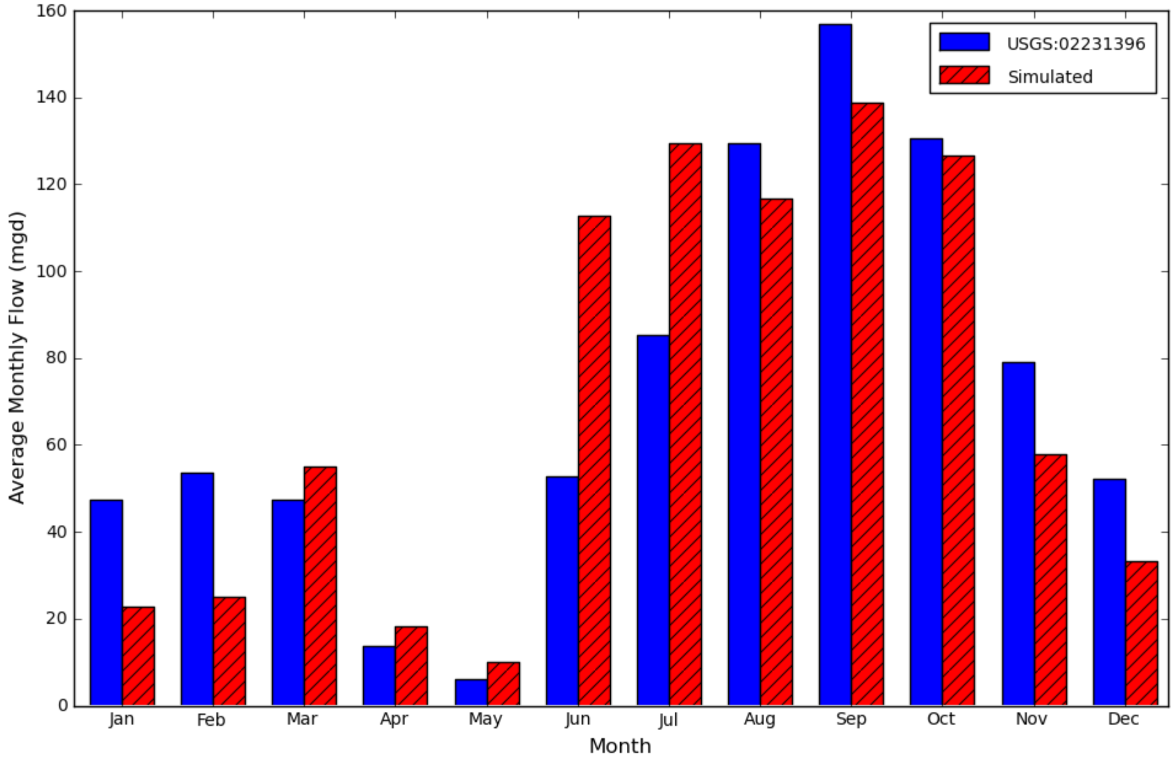

Figure 3. I.11: Blue Cypress Creek average monthly flow

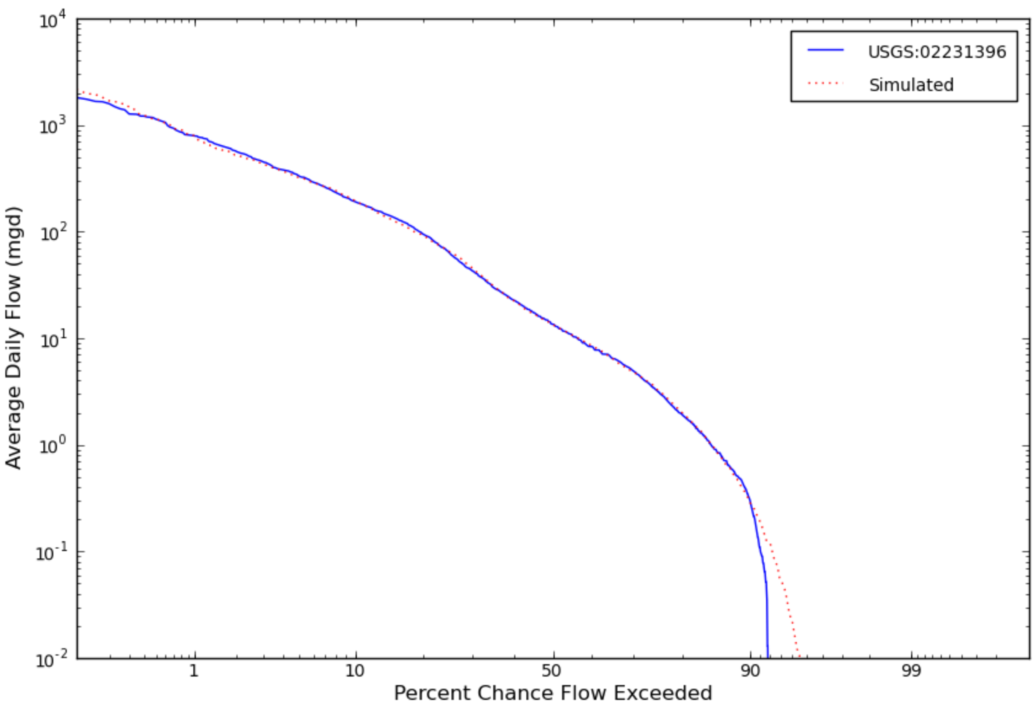

Figure 3. I.12: Blue Cypress Creek exceedance probability curve

6B BLUE CYPRESS WATERSHED. S-96C SUBWATERSHEDS

The S-96C watershed is located along the main stem near the southern end of the Blue Cypress watershed between natural tributaries on the western slopes such as Fort Drum Creek and Blue Cypress Creek, and extensively artificially drained farmland to the east, which is tributary to the adjacent S-96B structure. The drainage area is dominated by wetlands in the Fort Drum and Blue Cypress MCAs. S-96C is a large U.S. Army Corps of Engineers (USACE)-gated spillway that serves as the primary outlet structure for Blue Cypress MCA.

The total area of the S-96C model subwatersheds is 53,379 acres less 23,099 acres in two subwatersheds in Planning Unit 6A, making up Fort Drum MCA and marshes westward, and 30,280 in Planning Unit 6B, making up Blue Cypress MCA. Flows between Fort Drum MCA in 6A and Blue Cypress MCA in 6B are regulated by a series of small culverts (S-252 A to C). In addition, the entire Fort Drum Creek model subwatershed and 94,090 acres in the Blue Cypress Creek model area (except subwatersheds 11 to 14) drain primarily through this structure.

The observed flows at S-96C are taken from computed discharge based on measured up and downstream stages and recorded gate settings. Secondary flows through S-250A, S-250B, and S-250C are not included in these observed flows for calibration. In addition, a small flow is transferred into the S-96B model watershed from Fort Drum MCA to Blue Cypress Water Management Area (Blue Cypress WMA) via S-252D All of these smaller structure flows are modeled.

The Fort Drum MCA subwatersheds use rainfall data from the Fort Drum station while Blue Cypress MCA receives rainfall from the Fellsmere station. All three subwatersheds use the Fort Drum station for potential evapotranspiration data. The calibration period comprised calendar years 1995 to 2006.

The PEST model was run comparing simulated flows from S-96C against computed discharges using the project-common logic as a starting point. Adjustments to objective function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 139.92 was within 6.8% of the observed value of 131.07; and the Nash–Sutcliffe statistic on monthly flow was 0.57, which shows a satisfactory model fit efficiency. Other simulated statistics in the following tables are in general agreement with observed.

The hydrographs for daily and monthly flow show a fair fit in pattern with some differences in timing, especially on the daily. The average monthly flow shows that the model captures the seasonal variability of flows at the gauge reasonably well, although a little high in April and May and a little low in August and September. The flow duration plot shows a reasonable match of model performance on a frequency basis for such a regulated system. Overall, the calibration is fair.

Table 3.I.5: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.57	6.75

Table 3.I.6: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (SJRWMD:0098)	Simulated
Average	131.07	139.92
Median	50.93	48.47
Variance	41273.I.8	32528.87
Standard Deviation	203.I.6	180.36
Skew	2.24	2.17
Kurtosis	4.31	4.78
Minimum	-138.31	0.00
Maximum	1221.54	969.48
Range	1359.85	969.48

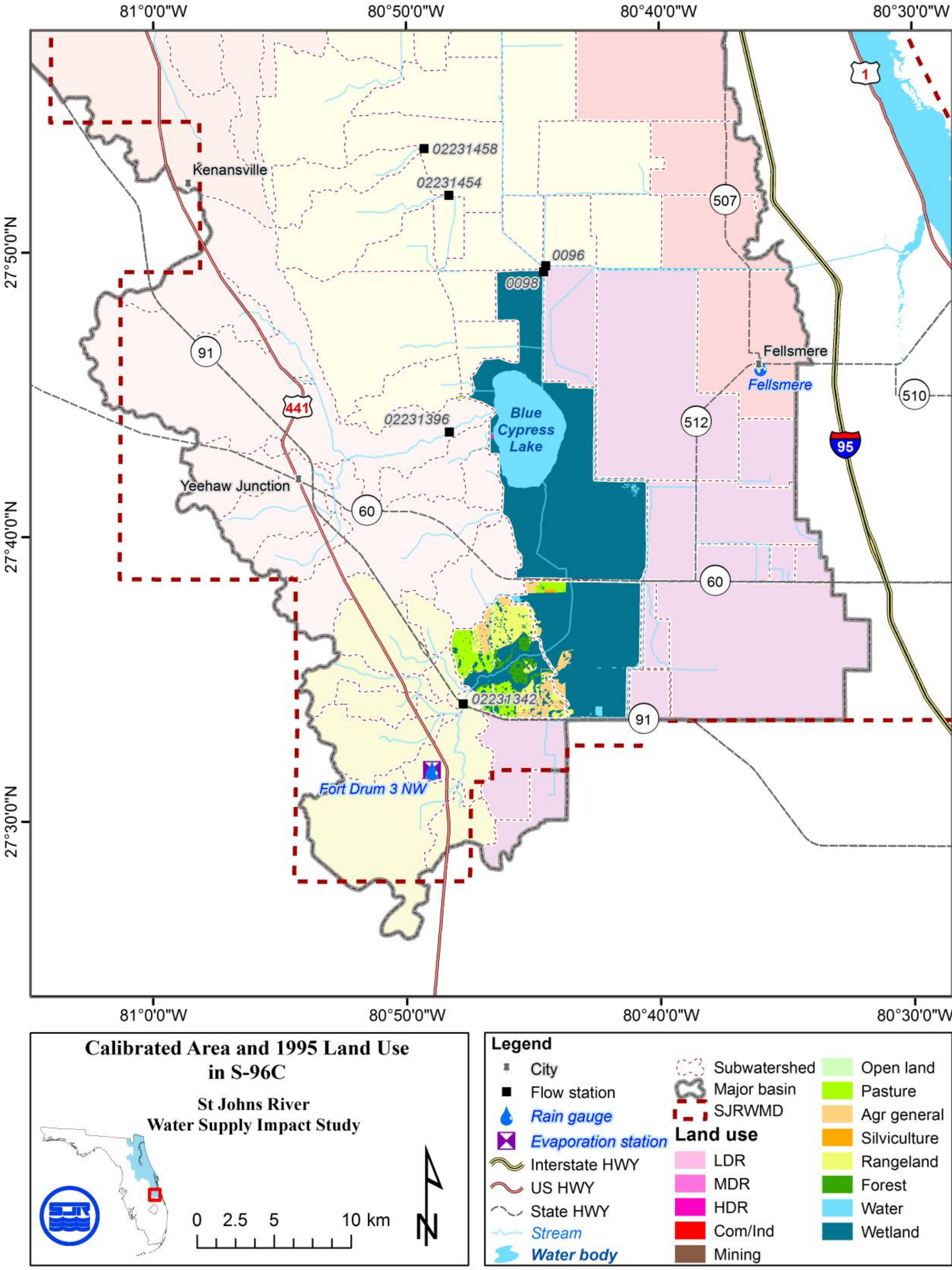

Figure 3I.13: S-96C land use map

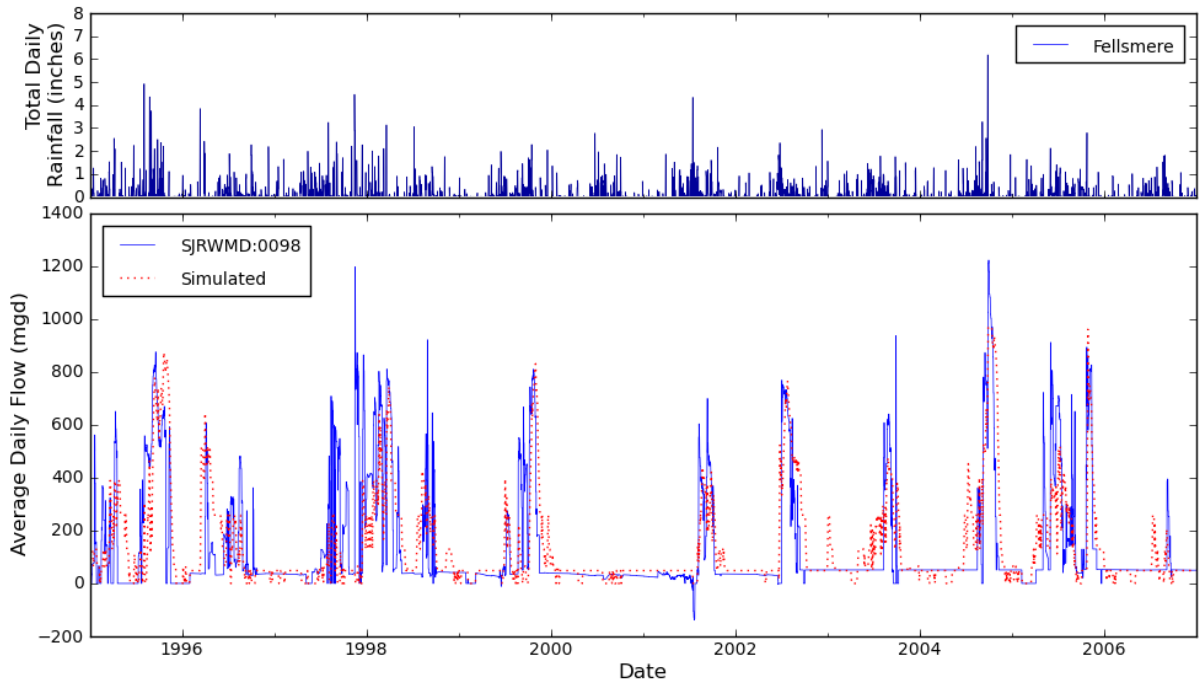

Figure 3I.14: S-96C daily hydrograph

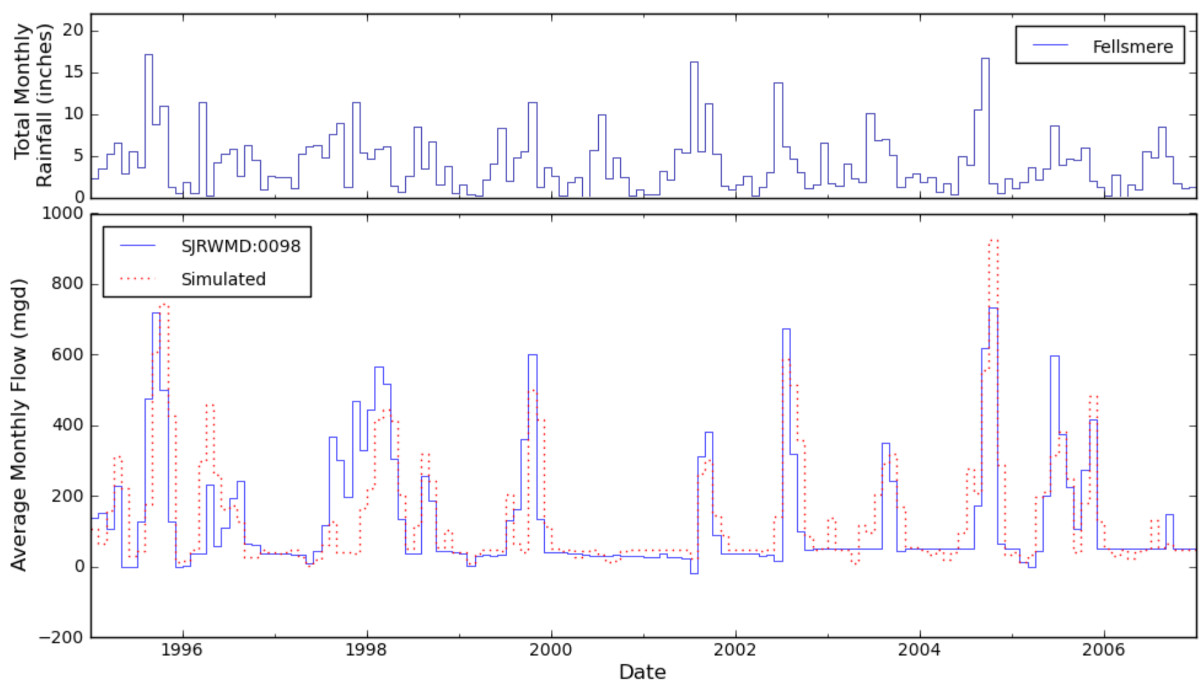

Figure 3. I.15: S-96C monthly hydrograph

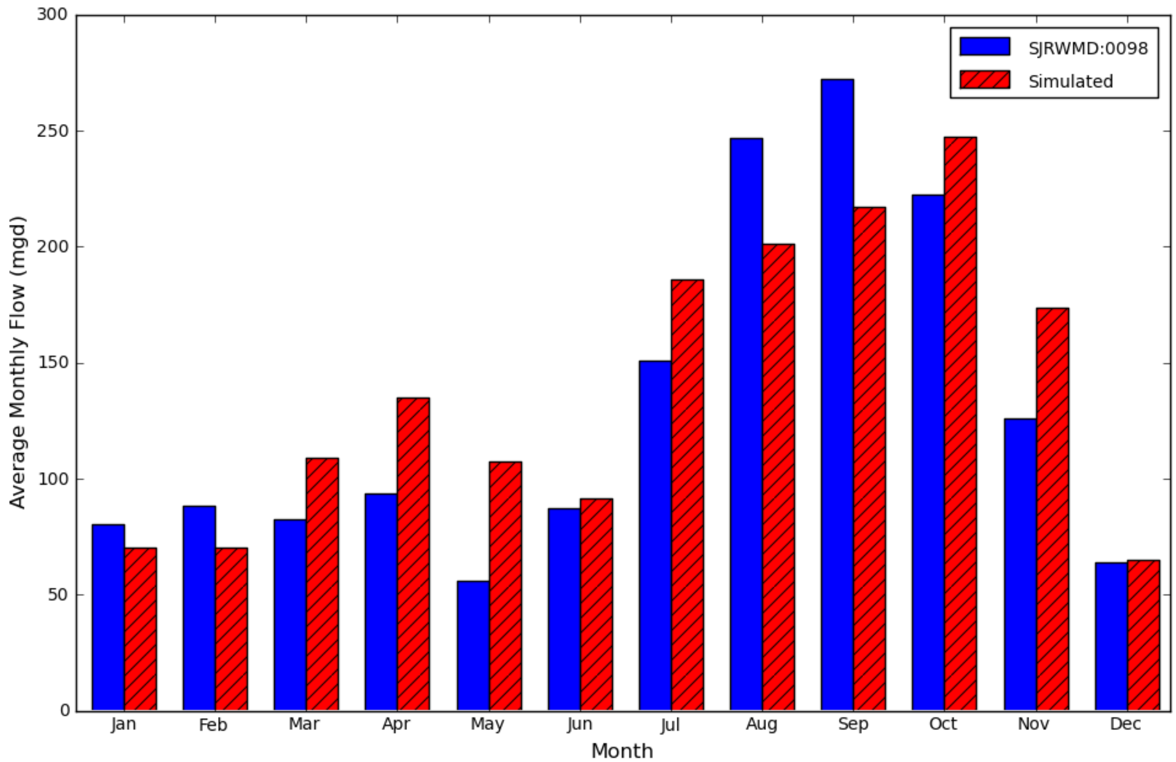

Figure 3. I.16: S-96C average monthly flow

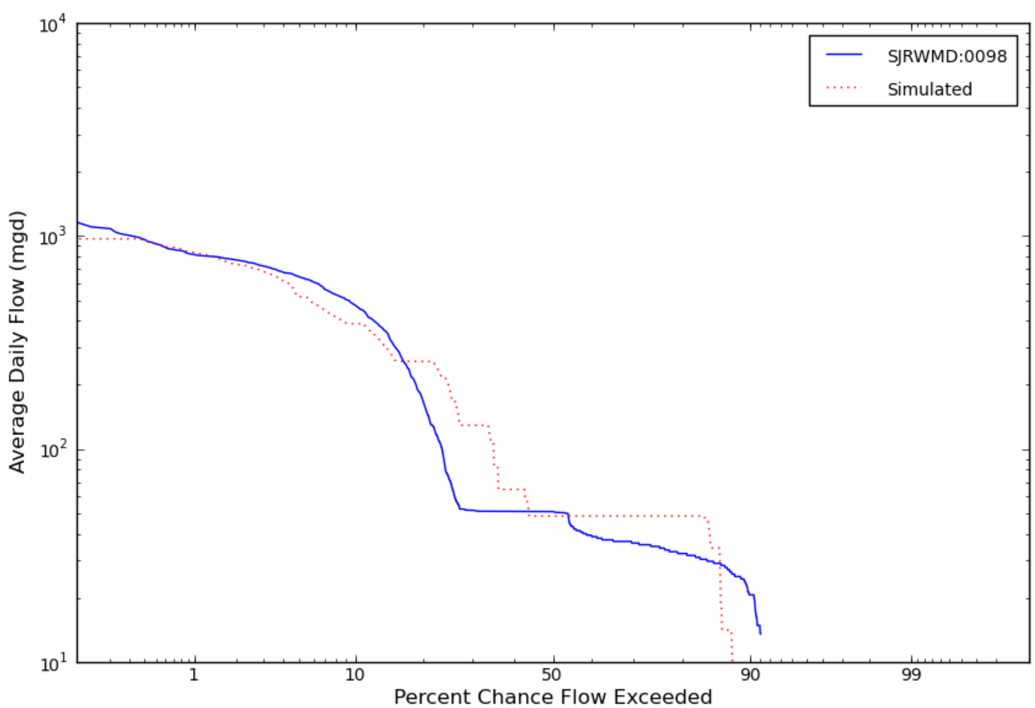

Figure 3. I.17: S-96C exceedance probability curve

6C Fellsmere

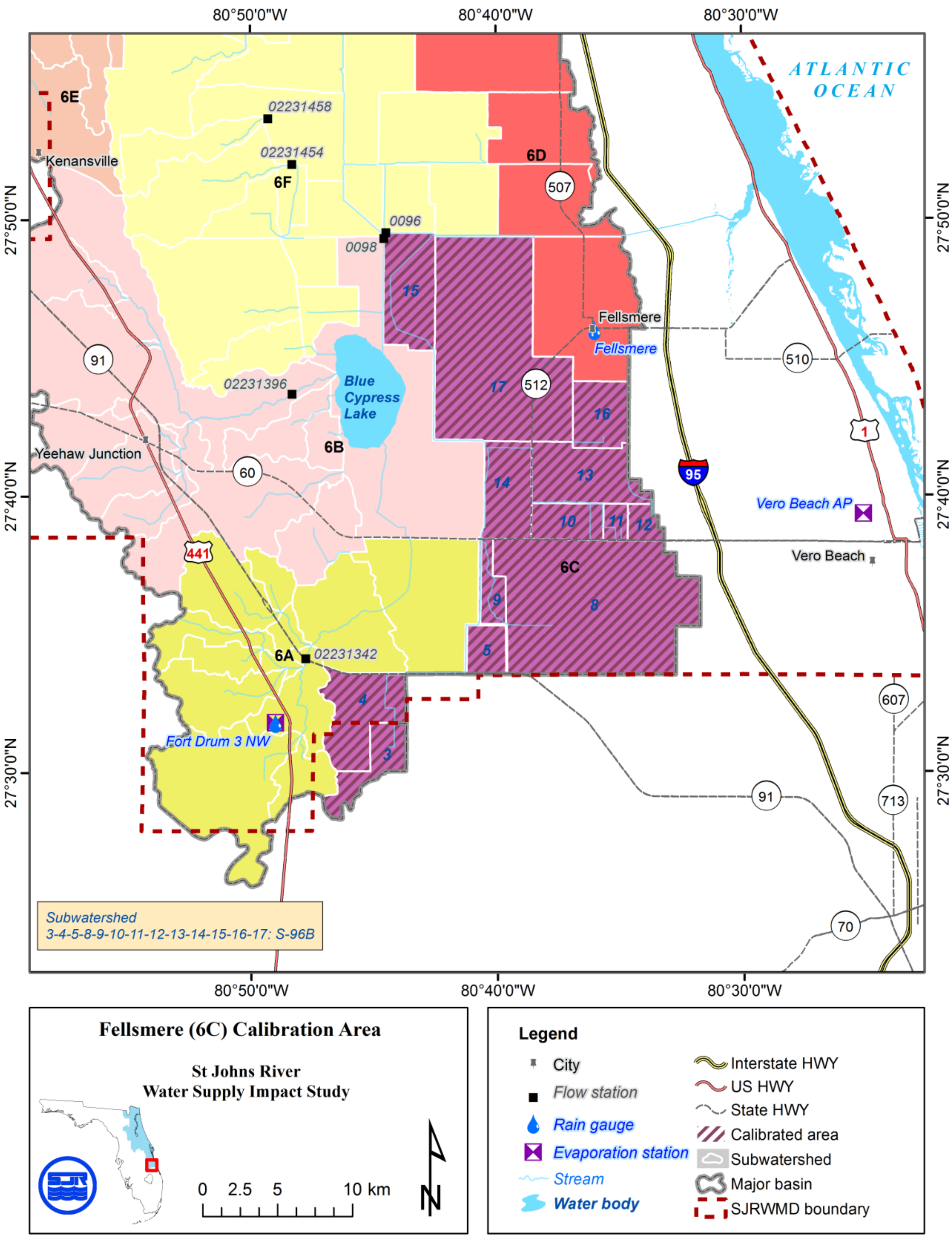

Figure 3. I.18: 6C Fellsmere calibration areas

6C FELLSMERE. S-96B SUBWATERSHEDS

The S-96B watershed is located in the southeastern portion of the basin, made up of a mix of farmland and Water Management Areas that provide water-quality treatment for runoff. They are also used for some irrigation supply although the majority comes from groundwater. It is entirely drained by canals with virtually no natural channels. S-96B is a large USACE-gated spillway that serves as the primary outlet structure for St. Johns Water Management Area (SJWMA). The structure S-96A can also be opened to drain SJWMA eastward directly to the Indian River Lagoon via canal C-54 for flood control purposes.

