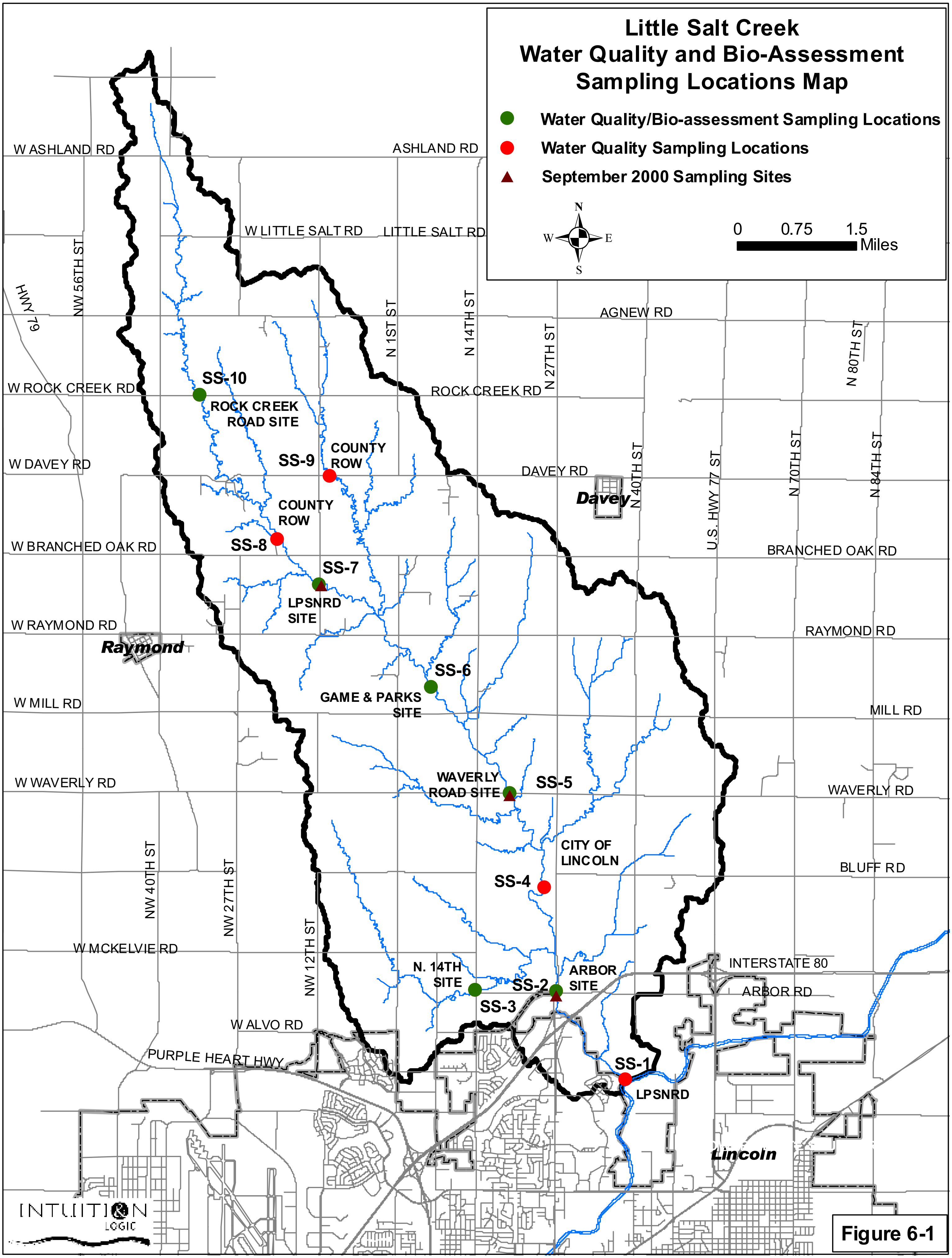
Section 6
Water Quality and Bio-Assessment

6.1 Water Quality

Water quality was assessed using three overview parameters, biological oxygen demand (BOD), total suspended solids (TSS) and total dissolved solids (TDS). The detailed report including laboratory analysis is presented in Appendix O. The stream was sampled twice, on November 19, 2008 and January 22, 2009. Both sample sets were taken during dry weather periods. The ten sample sites are depicted in Figure 6-1**.** The sample sites were adjusted to coincide with stream macroinvertebrate measurements in 2000. The locations of those earlier tests are also shown in Figure 6-1. However, because the sampling protocols differed widely, the results were not directly comparable.

The purpose of TDS testing in water quality is to gain a general understanding of how much material is dissolved in the water. Briefly, the test used to determine the concentration of total dissolved solids consists of filtering the sample to remove suspended particles then placing a portion of the sample in an oven until all of the water has evaporated. The solid material remaining in the crucible is that which was previously dissolved in the liquid sample. This test is not intended to distinguish between one dissolved material and another.