The total area is 90,625 acres, of which 78,092 acres lies in Planning Unit in 6C, and 12,533 acres lies in three subwatersheds that have been diverted into the watershed from the south, originally draining toward the South Florida Water Management District (SFWMD). The flow from the SFWMD subwatersheds flows across weir S-253 Blue Cypress WMA–west, first joining the diversion from Fort Drum MCA via S-252D and pumped outflow from a large agricultural area called St. Johns Improvement District. .

A group of smaller farms pumps their drainage into Blue Cypress WMA–east, which in turn drains via the S-251 culverts into Blue Cypress MCA–west. Canal C-65 carries the water northward into SJWMA via the S-96D gated spillway and an adjacent set of culverts called S-3. The S-254 weir, designed to allow Blue Cypress MCA–west to spill into Blue Cypress MCA, has flowed only once since construction (during Tropical Storm Fay in 2008). East of C-65 and SJWMA lies another large agricultural area, which is primarily pumped to SJWMA with small portions draining by gravity to the Indian River Lagoon via the Fellsmere Main Canal.

All of these structures listed are represented in the model, as well as a few smaller ones. The observed flows at S-96B are taken from computed discharge based on measured up and downstream stages and recorded gate settings. Model representation of irrigation and drainage pumping is necessarily simplified and regularized relative to actual human practice, which can result in significant mismatches in timing between observed and simulated flows.

In addition, a project underway is converting 10,000 acres of agricultural land into the Fellsmere Water Management Area (Fellsmere WMA). This land-conversion project is taken into account in some future scenarios but not in the calibration.

The two southwesternmost SFWMD subwatersheds are modeled using rainfall data from the Fort Drum station while the rest of the S-96B subwatersheds use the Fellsmere station. Potential evapotranspiration data from Fort Drum is applied to subwatersheds 3 to 7, 9, 14, and 15 along the western edge of the area while the remainder uses data from Vero Beach. The calibration period was calendar years 1995 to 2006.

The PEST model was run comparing simulated flows from S-96B against computed discharges, using the St. Johns River Water Management District's (SJRWMD) HSPF-common logic as a starting point (see Appendix 3.B). Adjustments to objective function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 91.35 was within 6.8% of the observed value of 92.20, and the Nash–Sutcliffe statistic on monthly flow was 0.11, which shows a poor model fit efficiency. This is due mostly to the necessarily simplified representation of agricultural operations, which drive the volumes and, especially, the timing of flows. Other simulated statistics in Tables E7 and E8 are in general agreement with observed.

The hydrographs for daily flows show a fair fit, with differences in timing. Also, the model tends to make small releases a bit more frequently. Much of these differences are likely because managers of the pumps and structures that dominate the system attempt to forecast weather. For example, to save fuel they may let pumps remain off when dry weather is predicted and levels are only moderately high, and they may choose to pump down the drainage canals preemptively when a large storm is forecast. The monthly hydrograph shows a fair fit also, with a mix of high and low months and years . The average monthly flow shows that the model captures the seasonal variability of flows at the gauge well, although high in April and low in June. The flow duration plot shows a fair match of model performance on a frequency basis for such a regulated system. Overall, the calibration is fair to poor.

Table 3.I.7: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.11	-0.92

Table 3.I.8: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (SJRWMD:0096)	Simulated
Average	92.20	91.35
Median	0.00	22.89
Variance	25559.54	23002.52
Standard Deviation	159.87	151.67
Skew	1.98	2.20
Kurtosis	3.I.3	4.44
Minimum	0.00	0.00
Maximum	1109.73	646.32
Range	1109.73	646.32

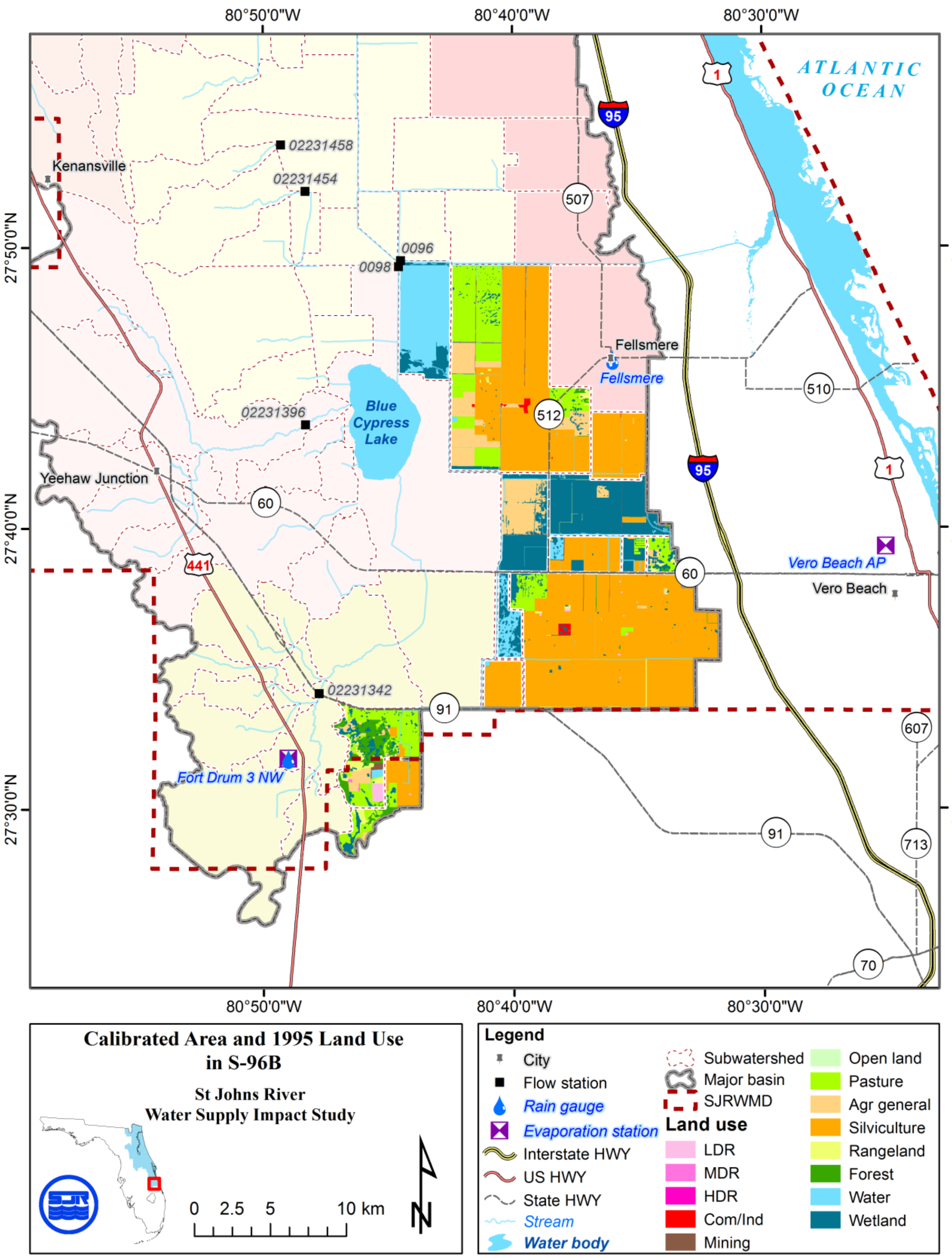

Figure 3. I.19: S-96B land use map

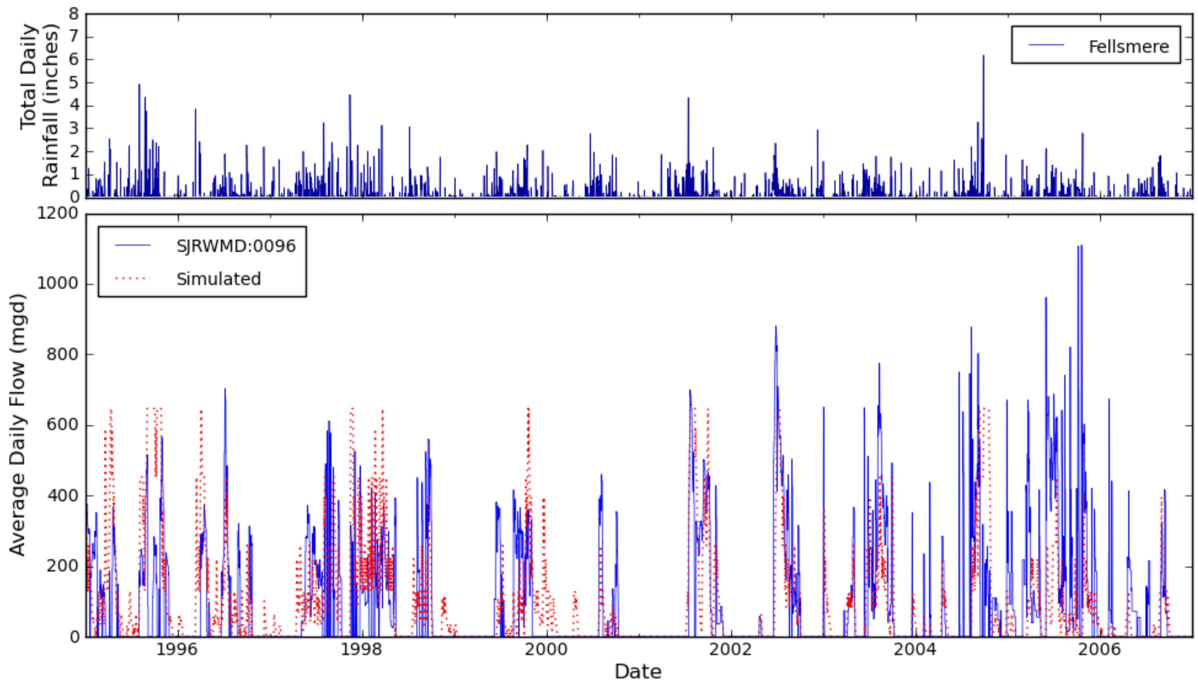

Figure 3. I.20: S-96B daily hydrograph

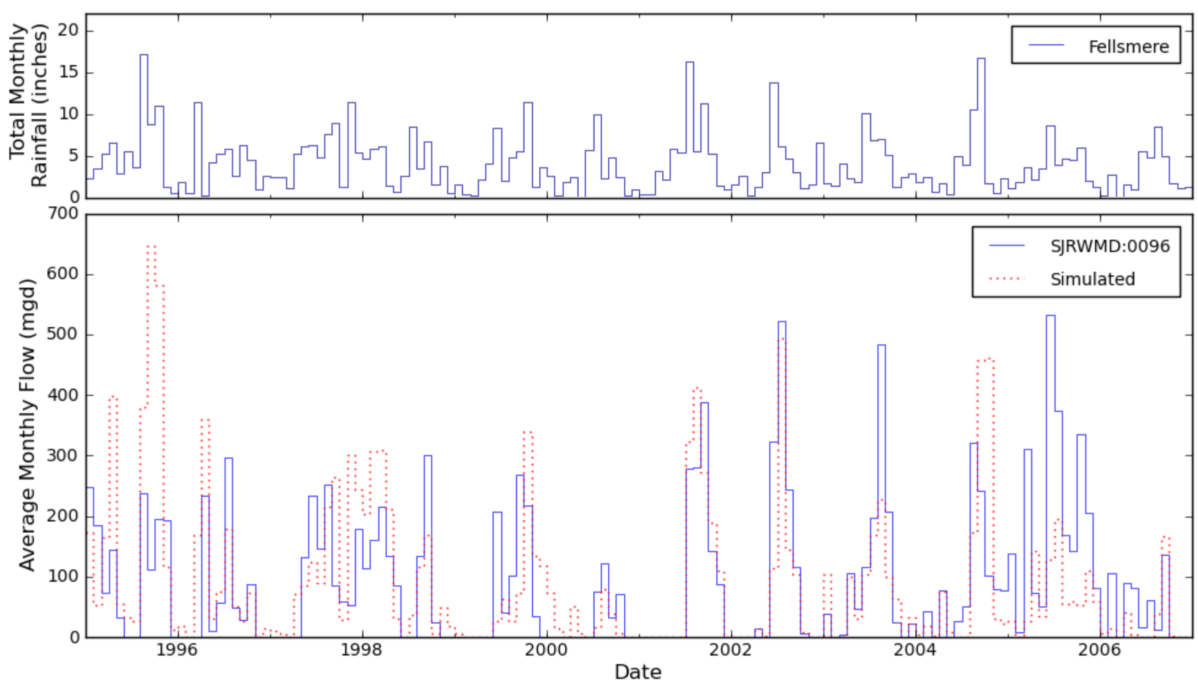

Figure 3. I.21: S-96B monthly hydrograph

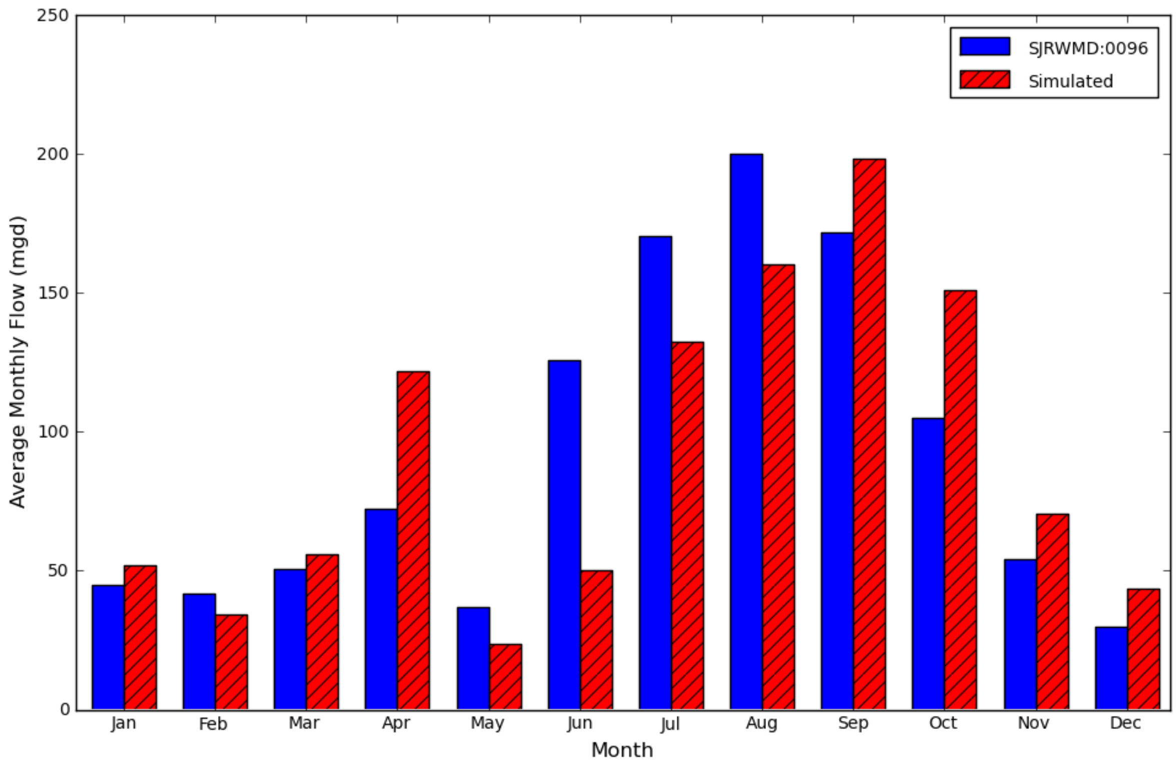

Figure 3. I.22: S-96B average monthly flow

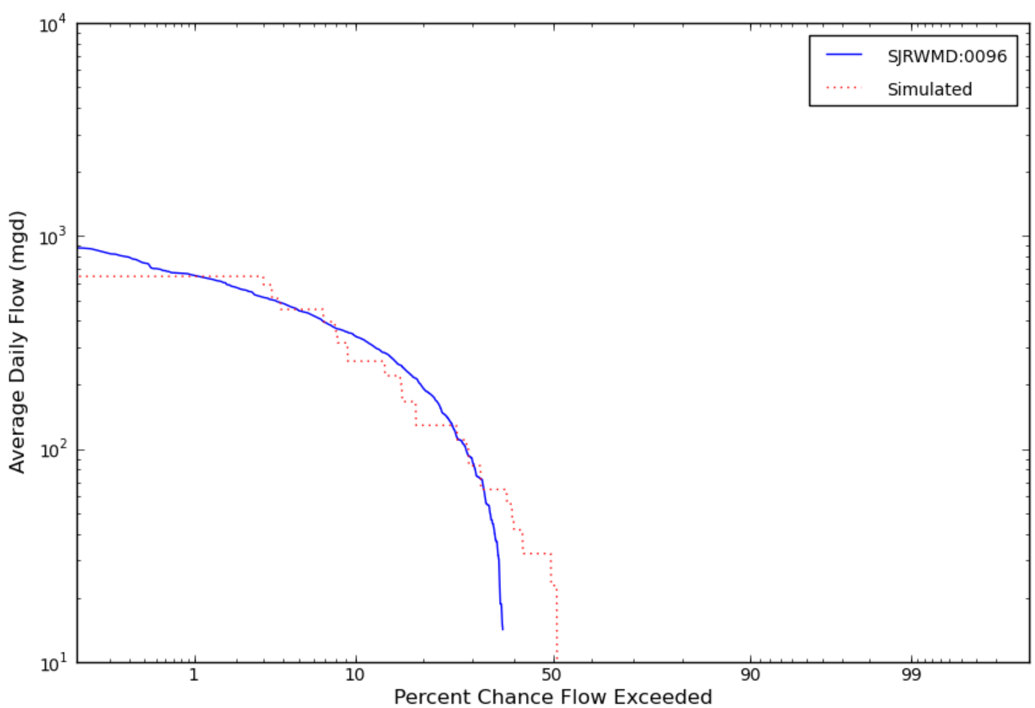

Figure 3. I.23: S-96B exceedance probability curve

6E Jane Green Swamp Watershed

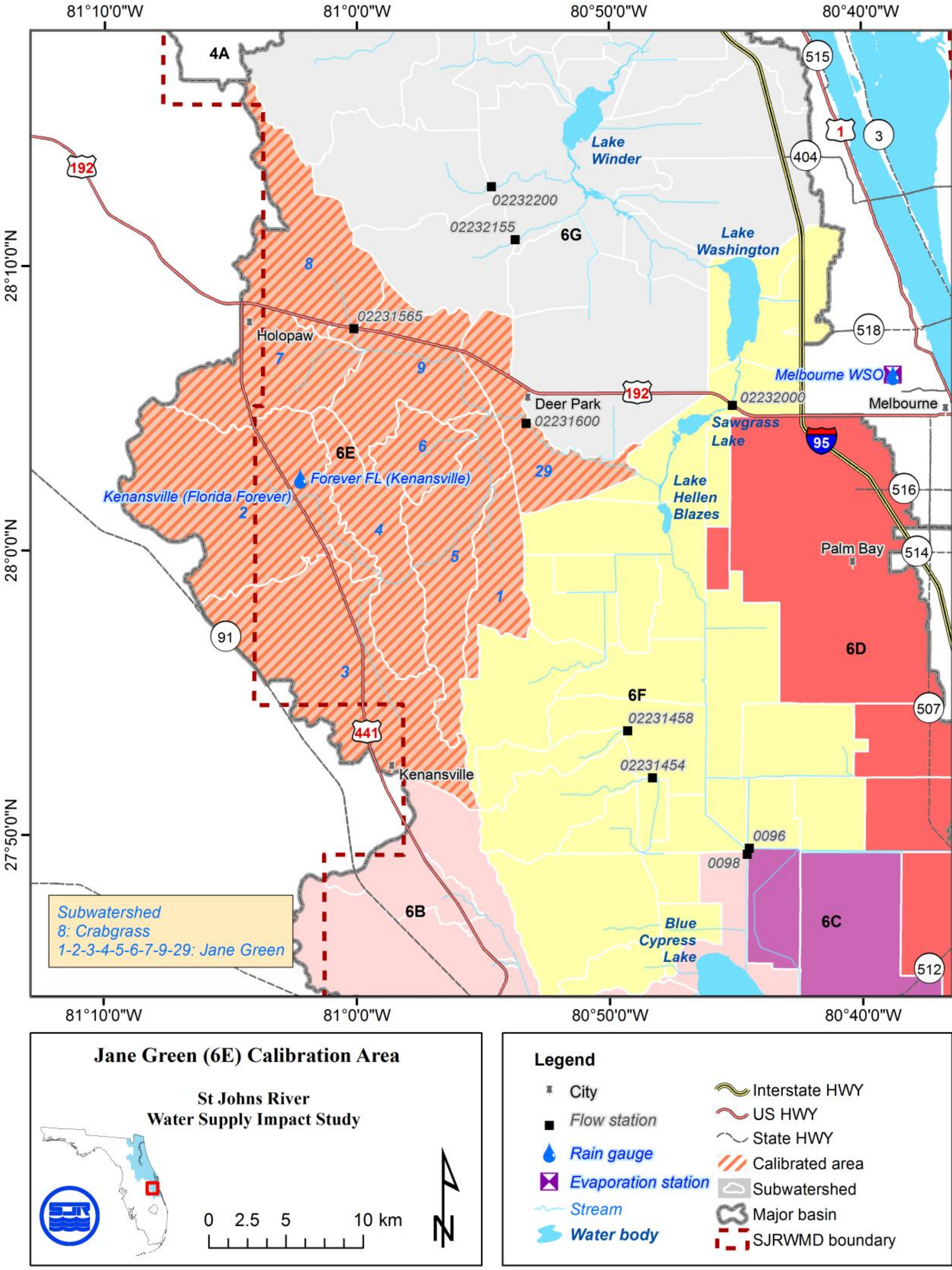

Figure 3. I.24: 6E Jane Green Swamp Watershed calibration areas

6E Jane Green Swamp Watershed. Crabgrass Creek Subwatersheds

The Crabgrass Creek subwatershed lies on the west side of the upper basin just north of US 192, in the northern tip of Planning Unit 6E. It is a natural channel that drains past USGS gauge 02231565, under the highway, and into the Jane Green Detention Area.

The drainage area is relatively small—18,072 acres modeled as a single subwatershed (8) dominated by wetlands. This subwatershed uses rainfall data from the Kenansville station just to the south and potential evaporation data from the Melbourne station directly to the east near the coast. The calibration period was calendar years 1997 to 2006.

The PEST model was run comparing simulated flows from subwatershed 8 against USGS-gauged flows, using the project-common logic as a starting point. Adjustments to objective function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 16.93 was within 4% of the observed value of 17.55, and the Nash–Sutcliffe statistic on monthly flow was 0.43, which shows somewhat poor model fit efficiency. Other simulated statistics in the following tables show a general tendency for simulated flows to vary more than observed.

The daily hydrograph shows that peak flows for a few large events are oversimulated greatly, driving the higher variability in the statistics. Attempts during calibration to bring down these peaks negatively impacted the rest of the simulation though. While the rainfall station is nearby, SJRWMD experience suggests that there is a great deal of spatial variability in peak rainfall intensities. The fact that volumes for this gauge are more heavily driven by large event surface runoff relative to baseflow and smaller events makes this subwatershed particularly sensitive to how such variability introduces error in measured rainfall when sampled at a single site.

The average monthly plot shows a fair representation of the seasonal variability in flows. The flow duration shows some oversimulation of highest flows and some undersimulation of the lowest, but a good job through the middle. Overall, the calibration is fair.

Table 3.I.9: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.43	-3.I.5

Table 3.I.10: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02231565)	Simulated
Average	17.55	16.93
Median	2.72	2.70
Variance	2239.76	3240.11
Standard Deviation	47.33	56.92
Skew	5.83	12.19
Kurtosis	49.64	220.23
Minimum	0.00	0.00
Maximum	748.53	1401.46
Range	748.53	1401.46

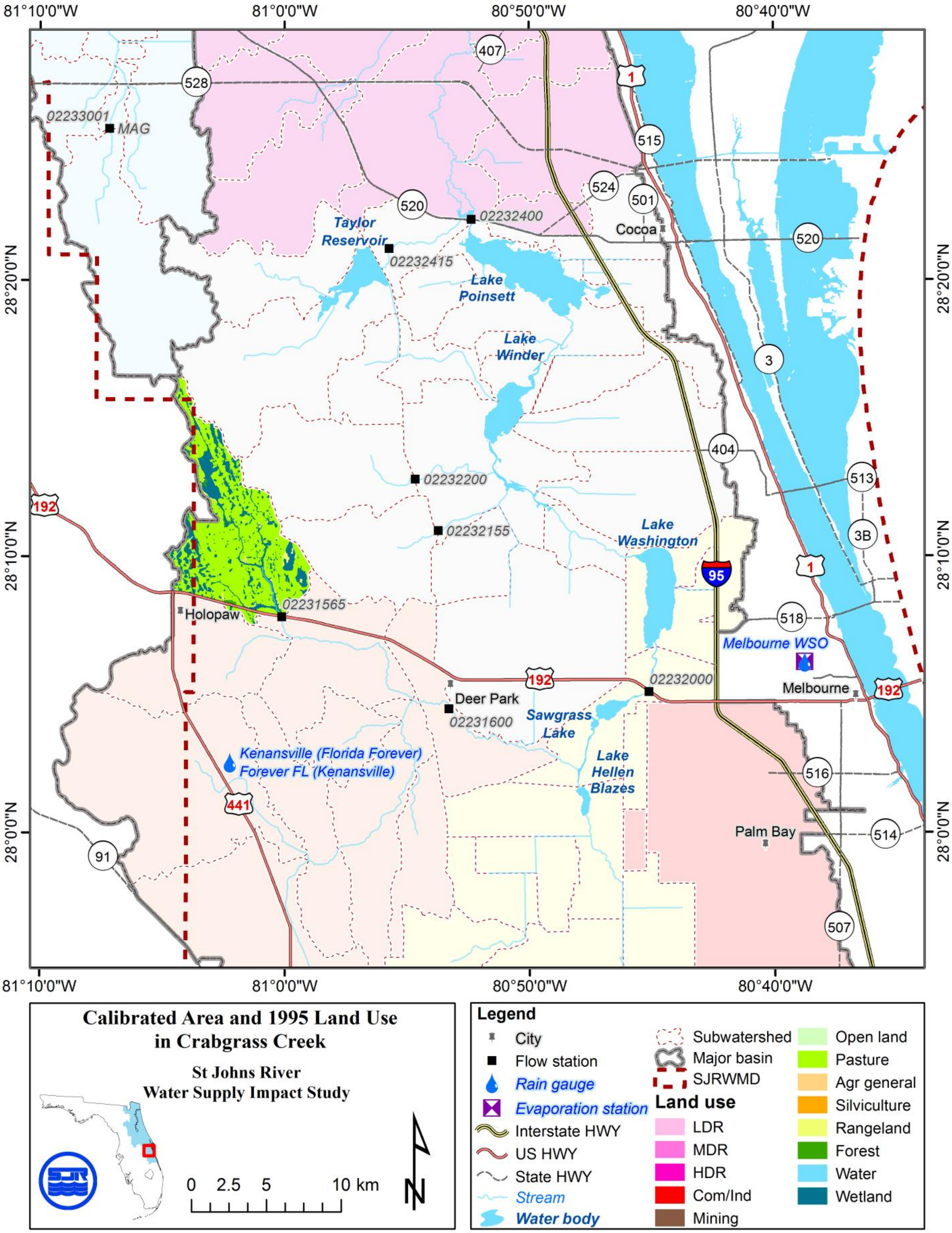

Figure 3. I.25: Crabgrass Creek land use map

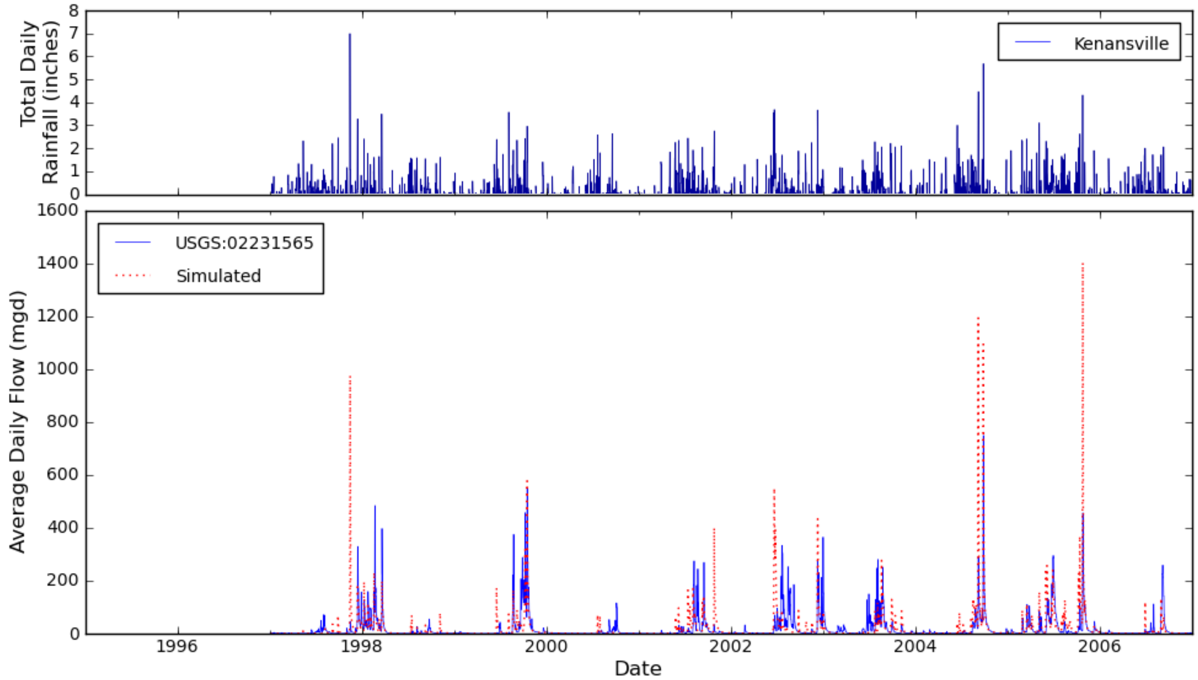

Figure 3. I.26: Crabgrass Creek daily hydrograph

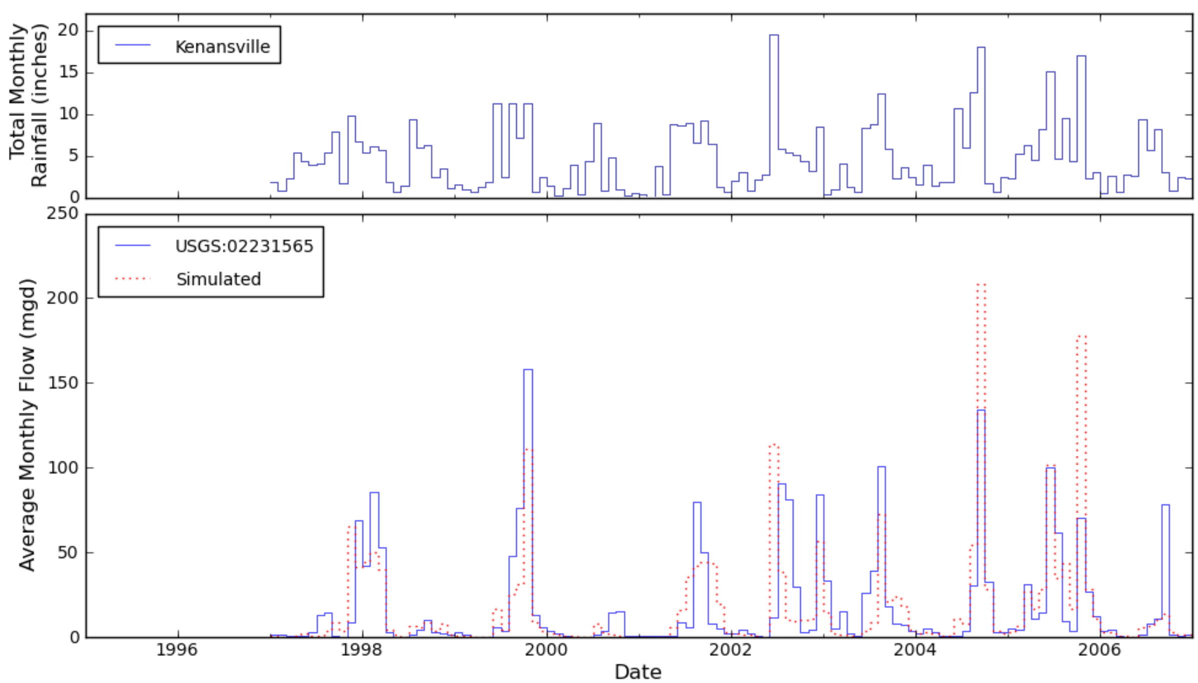

Figure 3. I.27: Crabgrass Creek monthly hydrograph

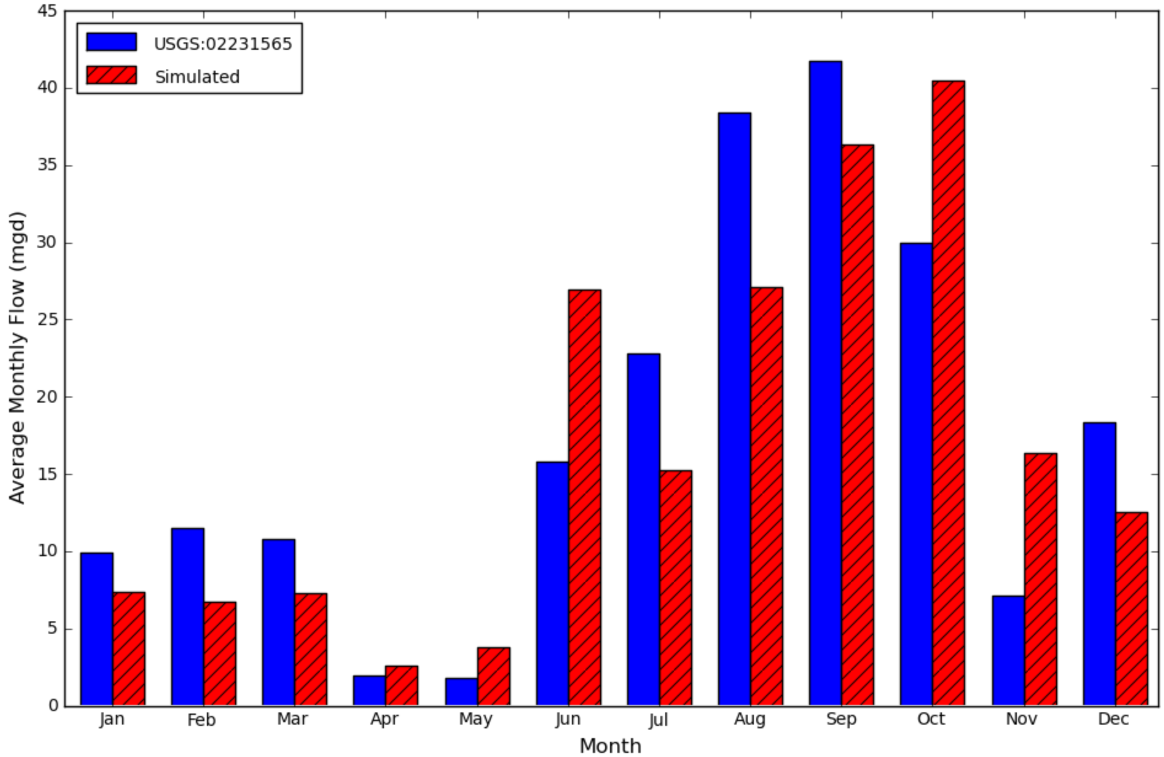

Figure 3. I.28: Crabgrass Creek average monthly flow

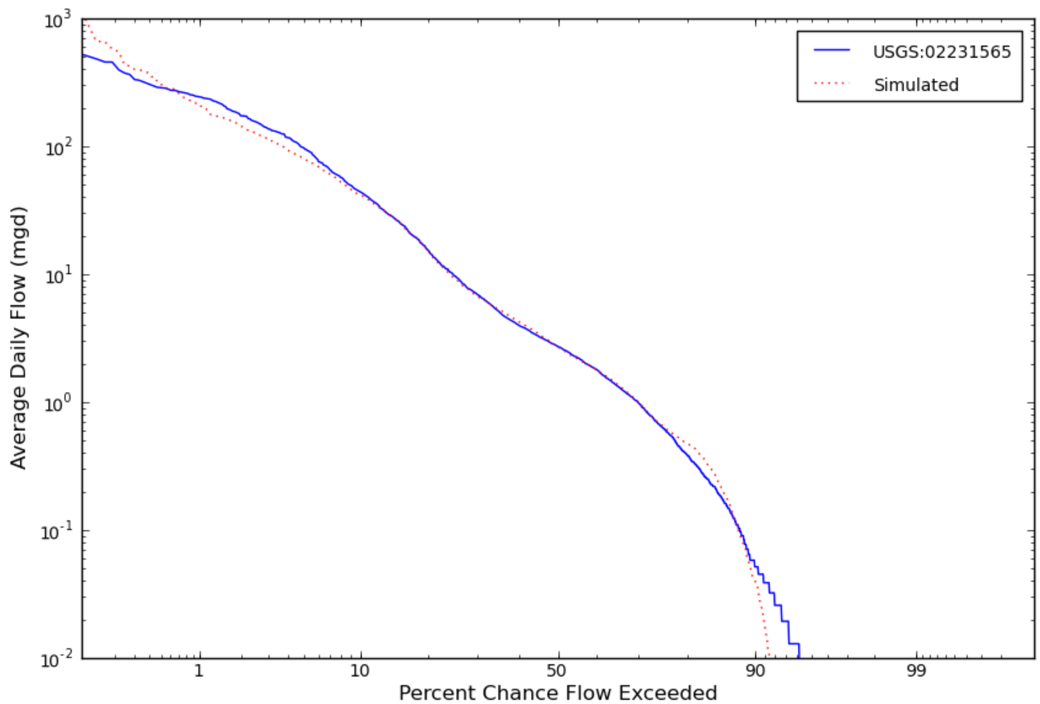

Figure 3. I.29: Crabgrass Creek exceedance probability curve

6E Jane Green Swamp Watershed. Jane Green Creek Subwatersheds

The Jane Green Creek subwatersheds are located in the west central part of the upper basin, receiving tributary flow from Crabgrass Creek and comprising the rest of Planning Unit 6E. It includes the Jane Green Detention Area, which is formed by USACE Levee L-73S and is controlled by structures S-161 and S-161A. The USGS gauge 02231600 lies downstream of the regulated structures. The area is dominated by wetlands and pasture.

The total area is 165,502 acres, including 18,072 acres above the Crabgrass Creek gauge that was calibrated separately. One subwatershed of 11,737 acres lies below the structure. The gauge lies upstream of the outlet of subwatershed 29, but the incremental area is small and therefore not segmented separately.

The entire area uses Kenansville rainfall station and Melbourne potential evaporation station. The calibration period was calendar years 1996 to 2006.

The PEST model was run comparing simulated flows at the outlet of subwatershed 29 against observed discharges, using the project-common logic as a starting point. Adjustments to objective function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 125.53 was within 0.1% of the observed value of 125.65, and the Nash–Sutcliffe statistic on monthly flow was 0.69, which shows a good model fit efficiency. Other simulated statistics in Tables E11 and E12 are in general agreement with observed.

The hydrographs for daily and monthly flow show a good fit in pattern. The average monthly flow shows that the model captures the seasonal variability of flows at the gauge well. The flow duration plot shows a good match of model performance on a frequency basis with some oversimulation at low flows and some undersimulation at high flows. Overall, the calibration is good.

Table 3.I.11: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.69	-0.09

Table 3.I.12: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02231600)	Simulated
Average	125.65	125.53
Median	27.78	29.74
Variance	68818.98	56455.39
Standard Deviation	262.33	237.60
Skew	4.31	3.I.3
Kurtosis	27.54	20.23
Minimum	0.00	0.00
Maximum	3421.56	2072.22
Range	3421.56	2072.22

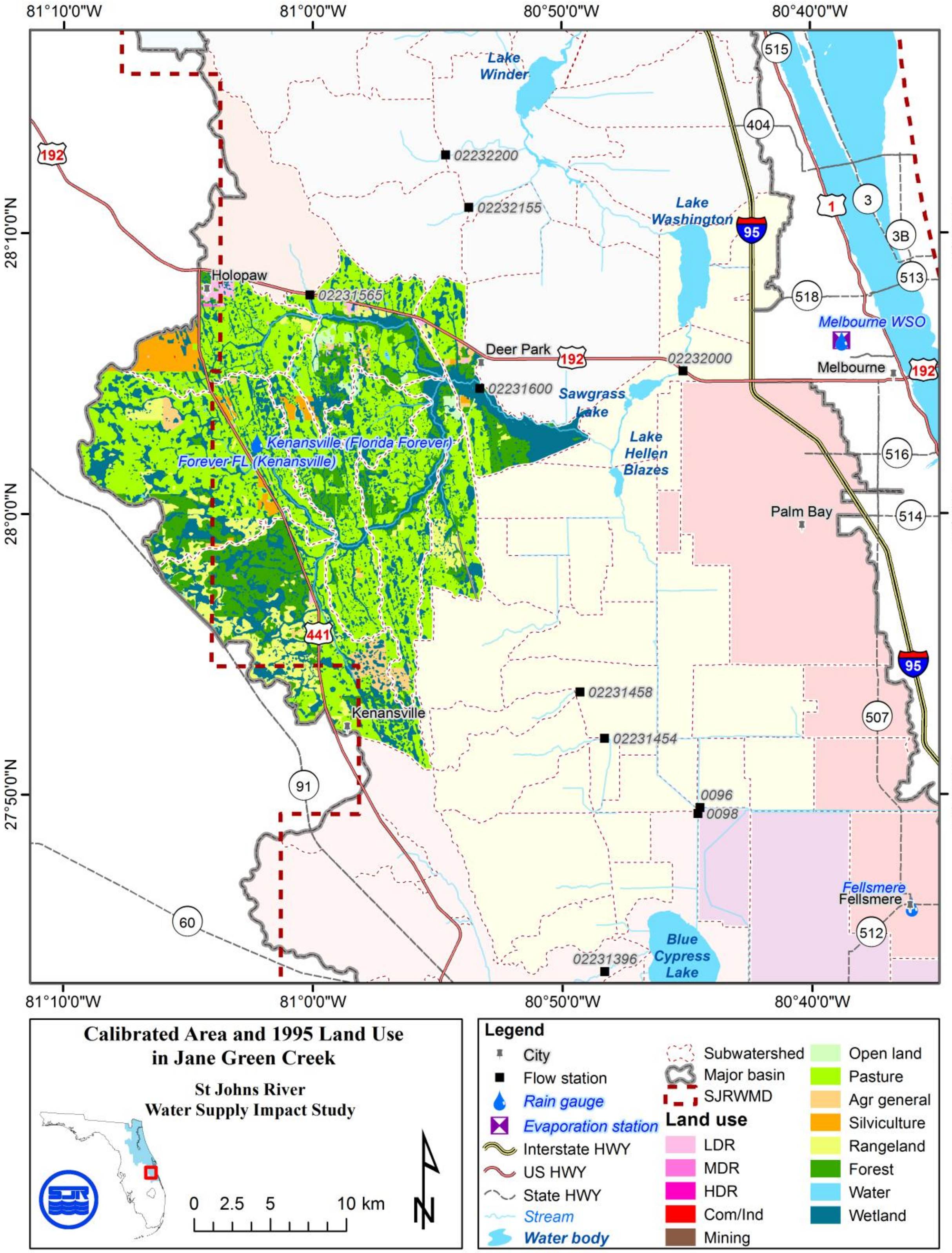

Figure 3. I.30: Jane Green Creek land use map

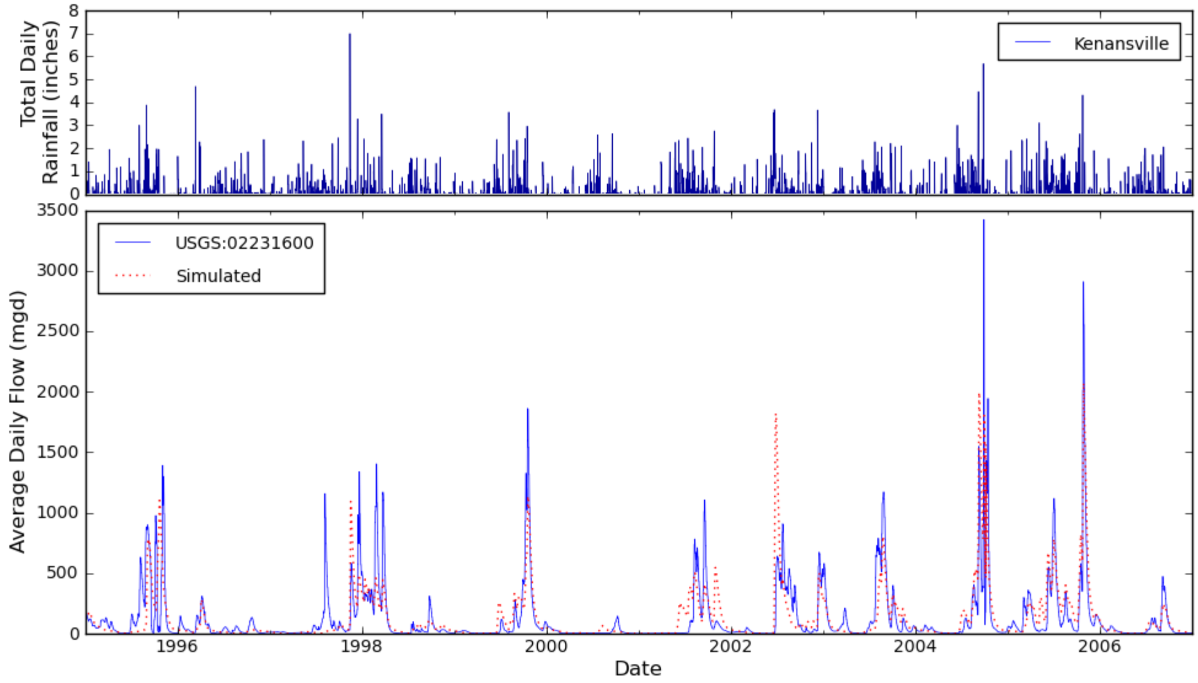

Figure 3. I.31: Jane Green Creek daily hydrograph

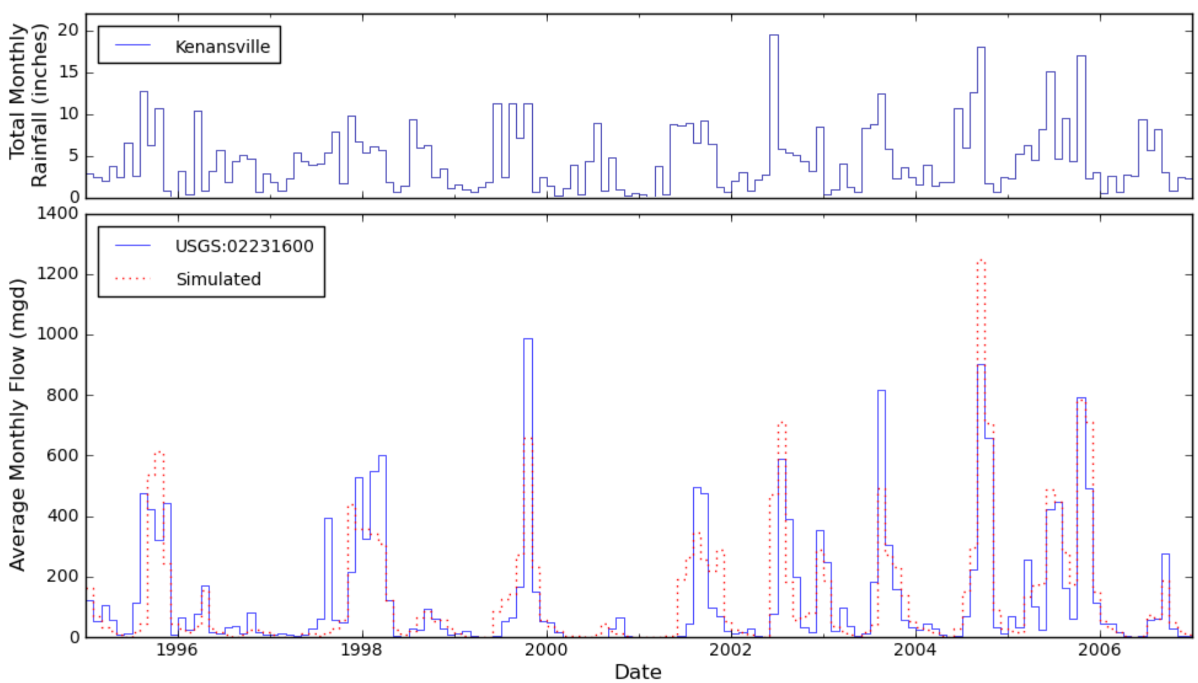

Figure 3. I.32: Jane Green Creek monthly hydrograph

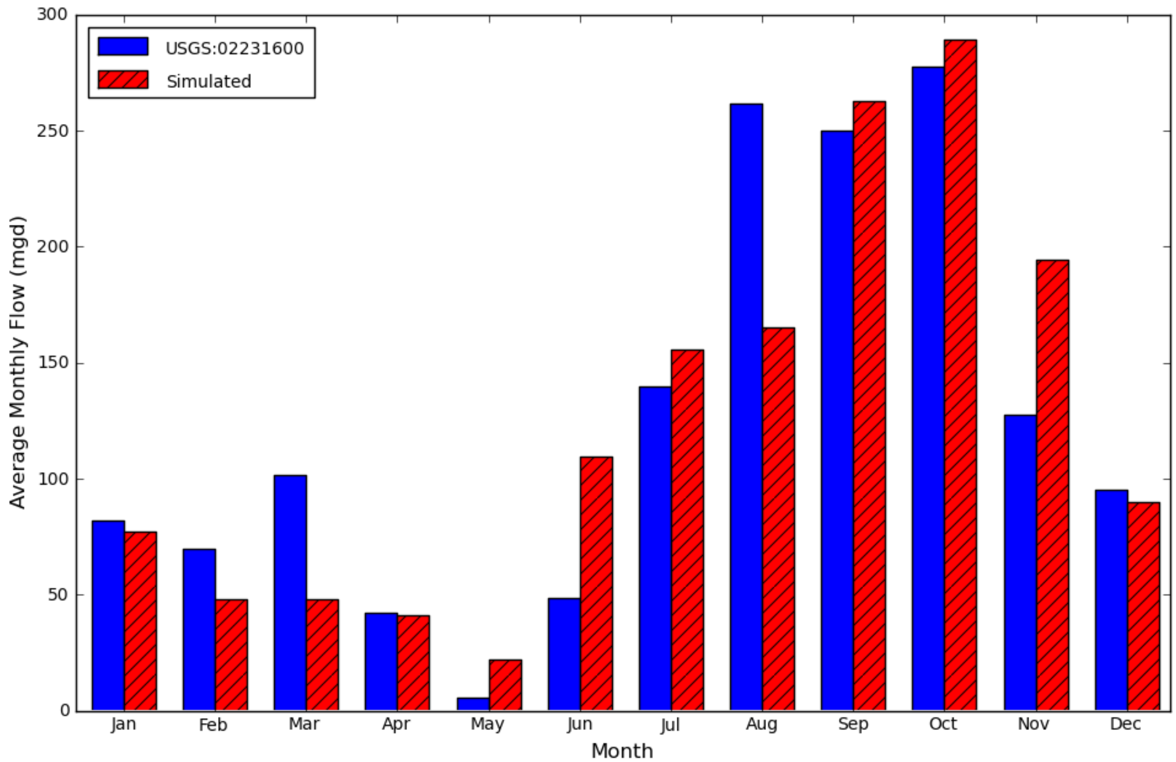

Figure 3.I. 33: Jane Green Creek average monthly flow

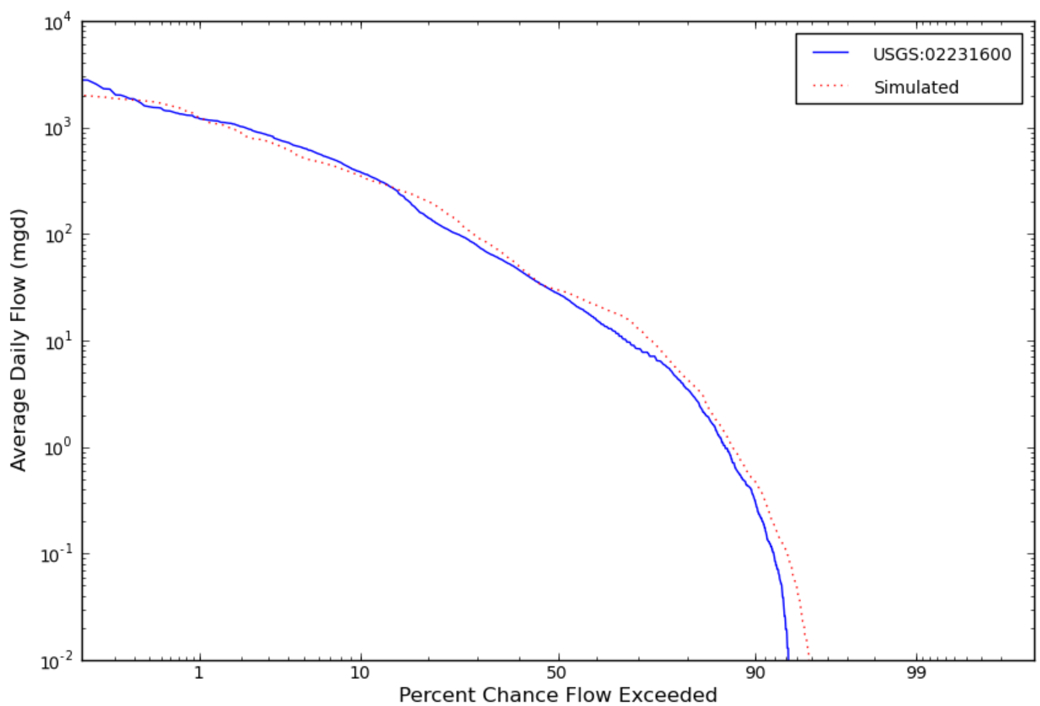

Figure 3. I.34: Jane Green Creek exceedance probability curve

6F St. Johns Marsh Watershed

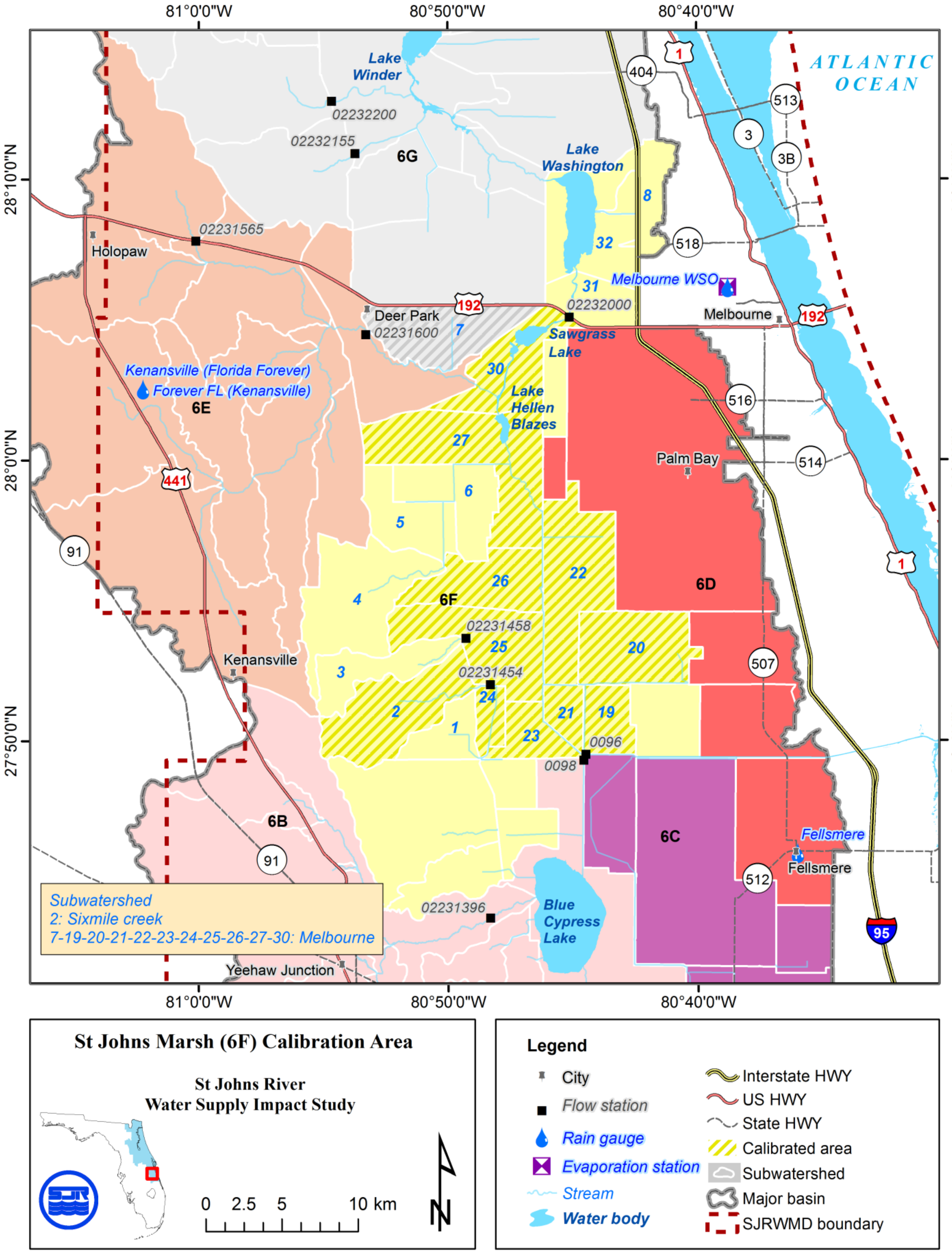

Figure 3I.35: 6F St. Johns Marsh Watershed calibration areas

6F St. Johns Marsh Watershed. Sixmile Creek Subwatersheds

The Sixmile Creek subwatershed is located to the west of the south end of the St. Johns Marsh Conservation Area (St. Johns MCA), into which it flows. It covers 10,063 acres in a single subwatershed, (2) dominated by pasture and wetlands, that drains to USGS gauge 02231454. The calibrated parameters are extended to subwatersheds 1 and 3 to 6 in Planning Unit 6F, covering an additional 32,540 acres along the west side of St. Johns MCA under similar conditions. There has been an active gauge on subwatershed 3 (Wolf Creek), but it represents similar conditions to Sixmile Creek and is due to be deactivated in the near future, so it was not chosen for calibration.

The rainfall for the Kenansville station is applied to subwatersheds 2to 6 while subwatershed 1 uses the Fellsmere station. The Melbourne station is used for potential evaporation data for all six subwatersheds. The calibration period is calendar years 1996 to 2006.

The PEST model was run comparing simulated flows for subwatershed 2 against observed discharges, using the project-common logic as a starting point. Adjustments to objective function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 5.84 was within 0.4% of the observed value of 5.87, and the Nash–Sutcliffe statistic on monthly flow was 0.60, which shows a satisfactory model fit efficiency. Other simulated statistics in the following table are in general agreement with observed.

The hydrographs for daily and monthly flow show a good fit in pattern. The average monthly flow shows that the model captures the seasonal variability of flows at the gauge very well. The flow duration plot shows a good match of model performance on a frequency basis, with some undersimulation at low flows (except some extremely small flows with very little volume) and some oversimulation at high flows. Overall, the calibration is good.

Table 3.I.13: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.60	-0.40

Table 3.I.14: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02231454)	Simulated
Average	5.87	5.84
Median	0.45	0.36
Variance	327.48	397.86
Standard Deviation	18.10	19.95
Skew	7.74	8.29
Kurtosis	96.99	97.86
Minimum	0.00	0.00
Maximum	385.20	366.41
Range	385.20	366.41

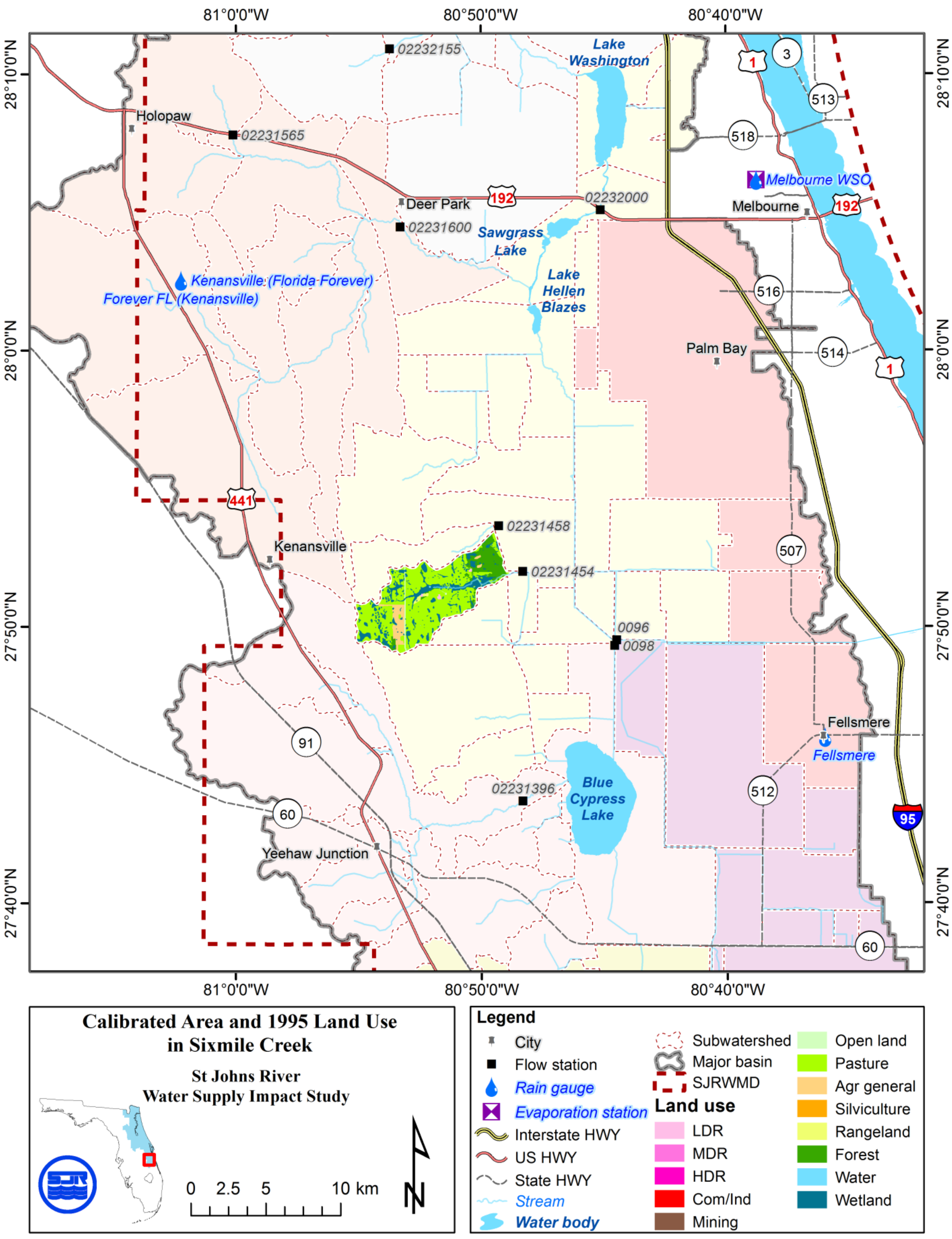

Figure 3. I.36: Sixmile Creek land use map

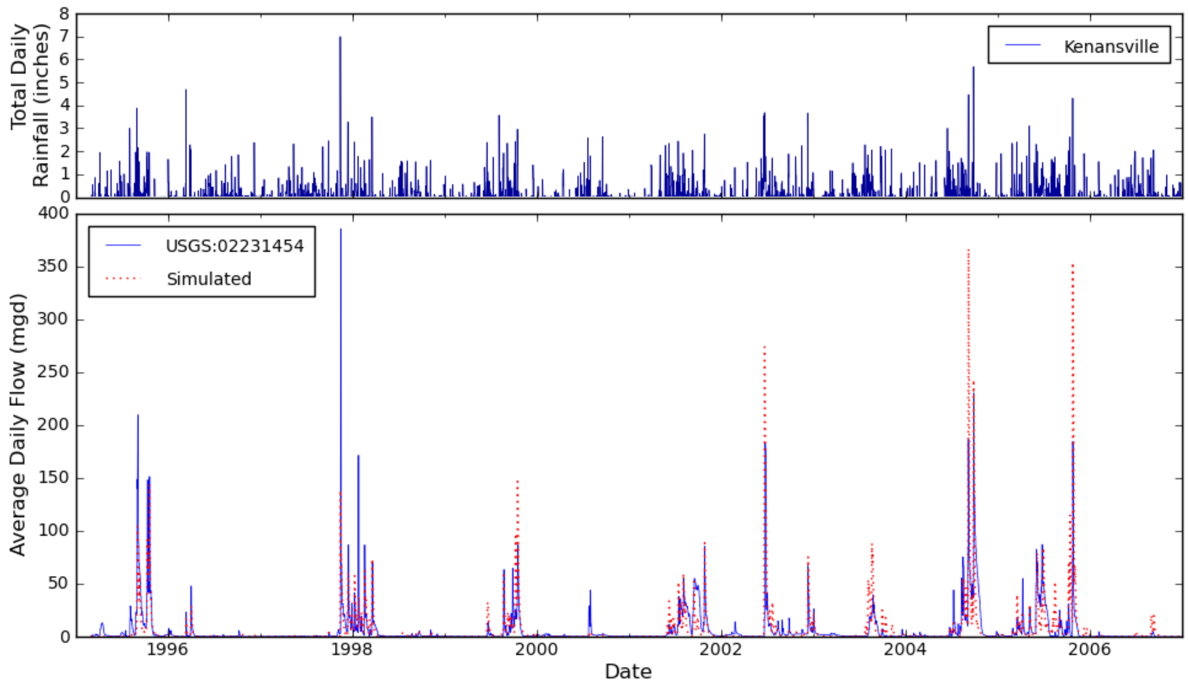

Figure 3. I.37: Sixmile Creek daily hydrograph

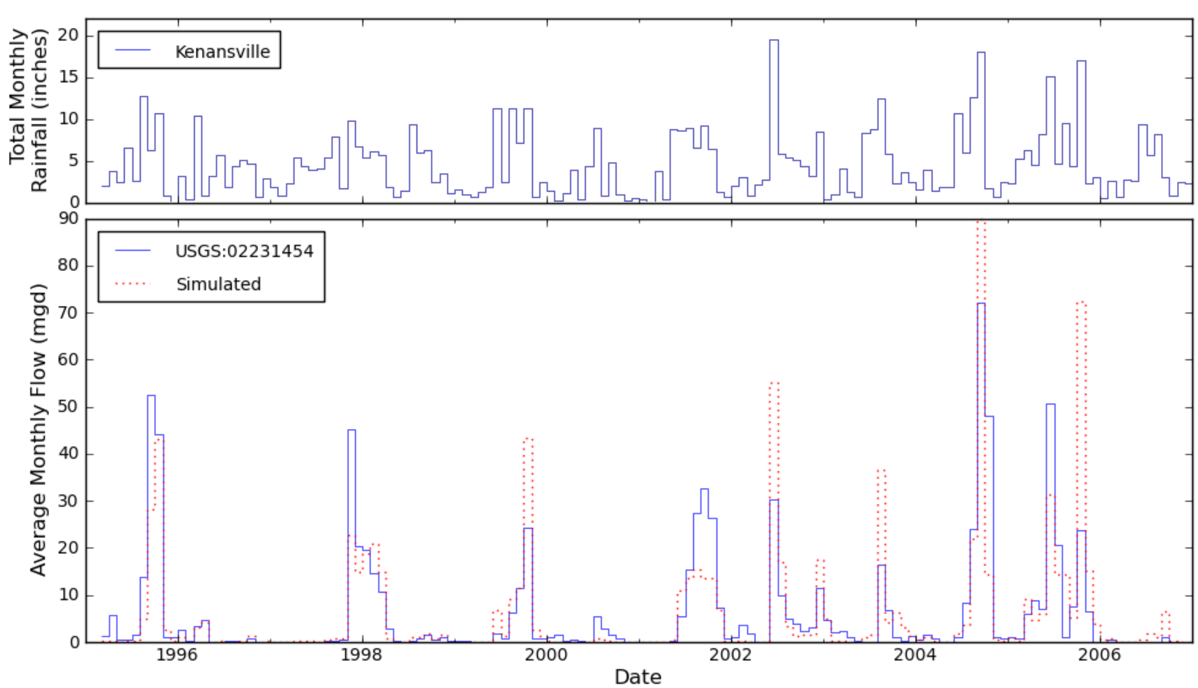

Figure 3. I.38: Sixmile Creek monthly hydrograph

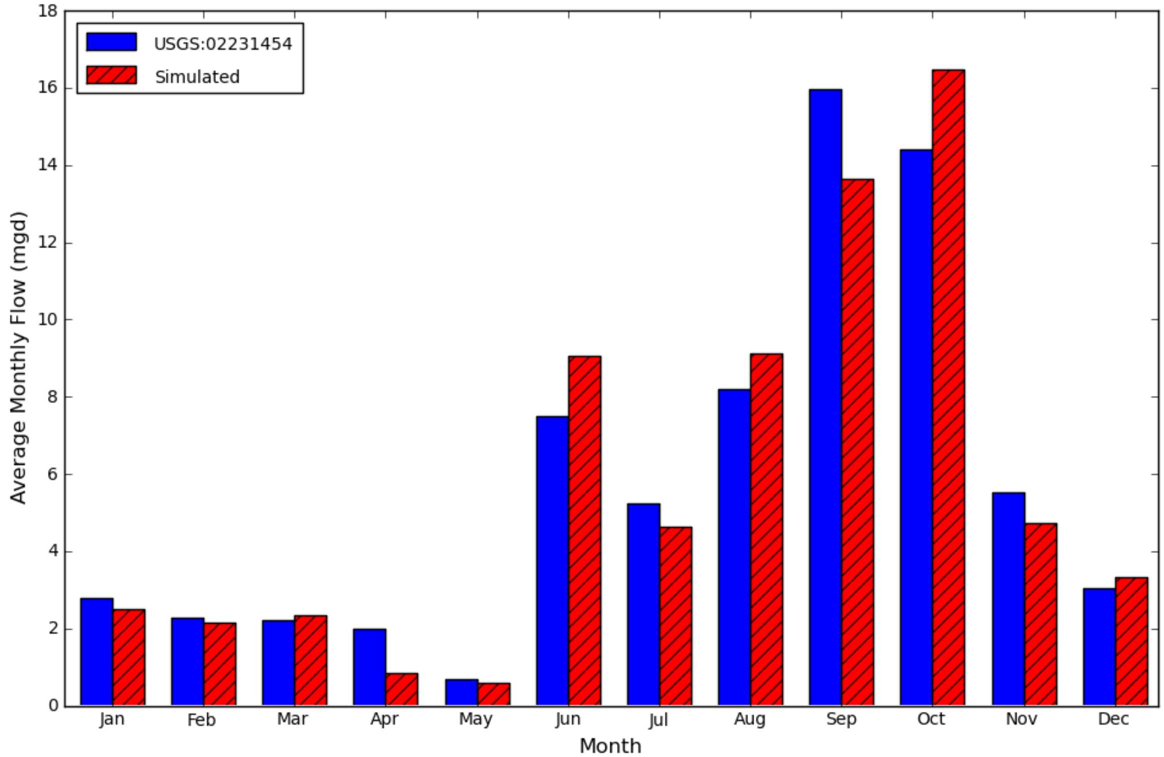

Figure 3I.39: Sixmile Creek average monthly flow

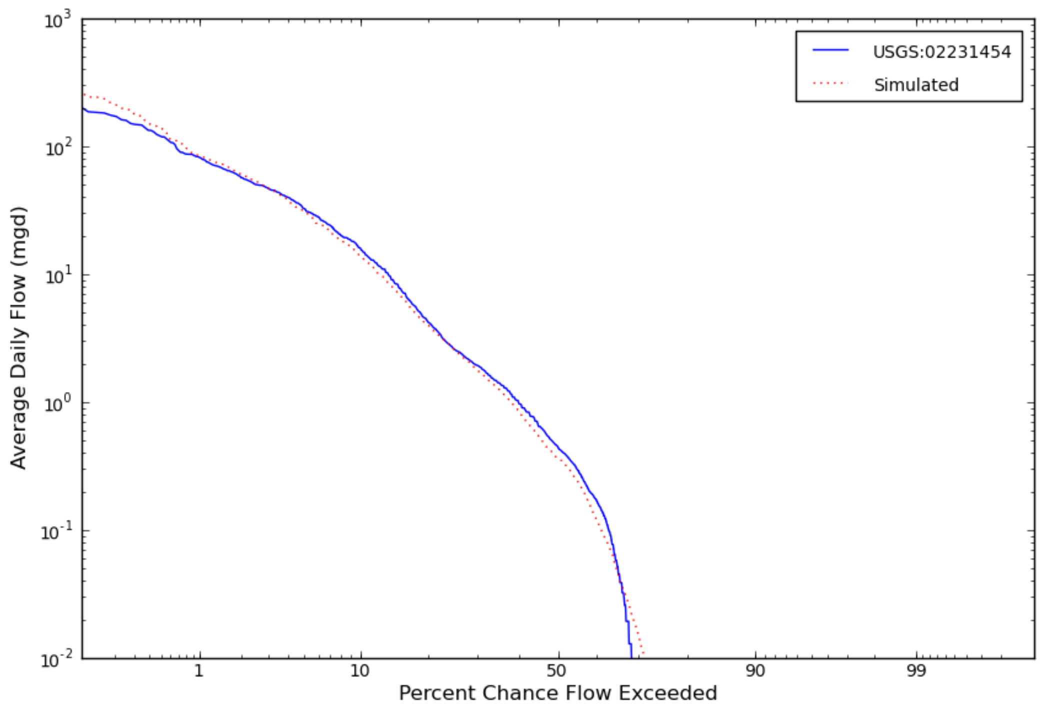

Figure 3. I.40: Sixmile Creek exceedance probability curve

6F St. Johns Marsh Watershed. St Johns River near Melbourne Subwatersheds

This area comprises the main stem of the river through St. Johns MCA, continuing northward toward Lake Washington, plus some tributary area to the west and north. It makes up the majority of Planning Unit 6F, comprising subwatersheds 19 to 27 and 30, plus subwatershed 7, which is in Planning Unit 6G but drains into the river upstream of the gauge. The parameters are extended northward into subwatersheds 8, 31, and 32 in 6F.

It receives tributary inflows from the S96C and S-96B structures at the south end, from Jane Green Creek at the northwest, and from the areas using Sixmile Creek parameters along the west edge. In addition, a project nearing completion is routing outflows from Three Forks Marsh Conservation Area (Three Forks MCA) into the main stem here, including rediversion of 11,191 acres of the C-1 basin back to the river. A second project will redivert an average of 25 to 30 mgd from the C-1 canal basin. These projects are taken into account in some future scenarios but not in the calibration.

At the south end, the river consists primarily of canals, with a short channel crossing St. Johns Marsh between C-40 and the Mormon Canal. Just downstream of Three Forks, the true natural channel of the St. Johns River appears for the first time. It passes through Lake Hellen Blazes and Sawgrass Lake before passing USGS gauge 02232000 on its way to Lake Washington. The Lake Washington weir is the last water-control structure on the main stem of the river.

The modeled area calibrated to this gauge consists of 78,235 acres, primarily wetland along the main stem floodplain with some pasture and other agriculture dominating the uplands on either side. The northward extension of parameters downstream of the gauge covers another 18,940 acres. The total modeled tributary area at the gauge, including all areas calibrated using upstream gauges, is 595,293 acres.

The calibrated area uses rainfall data from two stations. In the southern portion, subwatersheds 19 to 25 use the Fellsmere station while the northern subwatersheds 26, 27, 30, and 7 use Melbourne. The Melbourne potential evaporation data is applied to all of the subwatersheds.

The PEST model was run comparing simulated flows from the outlet of subwatershed 30 against observed discharges, using the project-common logic as a starting point. Adjustments to objective-function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 488.19 was within 6.5% of the observed value of 520.56, and the Nash–Sutcliffe statistic on monthly flow was 0.88, which shows a very good model fit efficiency. Other simulated statistics in the following table are in general agreement with observed.

The hydrographs for daily and monthly flow show a good fit in pattern. The average monthly flow shows that the model captures the seasonal variability of flows at the gauge well. The flow duration plot shows a fair match of model performance on a frequency basis through most of the domain, with some undersimulation at high flows but an oversimulation at the lowest flows, especially where observed flows are reported negative. Reverse flows in the river can be driven by tailwater from downstream high stage caused by downstream inflows that are not matched by upstream inflows, or by wind coming from the north when the water-surface gradient is at or near zero. HSPF is not designed to reproduce such negative flows, having a very simple hydraulic representation. Overall, the calibration is good.

Table 3.I.15: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.88	-6.22

Table 3.I.16: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02232000)	Simulated
Average	520.56	488.19
Median	219.43	297.36
Variance	511095.38	352703.I.6
Standard Deviation	714.91	593.I.9
Skew	2.25	2.61
Kurtosis	5.80	8.59
Minimum	-59.46	17.08
Maximum	5215.94	4418.84
Range	5275.40	4401.76

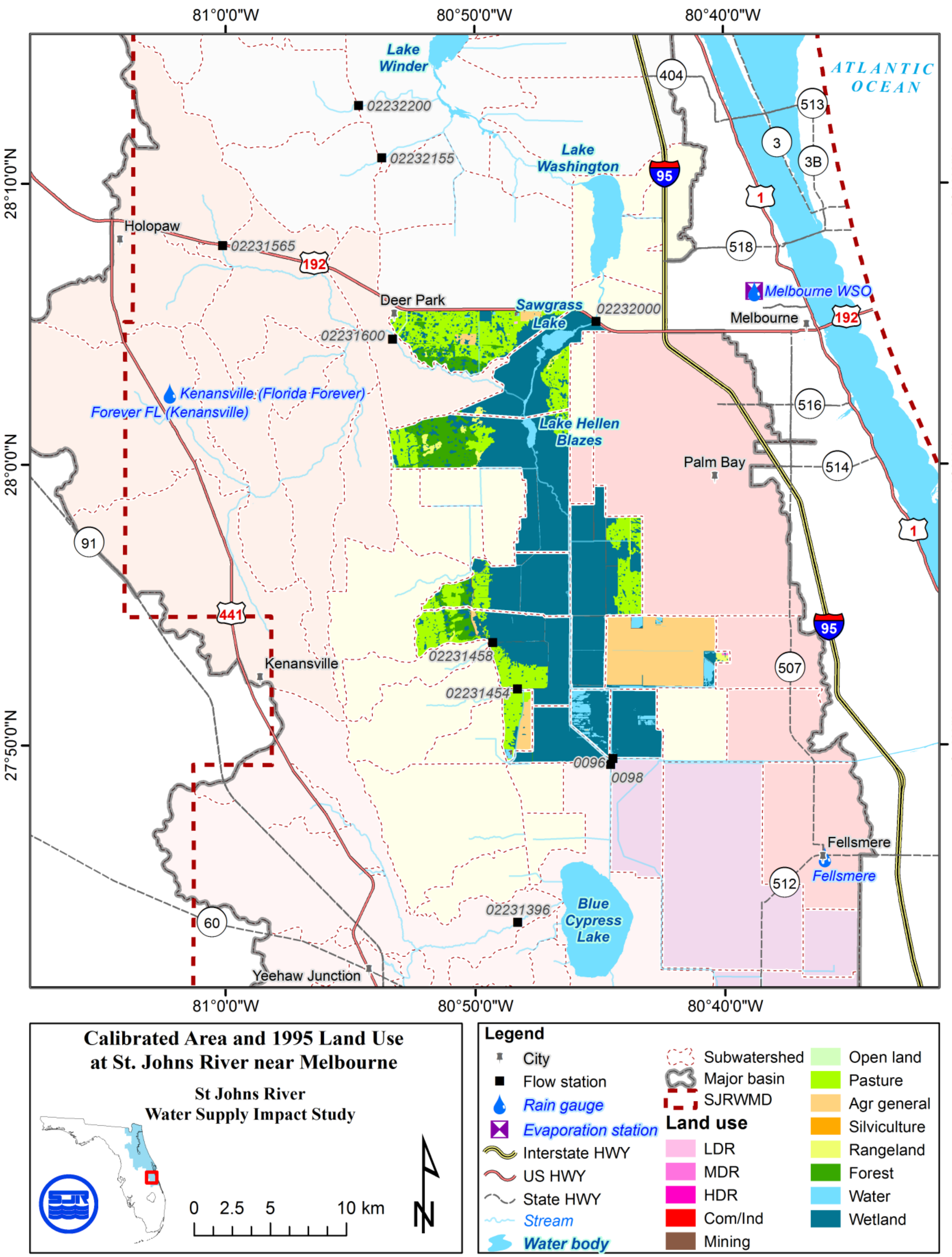

Figure 3. I.41: St Johns River near Melbourne land use map

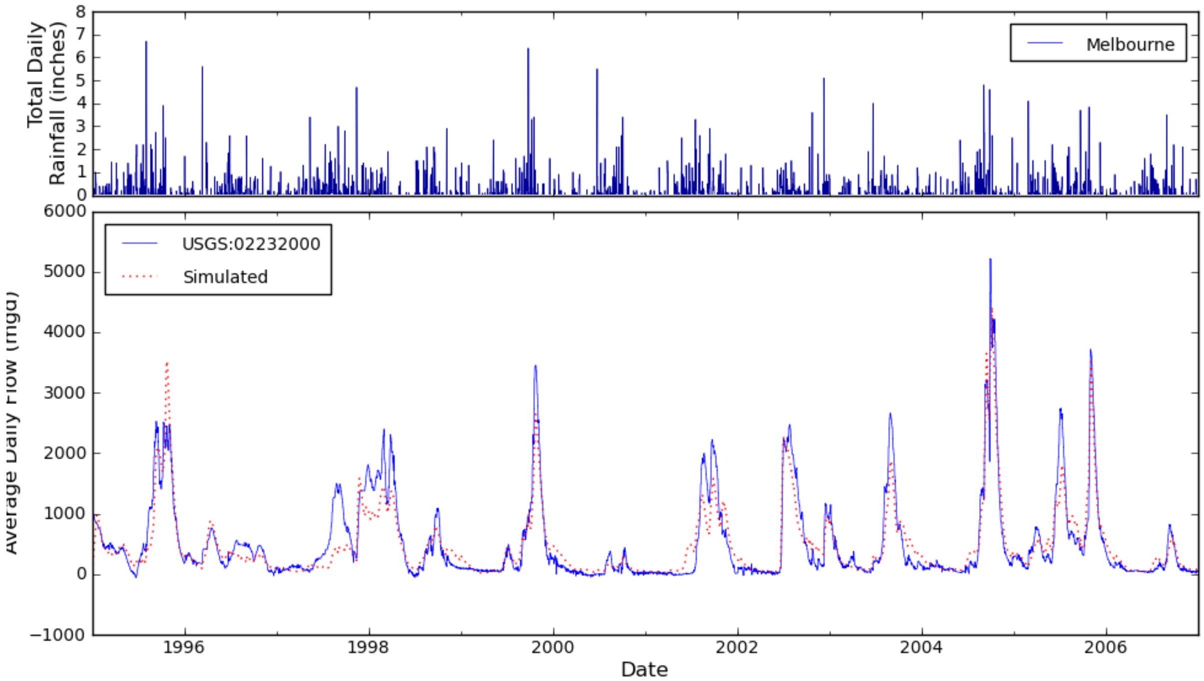

Figure 3. I.42: St Johns River near Melbourne daily hydrograph

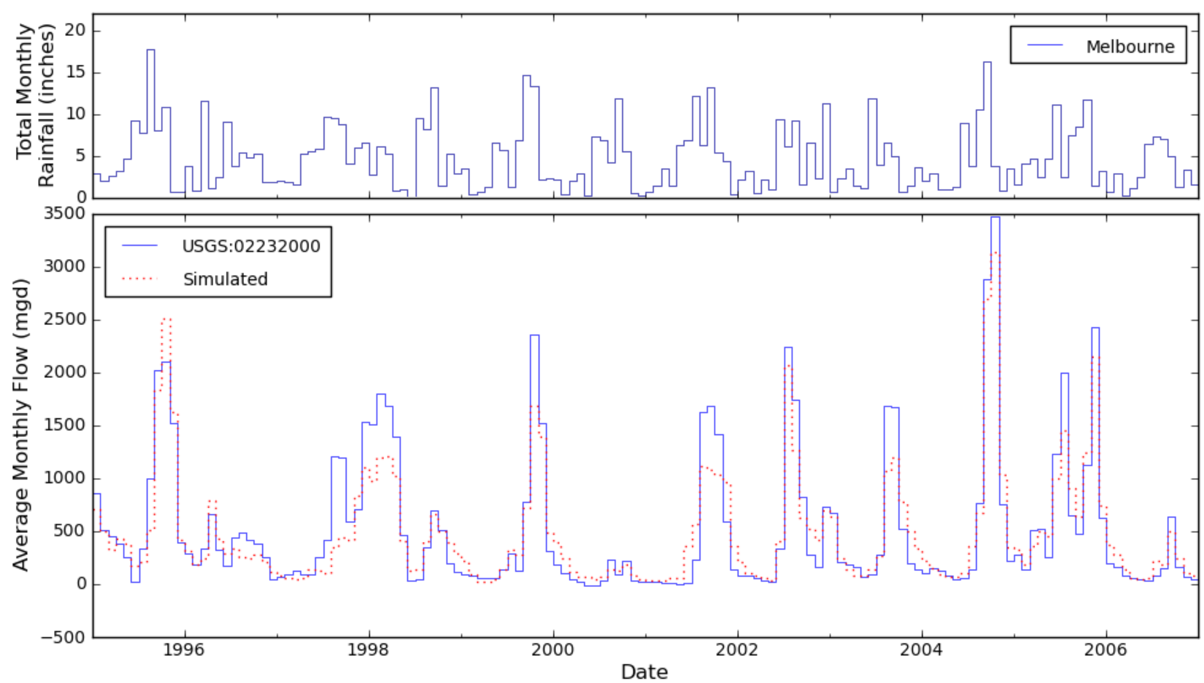

Figure 3. I.43: St Johns River near Melbourne monthly hydrograph

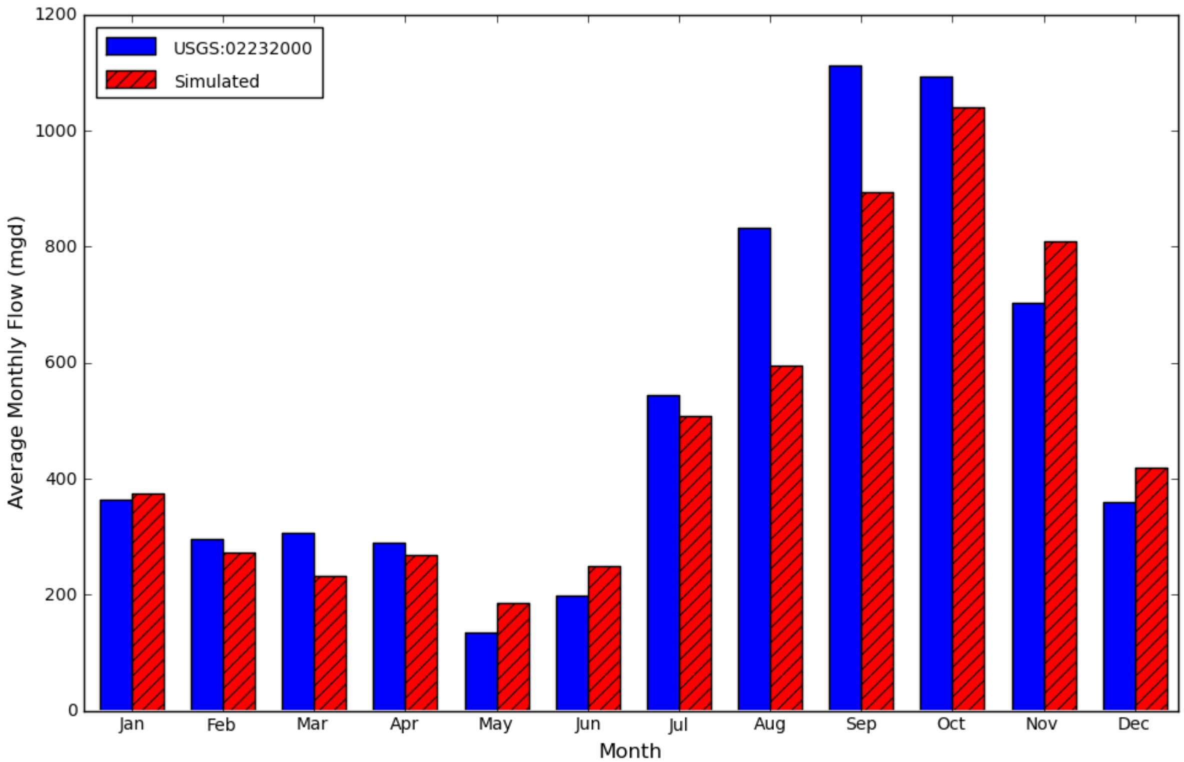

Figure 3. I.44: St Johns River near Melbourne average monthly flow

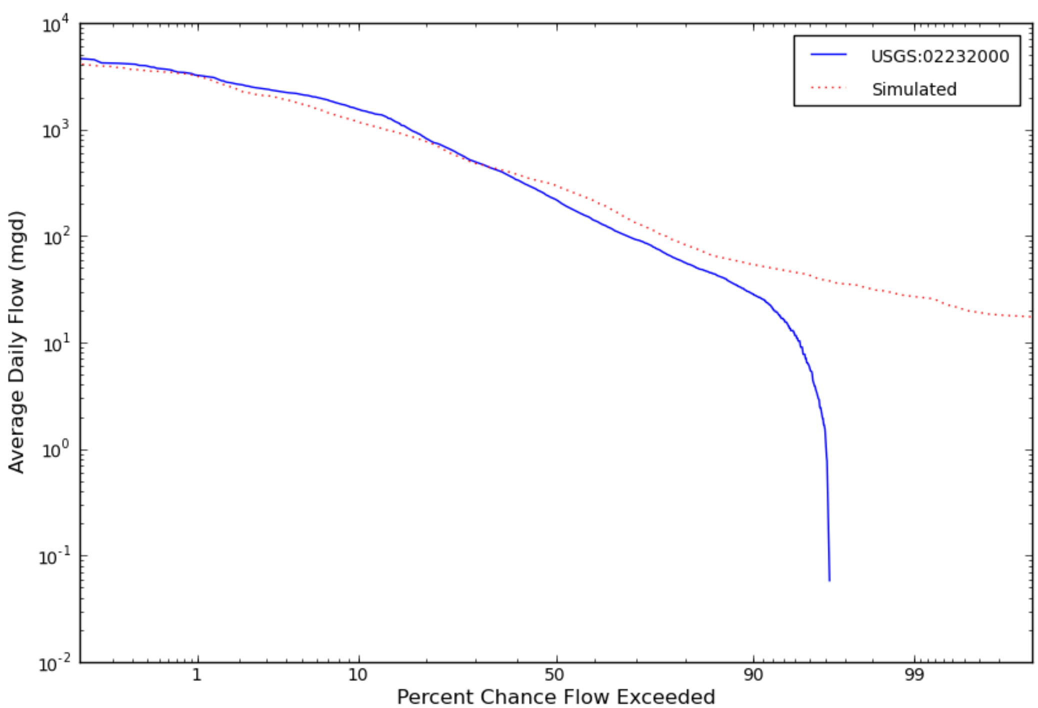

Figure 3I.45: St Johns River near Melbourne exceedance probability curve

6G Lake Poinsett Watershed

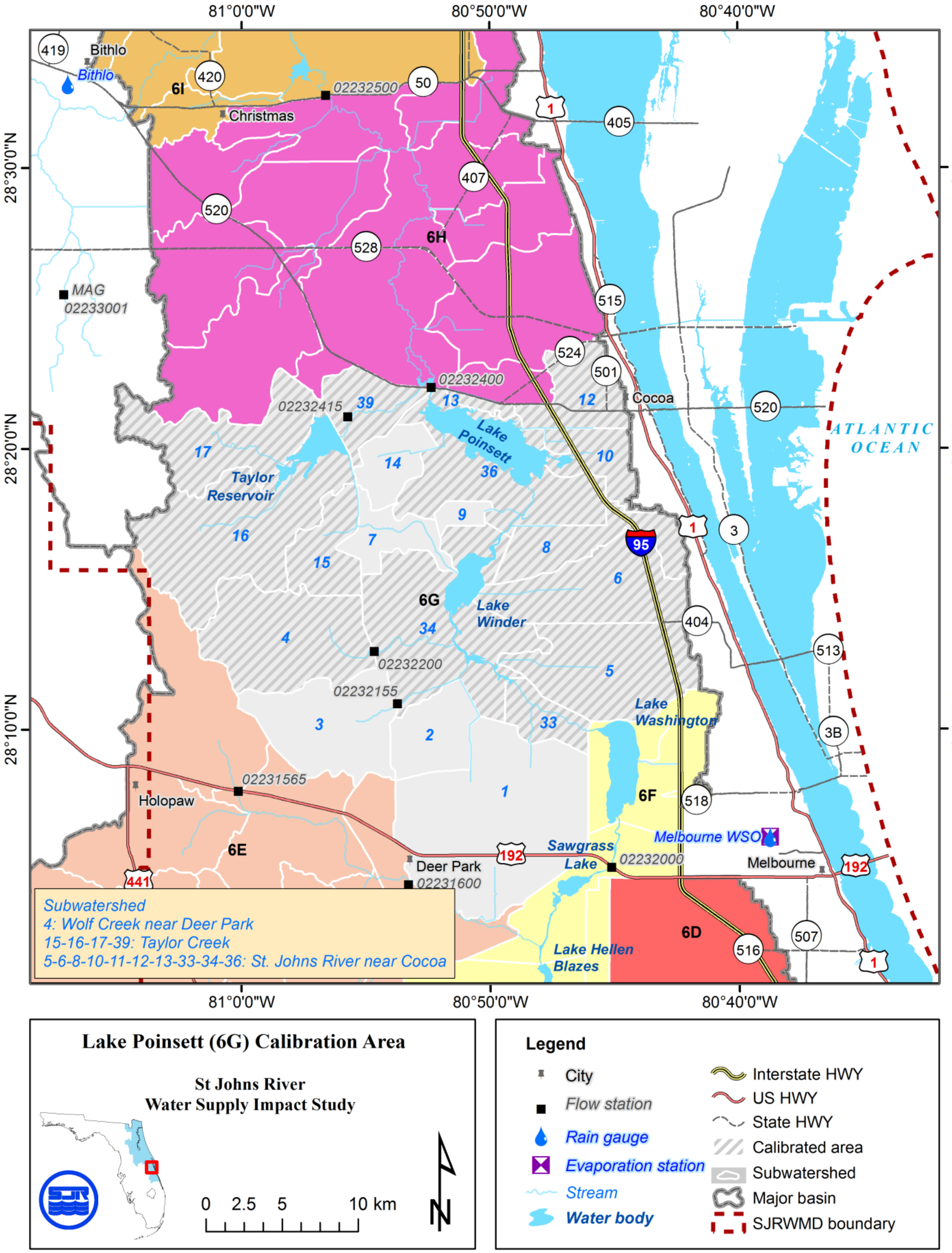

Figure 3.I.I.46: 6G Lake Poinsett Watershed calibration areas

6G Lake Poinsett Watershed. Wolf Creek near Deer Park Subwatersheds

The Wolf Creek near Deer Park subwatershed–is located in Planning Unit 6G, on the west side of the upper basin south of Taylor Creek Reservoir. It covers 16,045 acres in a single subwatershed (4) dominated by pasture that drains to USGS gauge 02232200. The calibrated parameters are extended to subwatersheds 1 to 3, 7, and 19, covering an additional 51,479 acres of similar landscape on the west side of the river. (This Wolf Creek should not be confused with Wolf Creek near Kenansville in Planning Unit 6F.) There has been an active USGS gauge on Pennywash Creek (subwatershed 3), but it represents similar conditions and is slated to be deactivated in the near future, so it was not chosen for calibration.

The rainfall for the Kenansville station is applied to subwatersheds 1 to 4, 7, and 14; subwatershed 9 uses the Melbourne station. The Melbourne station is used for potential evaporation data for subwatersheds 1 to 4, 7, and 9 while subwatershed 14 uses the Titusville station. The calibration period spans calendar years 1995 to 2006.

The PEST model was run comparing simulated flows for subwatershed 4 against observed discharges, using the project-common logic as a starting point. Adjustments to objective function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 18.63 was within 5% of the observed value of 19.58, and the Nash–Sutcliffe statistic on monthly flow was 0.61, which shows a satisfactory model fit efficiency. Other simulated statistics in Tables E17 and E18 are in general agreement with observed.

The hydrographs for daily and monthly flow show a good fit in pattern. The average monthly flow shows that the model captures the seasonal variability of flows at the gauge fairly well, with some undersimulation in winter and oversimulation in spring. The flow duration plot shows a very good match of model performance on a frequency basis. Overall, the calibration is good.

Table 3.I.17: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.61	-4.86

Table 3.I.18: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02232200)	Simulated
Average	19.58	18.63
Median	2.65	2.68
Variance	4914.85	3584.17
Standard Deviation	70.11	59.87
Skew	13.I.2	10.57
Kurtosis	311.96	174.49
Minimum	0.00	0.00
Maximum	2184.55	1499.04
Range	2184.55	1499.04

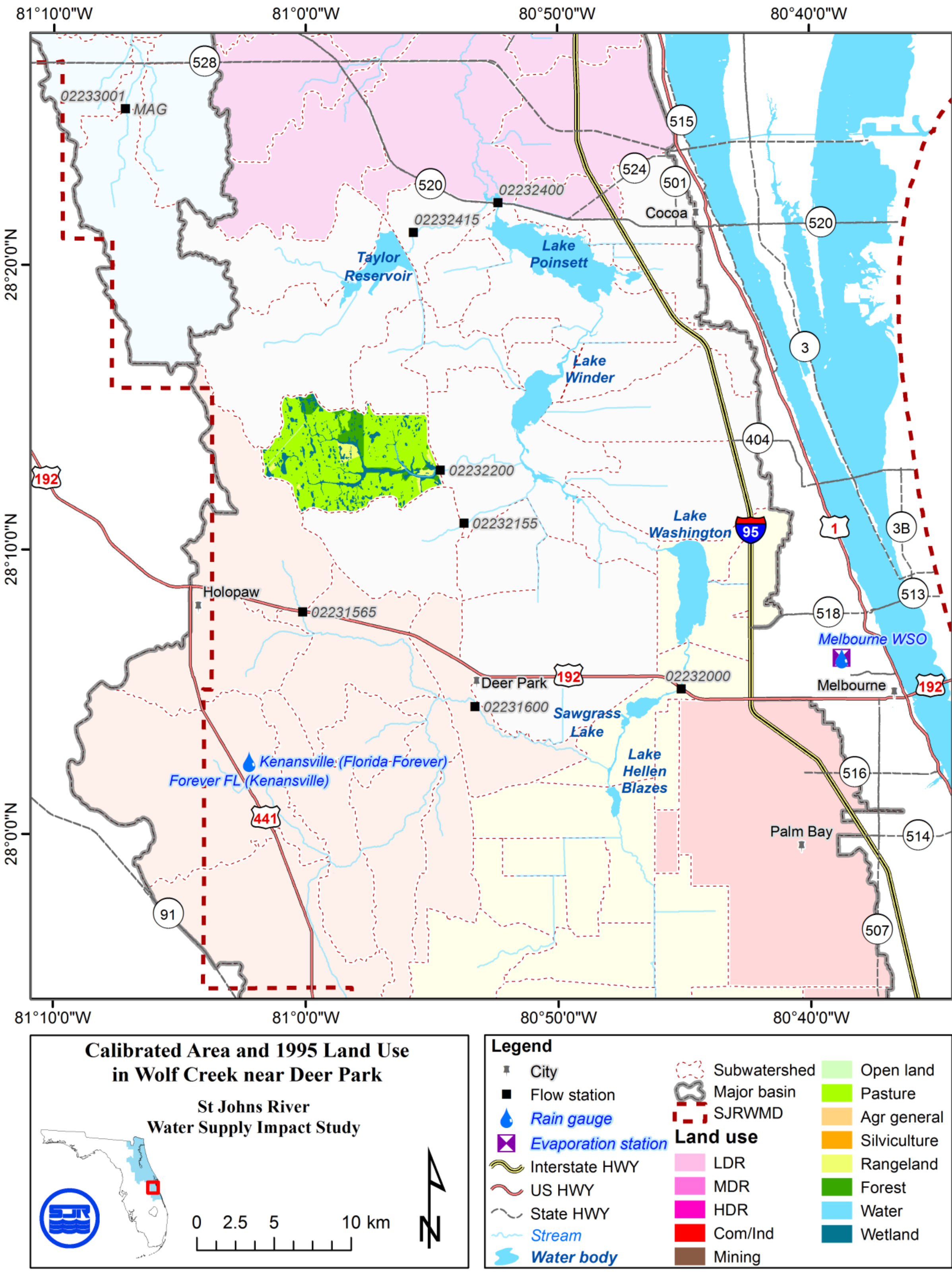

Figure 3. I.47: Wolf Creek near Deer Park land use map

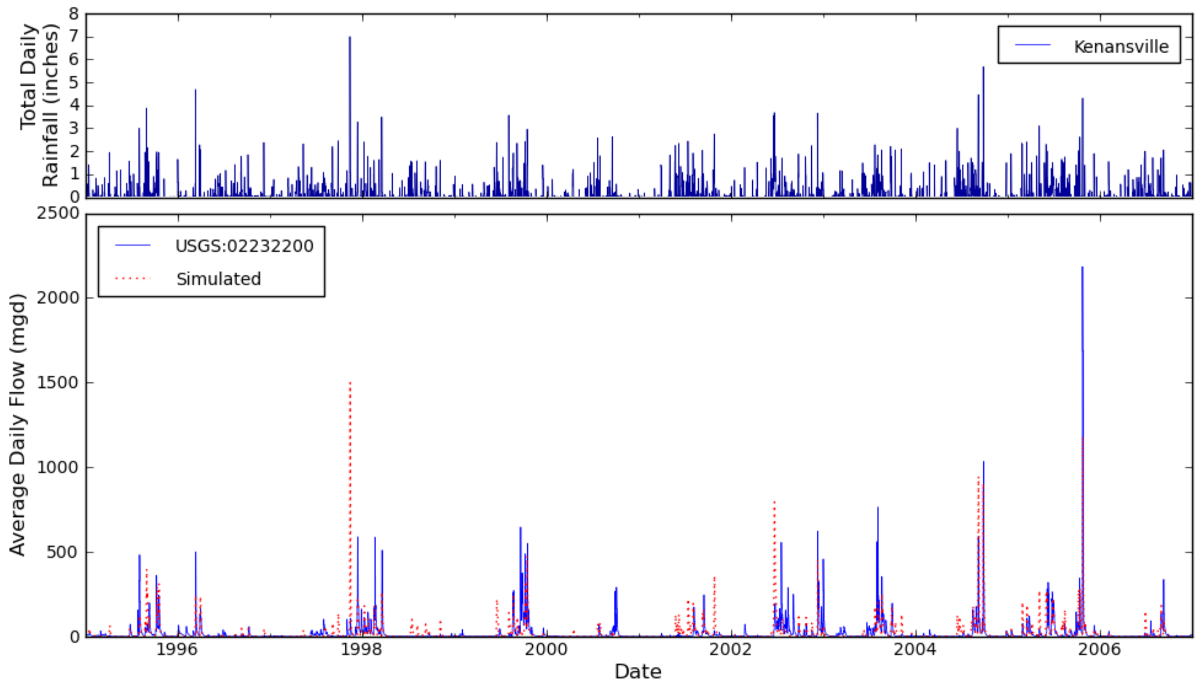

Figure 3. I.48: Wolf Creek near Deer Park daily hydrograph

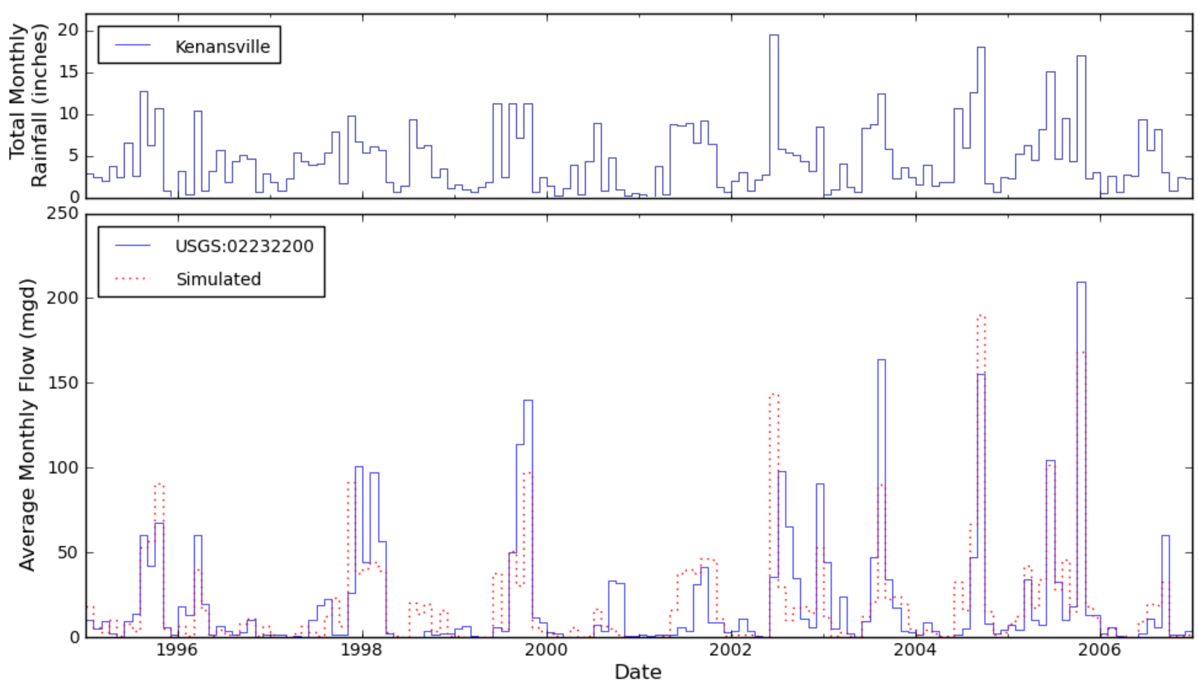

Figure 3. I.49: Wolf Creek near Deer Park monthly hydrograph

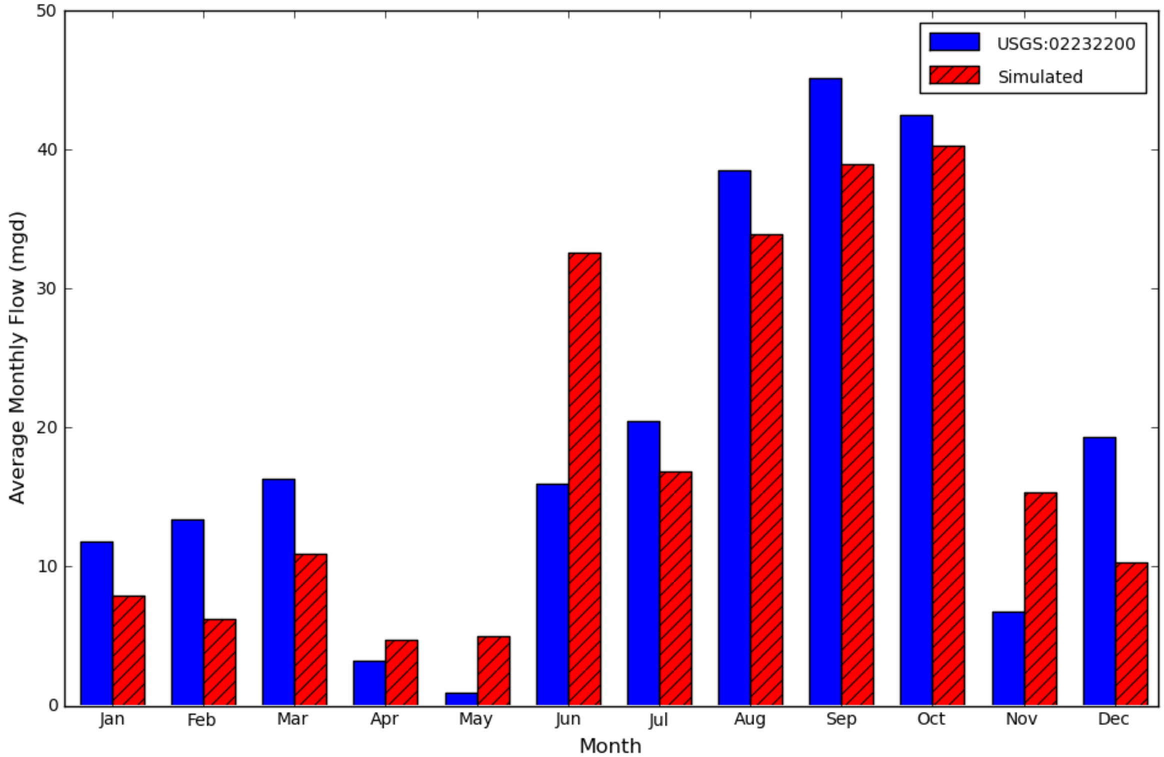

Figure 3. I.50: Wolf Creek near Deer Park average monthly flow

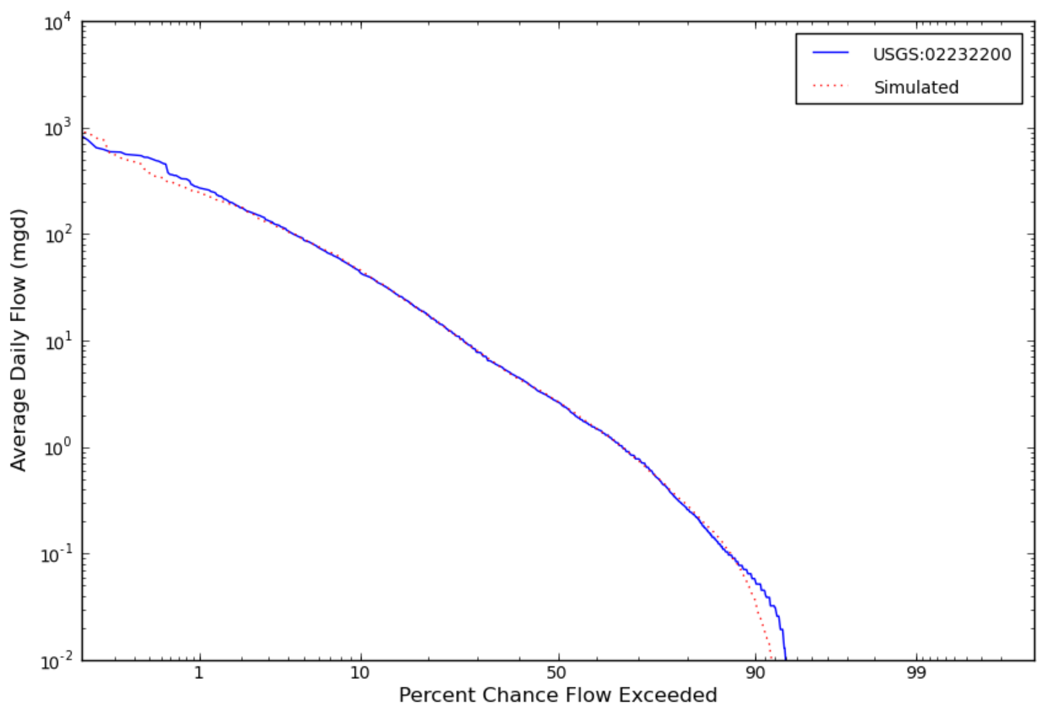

Figure 3. I.51: Wolf Creek near Deer Park exceedance probability curve

6G Lake Poinsett Watershed. St Johns River near Cocoa Subwatersheds

This area covers the east side and main stem of the river in Planning Unit 6G. The river flows north from the Lake Washington weir by a natural channel through Lake Winder and downstream as far as the outlet of Lake Poinsett. It receives tributary inflows upstream at the weir, including all areas tributary to the Melbourne gauge plus areas around Lake Washington. Flows from the west include Pennywash, Wolf, and Cox creeks, which are calibrated based on the Wolf Creek gauge.

The flows are calibrated to USGS gauge 02232400, which lies at the SR 528 bridge just north of the outlet of Lake Poinsett. The local calibrated subwatersheds are 5,6,8,10 to 13, 33, 34, and 36, covering 94,711 acres. The total modeled area contributing to the gauge is 775,900 acres.

The rainfall and potential evaporation data from the Melbourne station are applied to all but subwatersheds 12 and 13, which use Titusville for both sets of meteorological inputs. The calibration period was calendar years 1995 to 2006. Input of diffuse groundwater inflows from the Upper Floridan aquifer is represented as a point source to Lake Poinsett, taken from a time series of flows estimated using chloride data.

The PEST model was run comparing simulated flows at the outlet of subwatershed 36 against observed discharges, using the project-common logic as a starting point. Adjustments to objective function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 765.82 was within 3.5% of the observed value of 793.31, and the Nash–Sutcliffe statistic on monthly flow was 0.85, which shows a very good model fit efficiency. Other simulated statistics in the following table are in general agreement with observed.

The hydrographs for daily and monthly flow show a good fit in pattern. The average monthly flow shows that the model captures the seasonal variability of flows at the gauge well. The flow duration plot shows a fair match of model performance on a frequency basis through most of the domain, with some undersimulation at high flows but an oversimulation at the lowest flows—especially where observed flows are reported negative. Reverse flows in the river can be driven by tailwater from downstream high stage caused by downstream inflows that are not matched by upstream inflows, or by wind coming from the north when the water surface gradient is at or near zero. HSPF is not designed to reproduce such negative flows, having a very simple hydraulic representation. Overall, the calibration is good.

Table 3.I.19: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.85	-3.I.7

Table 3.I.20: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02232400)	Simulated
Average	793.I.1	765.82
Median	429.61	496.24
Variance	856059.74	617137.73
Standard Deviation	925.23	785.58
Skew	1.83	1.96
Kurtosis	3.I.6	5.12
Minimum	-80.79	8.29
Maximum	4886.16	5310.73
Range	4966.95	5302.43

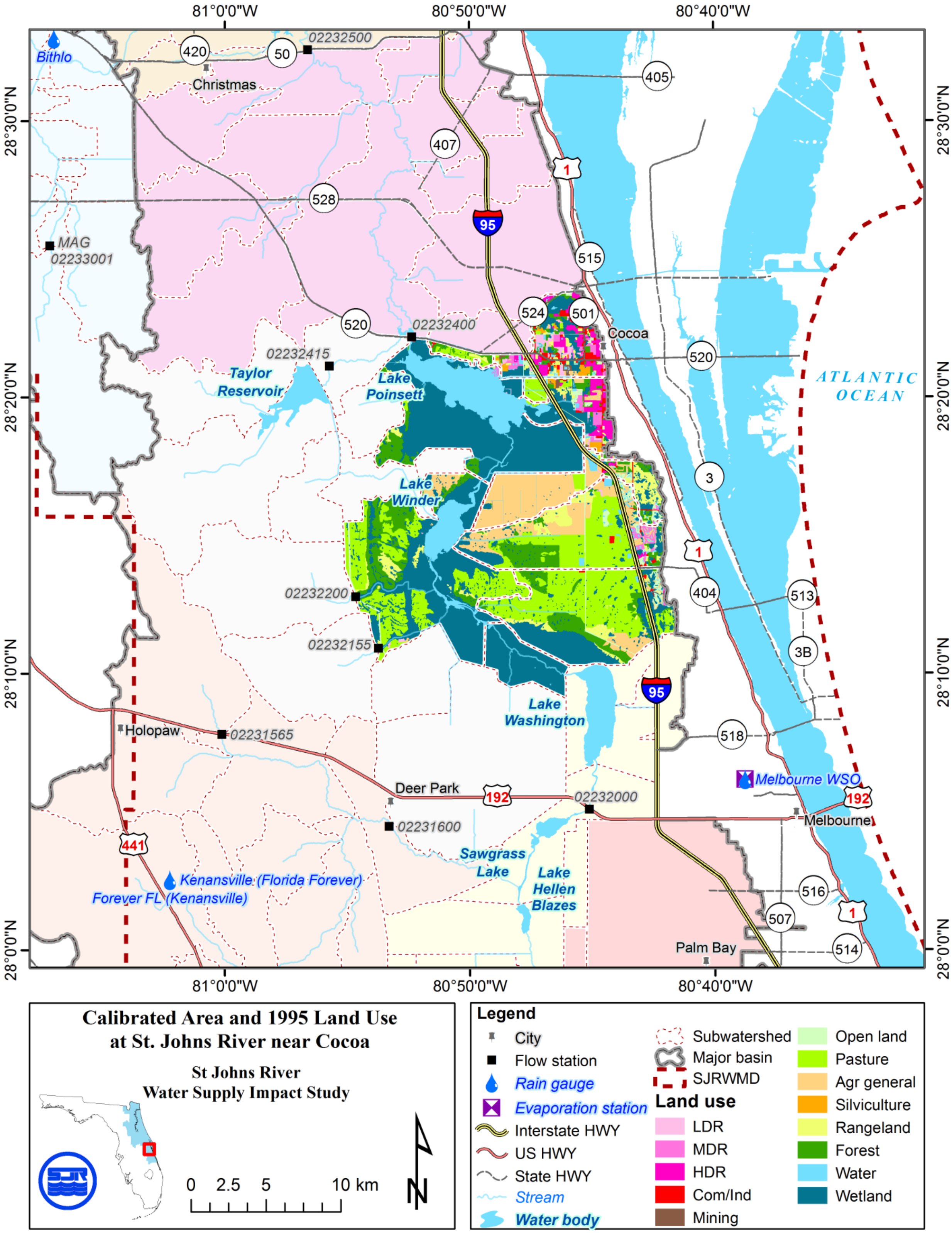

Figure 3I.52: St Johns River near Cocoa land use map

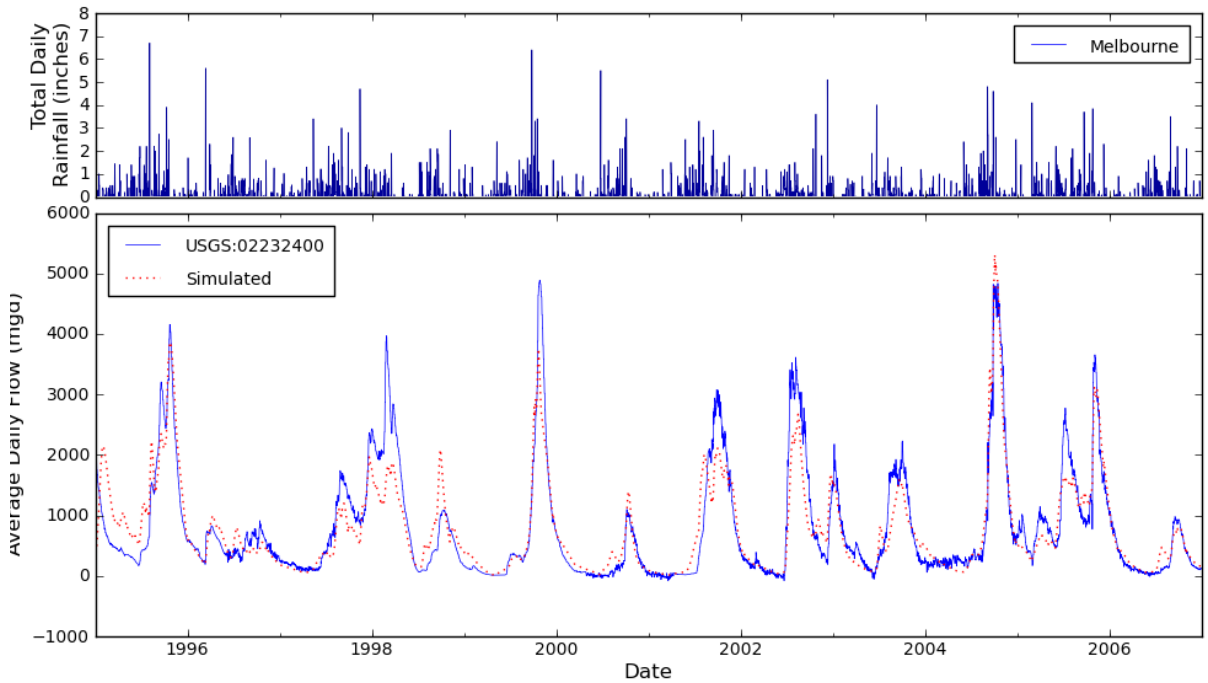

Figure 3I.53: St Johns River near Cocoa daily hydrograph

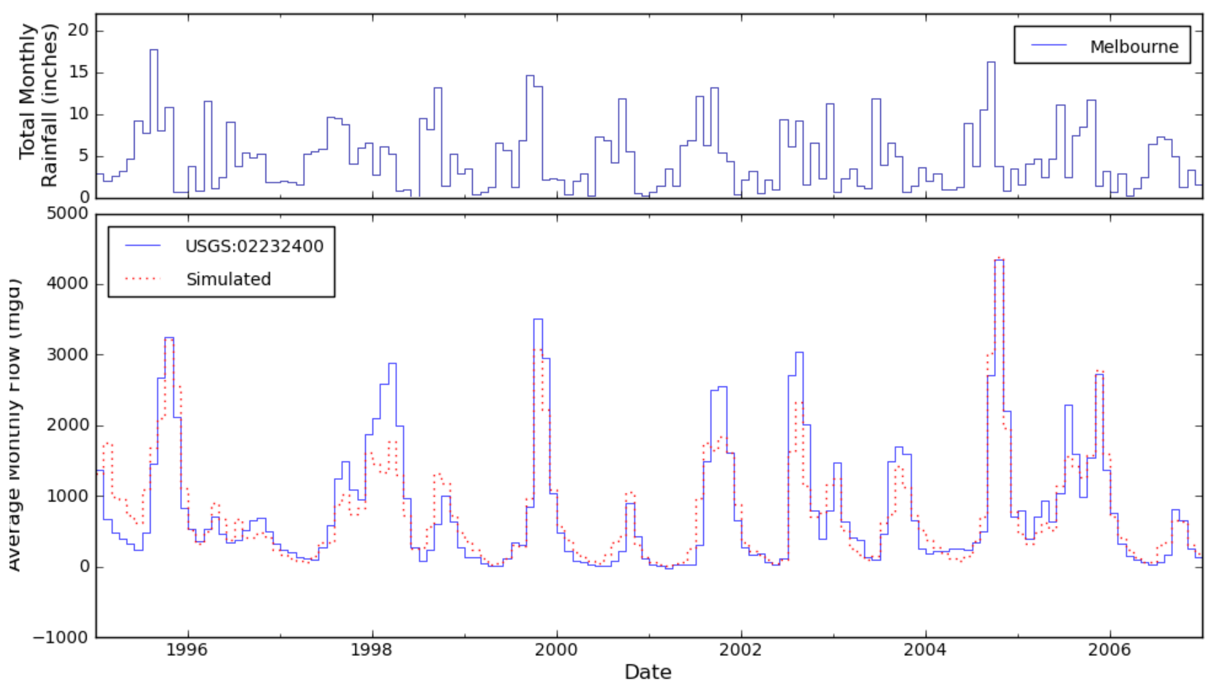

Figure 3. I.54: St Johns River near Cocoa monthly hydrograph

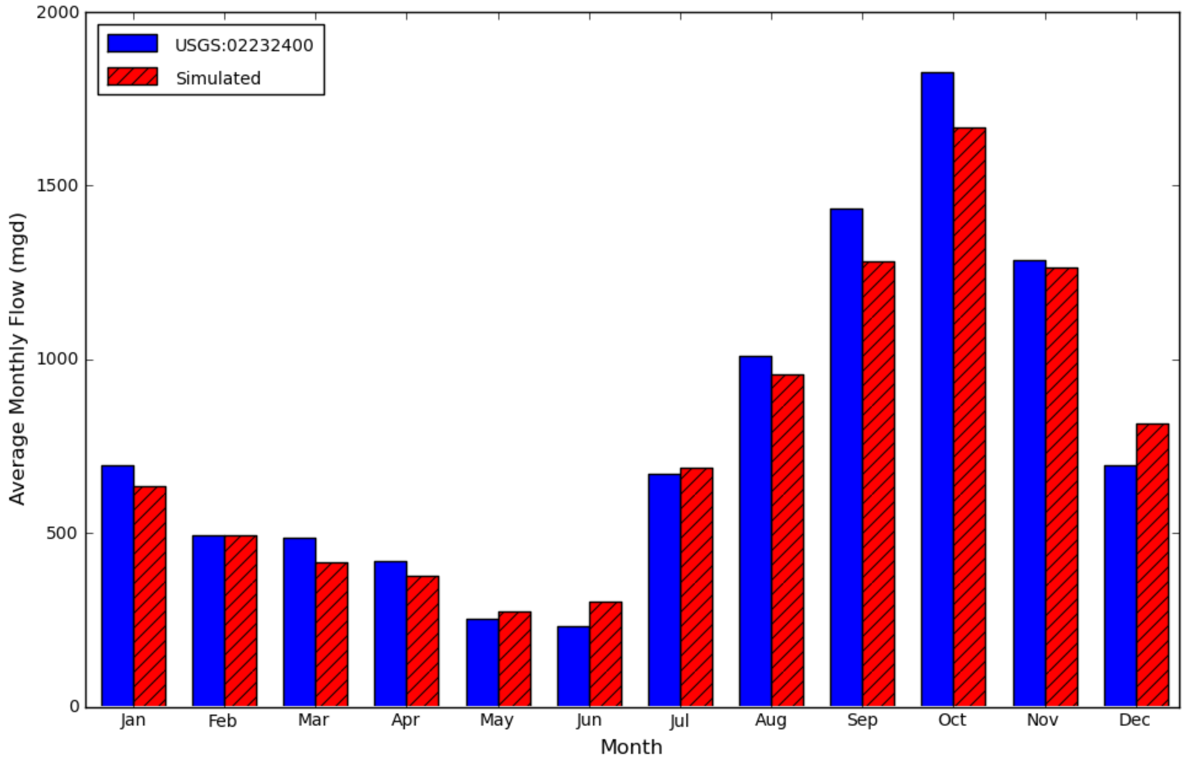

Figure 3. I.55: St Johns River near Cocoa average monthly flow

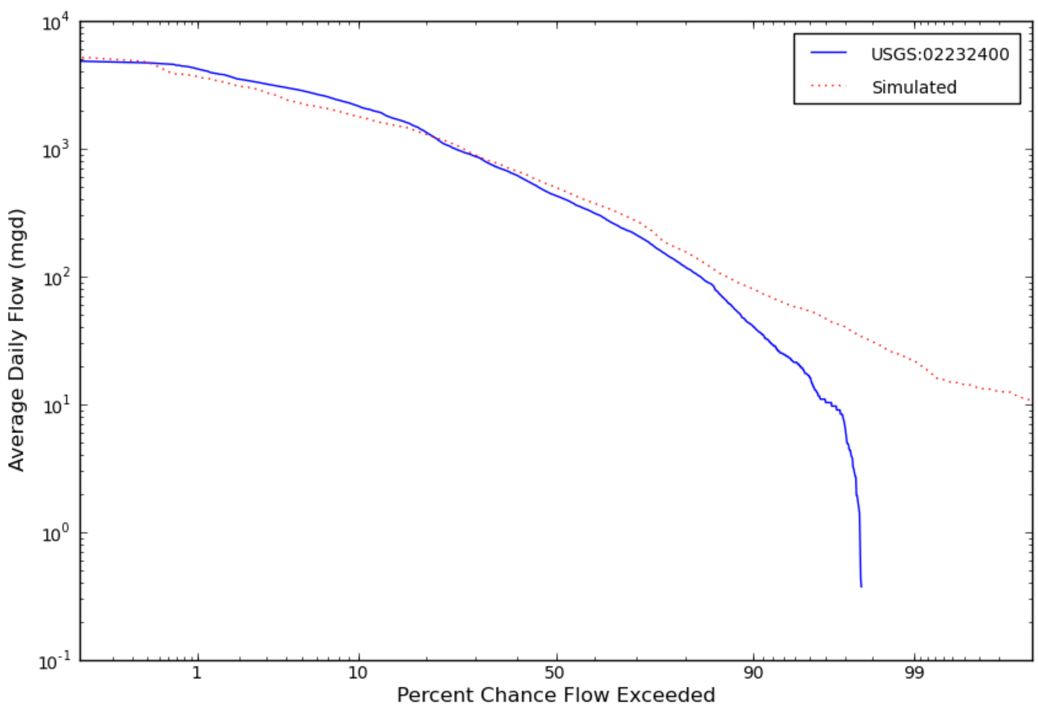

Figure 3I.56: St Johns River near Cocoa exceedance probability curve

6G Lake Poinsett Watershed. Taylor Creek Subwatersheds

The hydrology of Taylor Creek is dominated by Taylor Creek Reservoir, which lies in the northwest corner of Planning Unit 6G. The reservoir is formed by USACE Levee L-73N. Its primary outlet is S-164, a gated spillway set in the levee at the thalweg of the original creek channel. Below the regulated structure lies USGS gauge 02232415. A secondary outlet on upper Cox Creek in subwatershed 15 is rarely used and was not modeled.

The total calibrated area is 47,283 acres, covering subwatersheds 15 to 17 above the structure (41,420 acres), and subwatershed 39 below the structure (5,812 acres). Although a minority of 39 acres lies above the gauge, the incremental area is small relative to the overall area, and it was felt to be important to include the downstream reach to account for the effects of routing and local inflows at the gauge.

The two southerly subwatersheds 15 and 16 were modeled with rainfall from the Kenansville station, while 17 and 39 used the Bithlo station. For potential evaporation data, subwatershed 15 used Melbourne, 16 and 17 used Orlando, and 39 used Titusville. The calibration period was calendar years 1997 to 2006, with the exception of the first 15 days of 1997, which were missing from the record. This is short enough to avoid introducing any seasonal bias that can sometimes result from using incomplete years.

The PEST model was run comparing simulated flows at the outlet of subwatershed 39 against observed discharges, using the project-common logic as a starting point. Adjustments to objective-function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 35.40 was within 6% of the observed value of 33.48, and the Nash–Sutcliffe statistic on monthly flow was 0.29, which shows a poor model fit efficiency. This is felt to be due to difficulty in reproducing human operation of the reservoir. Other simulated statistics in Tables E21 and E22 are in general agreement with observed.

The hydrographs for daily and monthly flow show a fair fit in pattern, though there is some disagreement of when reservoir releases were made. The average monthly flow shows that the model captures the seasonal variability of flows at the gauge well, with oversimulation in August and September but undersimulation in October. The flow-duration plot shows some difficulty in matching observed values on a frequency basis, with oversimulation at low flows and some differences in shape. Overall, the calibration is fair.

Table 3.I.21: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.29	5.74

Table 3.I.22: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02232415)	Simulated
Average	33.I.8	35.40
Median	0.97	0.69
Variance	8352.31	7008.25
Standard Deviation	91.39	83.I.2
Skew	3.I.7	4.04
Kurtosis	17.10	21.08
Minimum	0.00	0.00
Maximum	717.41	817.00
Range	717.41	817.00

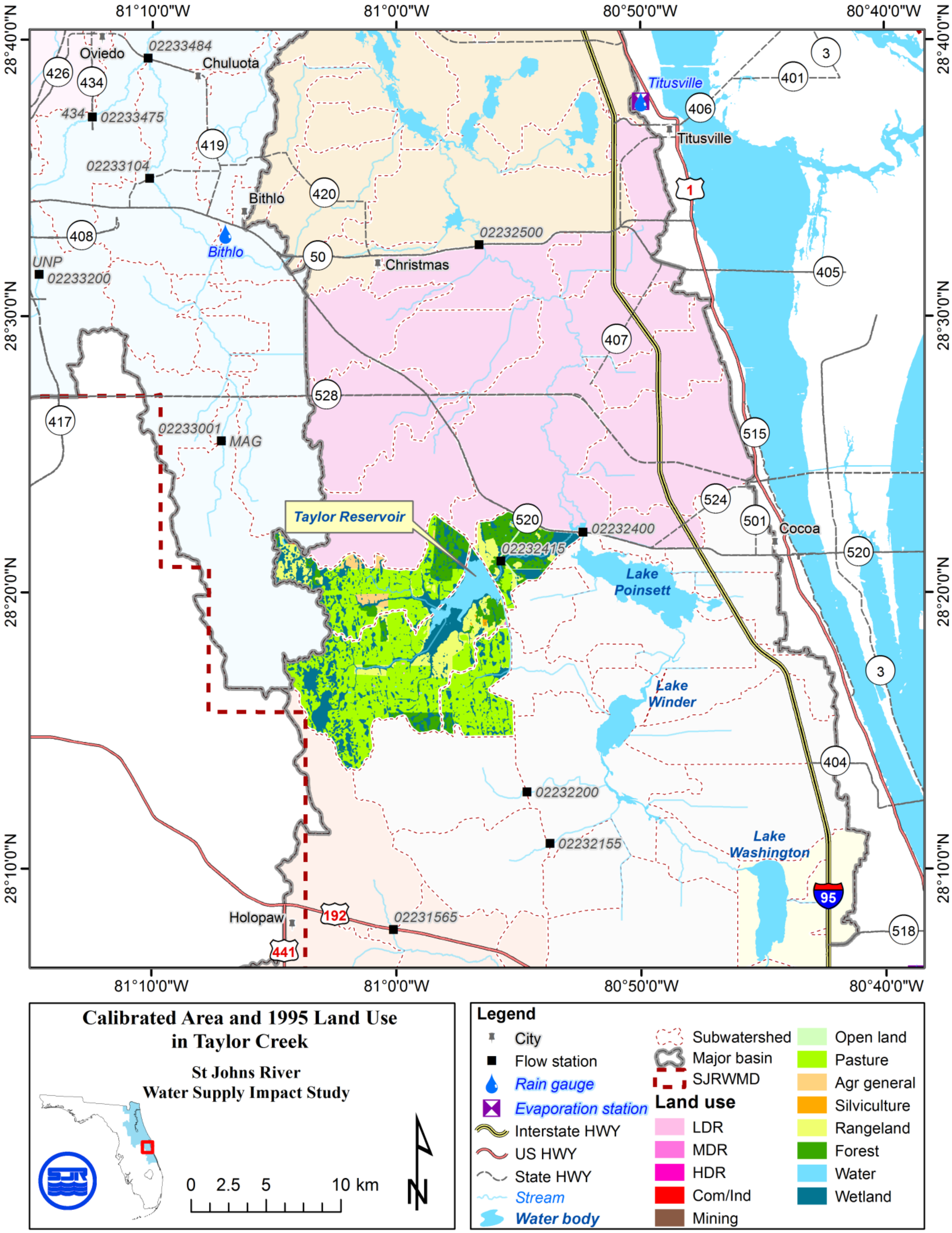

Figure 3. I.57: Taylor Creek land use map

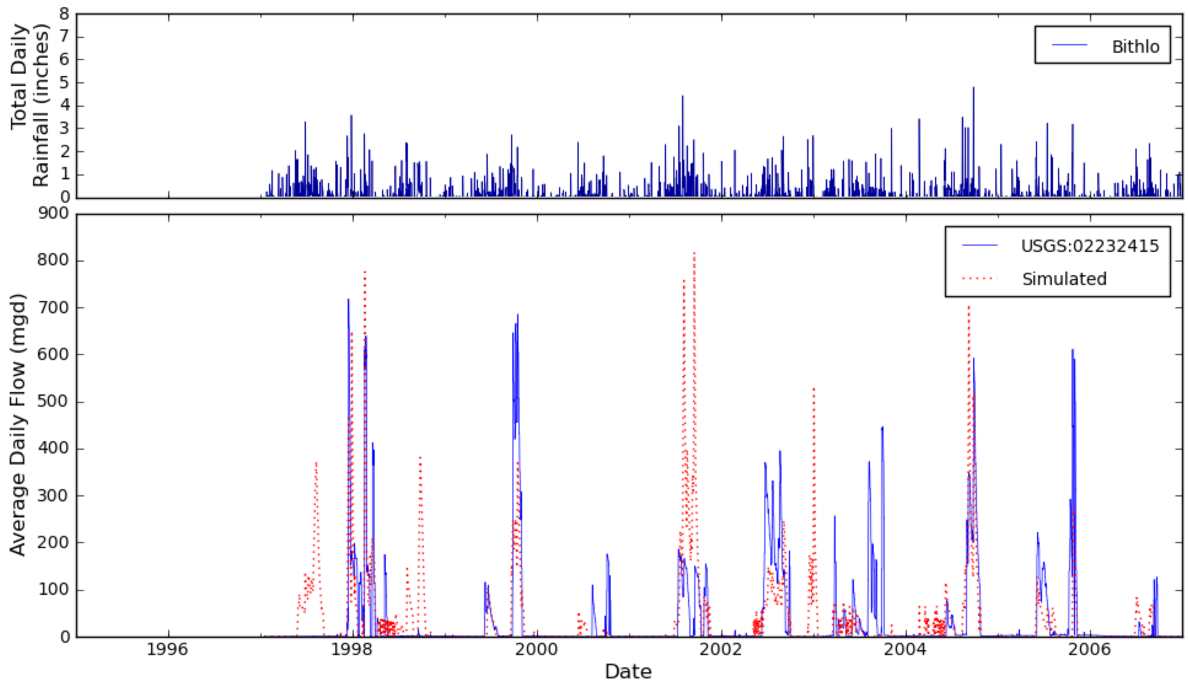

Figure 3I.58: Taylor Creek daily hydrograph

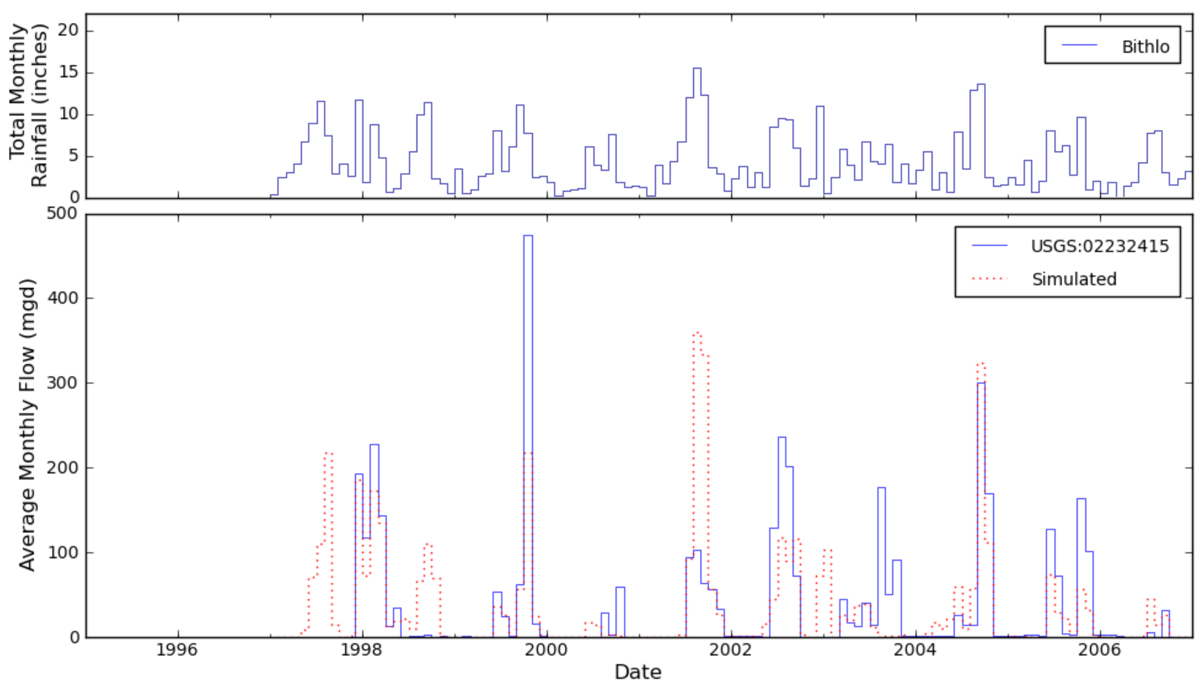

Figure 3. I.59: Taylor Creek monthly hydrograph

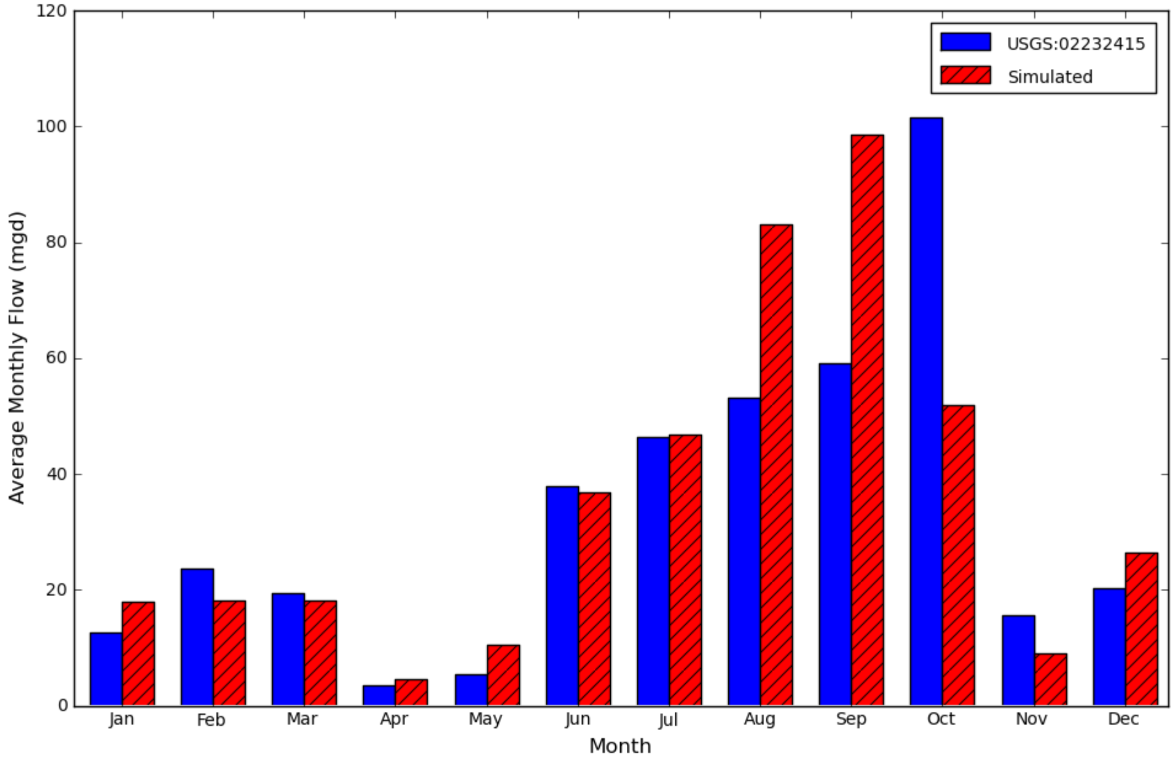

Figure 3. I.60: Taylor Creek average monthly flow

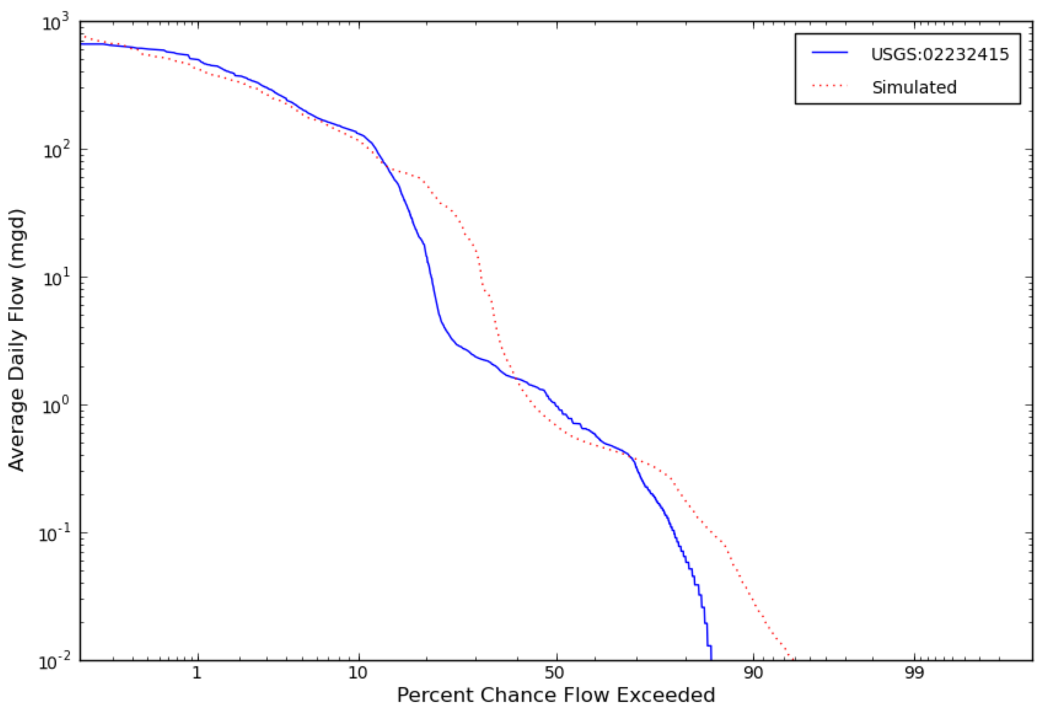

Figure 3. I.61: Taylor Creek exceedance probability curve

6H TOSOHATCHEE

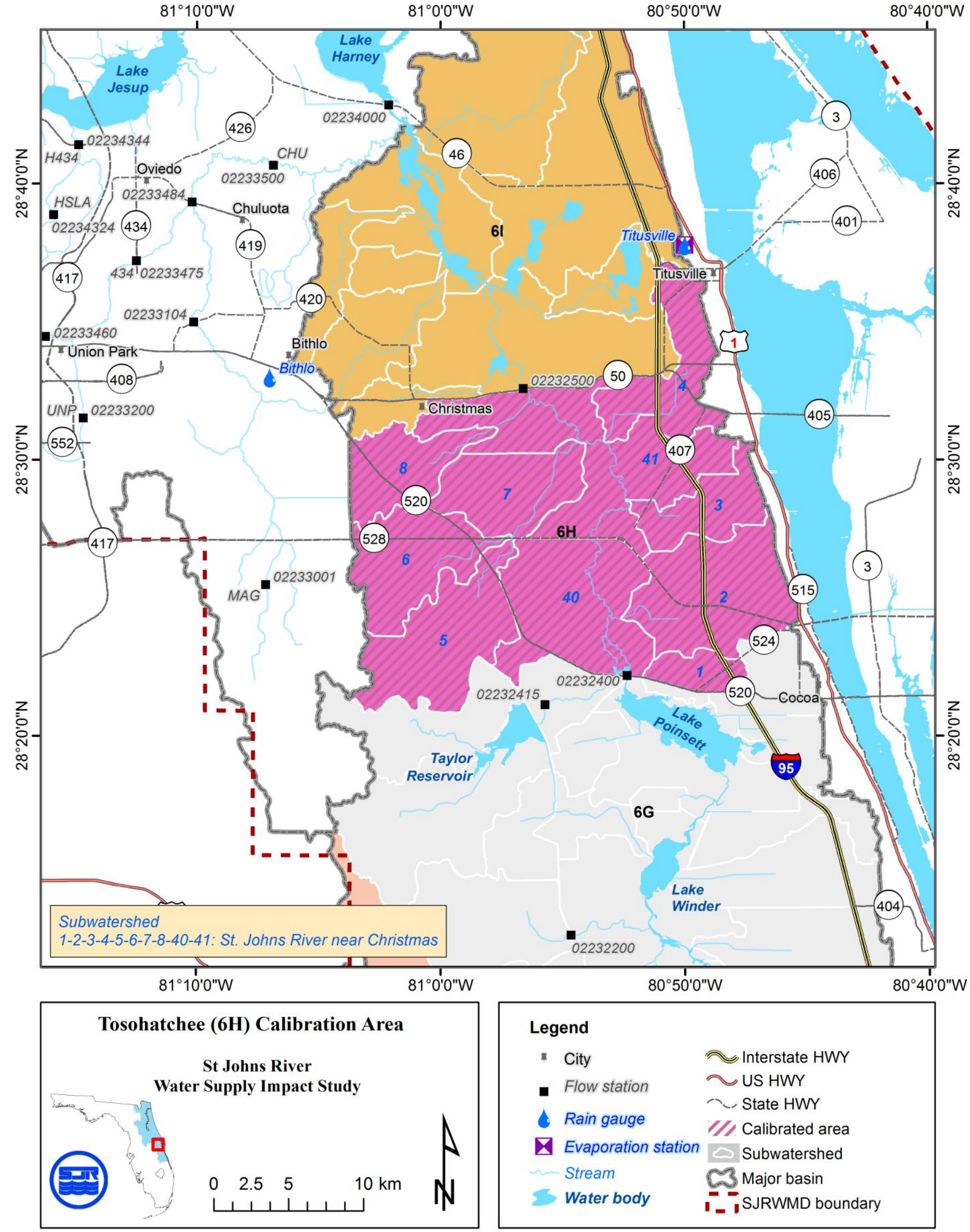

Figure 3I.62: 6H Tosohatchee calibration areas

6H Tosohatchee. St Johns River near Christmas Subwatersheds

The Christmas gauge–USGS 02232500–is the most-downstream flow gauge within the upper basin. It lies on the SR 50 bridge crossing. The model area calibrated to this gauge consists of the entirety of Planning Unit 6I. The main stem in this stretch of the river is a natural, frequently braided channel with no lakes. Upstream tributary flows come in from the main stem at Cocoa (Lake Poinsett) and from Taylor Creek at its confluence just below Cocoa.

The modeled area for the segment of the watershed is 134,215 acres, covering subwatersheds 1 to 8 plus 40 and 41. The parameters were extended to the entire downstream Planning Unit 6I, which covers an additional 142,493 acres. The total modeled contributing area at the gauge is 963,710 acres.

The model applies rainfall data from the Titusville station to subwatersheds 1 to 4 on the east side plus the main stem subwatersheds 40 and 41, while the Bithlo station is applied to the western subwatersheds 5 to 8. Titusville potential evaporation data is used for the entire area. Input of diffuse groundwater inflows from the Upper Floridan aquifer is represented as a point source to each of the main stem reaches (40 and 41), taken from a time series of flows estimated using chloride data.

The PEST model was run comparing simulated flows at the outlet of subwatershed 41 against observed discharges, using the project-common logic as a starting point. Adjustments to objective-function weights and parameter bounds were made until statistical and graphical comparisons were satisfactory.

The resulting overall simulated mean flow of 922.95 was within 0.5% of the observed value of 919.09, and the Nash–Sutcliffe statistic on monthly flow was 0.88, which shows a very good model fit efficiency. Other simulated statistics in Tables E23 and E24 are in agreement with observed.

The hydrographs for daily and monthly flow show a good fit in pattern. The average monthly flow shows that the model captures the seasonal variability of flows at the gauge very well. The flow-duration plot shows a good match of model performance on a frequency basis through most of the domain but with an oversimulation at the lowest flows, especially where observed flows are reported negative. Reverse flows in the river can be driven by tailwater from downstream high stage caused by downstream inflows that are not matched by upstream inflows, or by wind coming from the north when the water surface gradient is at or near zero. HSPF is not designed to reproduce such negative flows, having a very simple hydraulic representation. Overall, the calibration is good.

Table 3.I.23: Calibration Model Performance

Nash-Sutcliffe (Monthly Mean Flow)	Percent Error of the Mean
0.88	0.42

Table 3.I.24: Descriptive Calibration Statistics

Statistic (Daily Flow (mgd))	Observed (USGS:02232500)	Simulated
Average	919.09	922.95
Median	543.I.2	616.45
Variance	985091.21	831767.21
Standard Deviation	992.52	912.01
Skew	1.47	1.80
Kurtosis	1.59	3.I.3
Minimum	-88.55	26.28
Maximum	4881.11	5647.19
Range	4969.65	5620.91

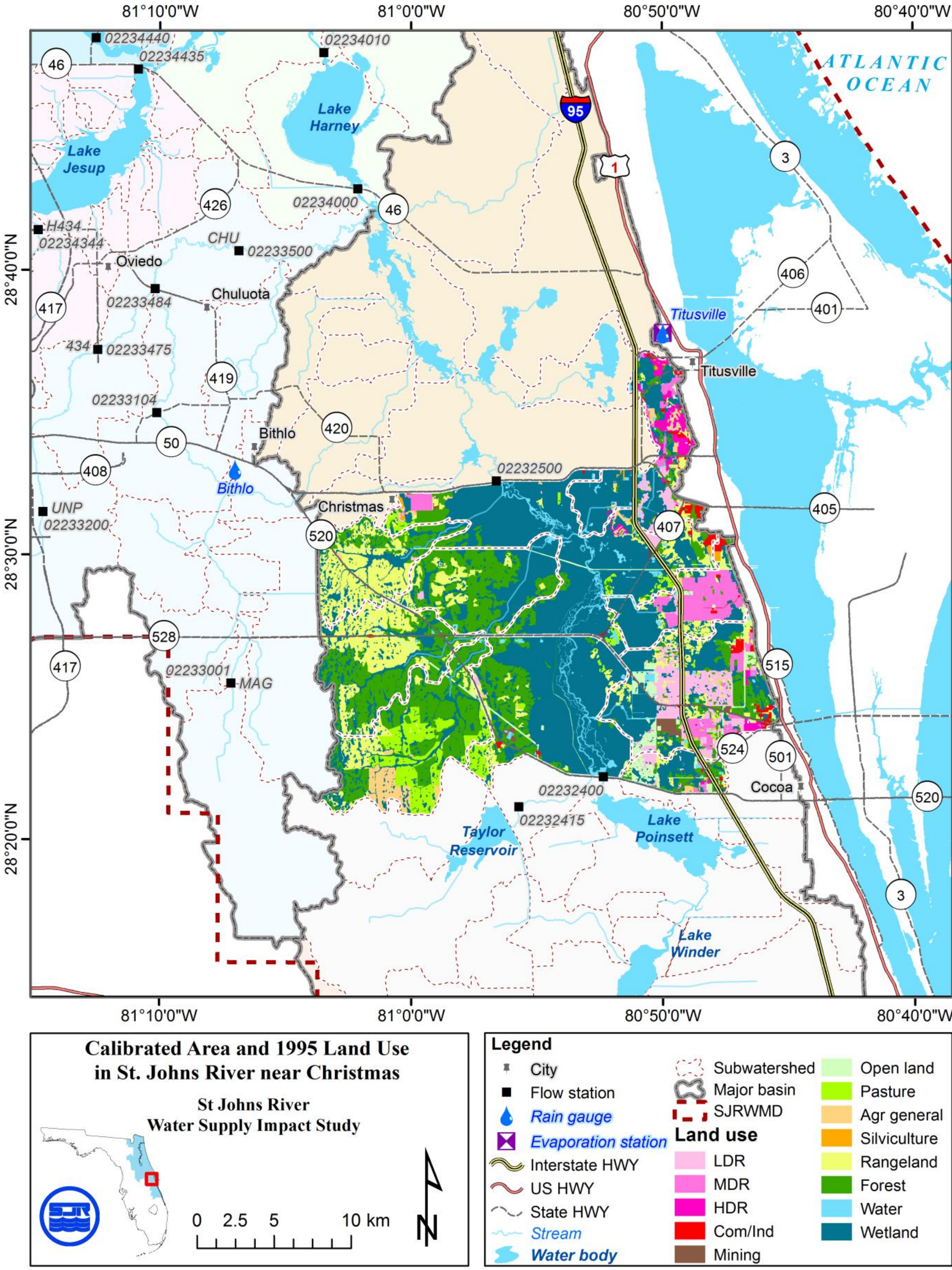

Figure 3. I.63: St Johns River near Christmas land use map

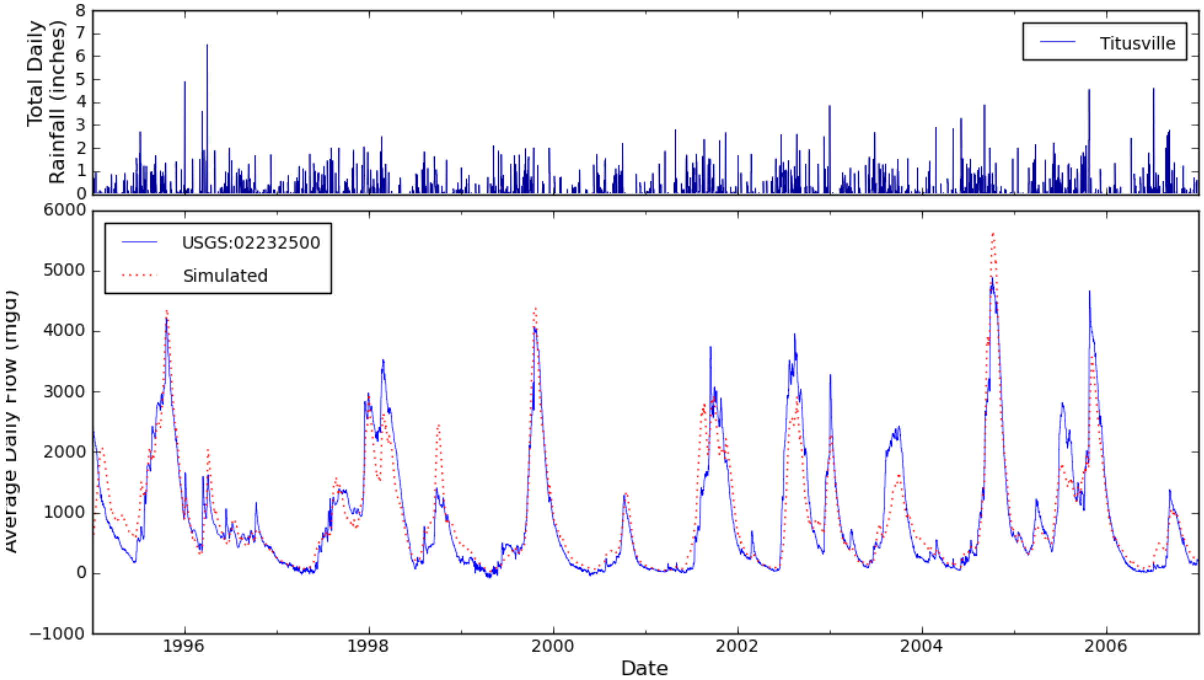

Figure 3. I.64: St Johns River near Christmas daily hydrograph

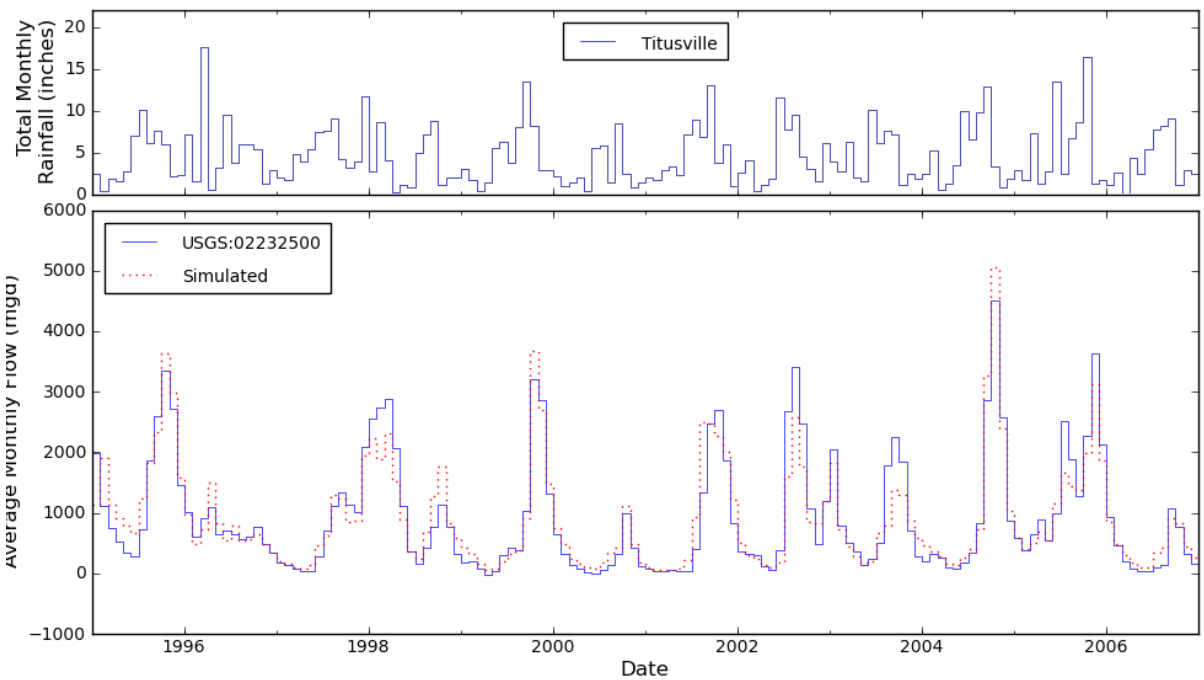

Figure 3. I.65: St Johns River near Christmas monthly hydrograph

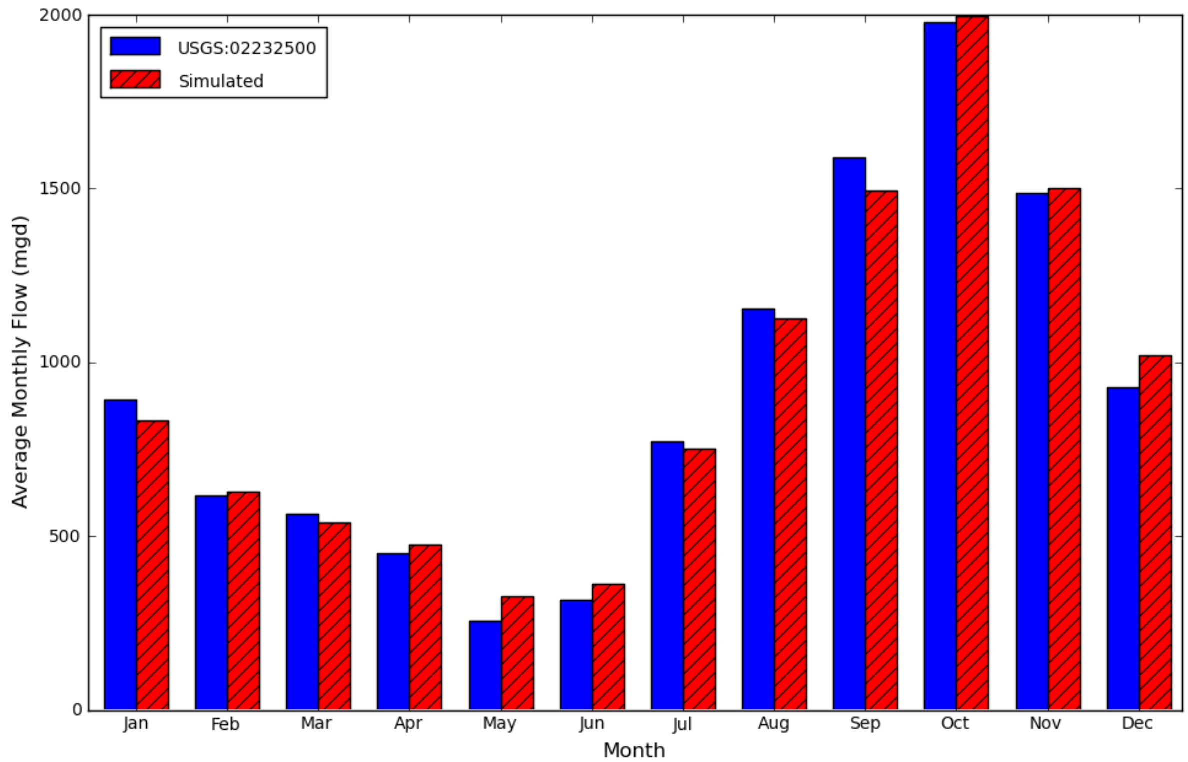

Figure 3I.66: St Johns River near Christmas average monthly flow

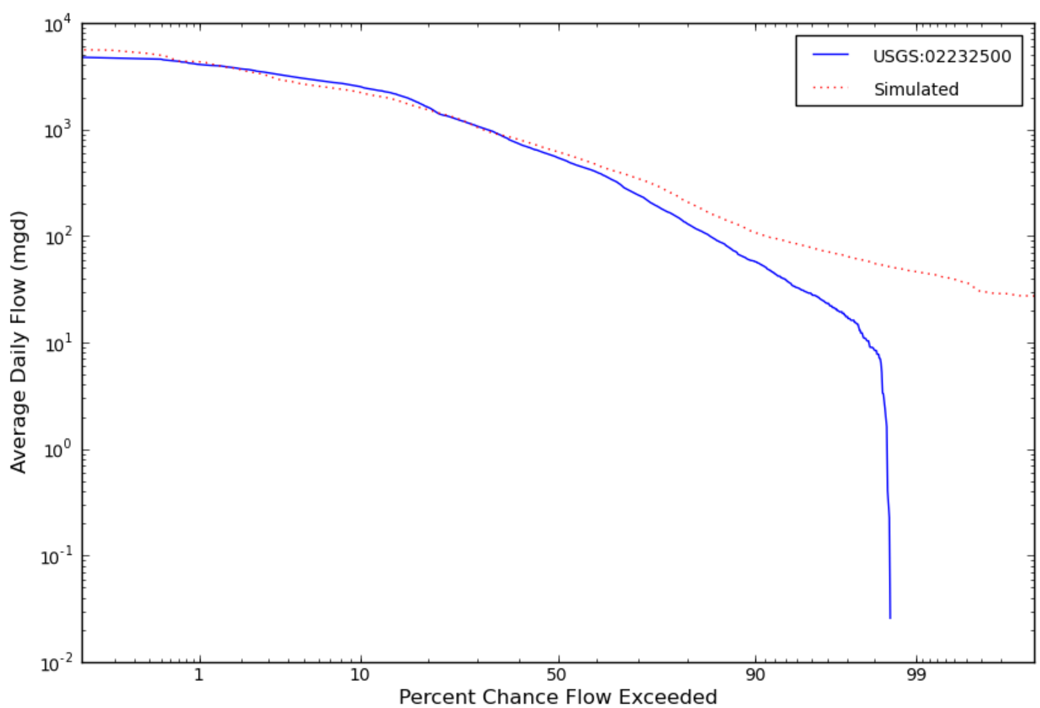

Figure 3. I.67: St Johns River near Christmas exceedance probability curve