Little Salt Creek Water Quality and Bio-Assessment Sampling Locations Map

- 🟢 Water Quality/Bio-assessment Sampling Locations
- 🔴 Water Quality Sampling Locations
- ▲ September 2000 Sampling Sites

Figure 6-1

The results of these tests are depicted in Figure 6-2 below. The two series of water quality tests were consistent and demonstrated that the reaches below Raymond Road have markedly higher total dissolved solids than the upper reaches. These concentrations, over 4000 mg/L in the lower reaches of the basin, approach levels that may be toxic to livestock. While at first blush this is disturbing, high TDS levels in isolation do not necessarily imply a water quality problem. *Naturally* saline water bodies may not be suited for watering livestock but that does not mean that the salinity is a pollutant. These data should be evaluated in a broader context and supported by more extensive testing.

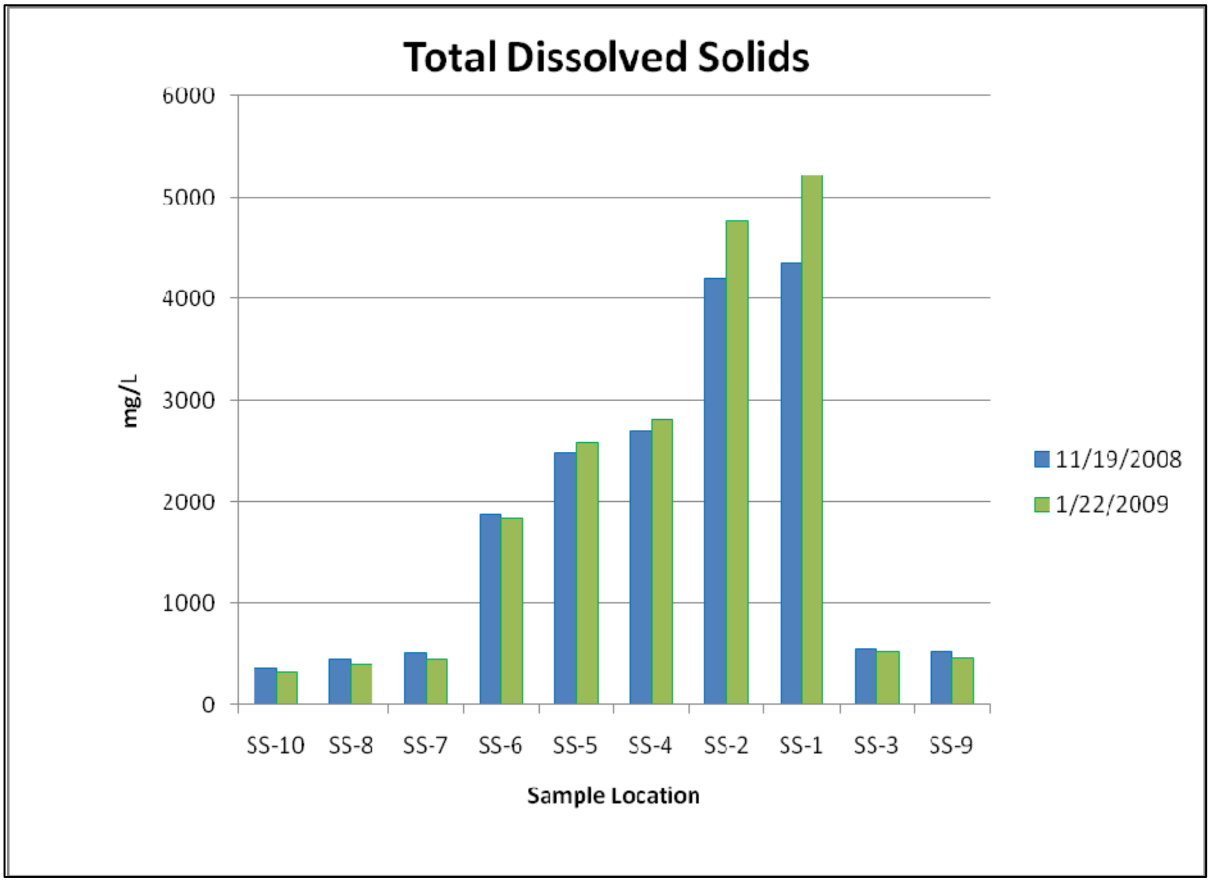


Figure 6-2: Total Dissolved Solids Results

There are several potential causes of the high level of TDS including the stream's salinity, leachate from the soil, animal waste or agrichemicals such as fertilizer or pesticides. Given that the testing was conducted in winter when the fields were not being worked and that TDS increases lower in the watershed, it is likely that much if not most of the TDS is associated with salt. This is generally consistent with the findings of Greene, et al (2008) [1]in which the authors measured the seasonal salinity of Little Salt Creek. These authors also noted that salinity was highest during periods of base flow, a condition that generally corresponds to the testing here.

Biological oxygen demand is a measure of the oxygen consumed by bacteria as they consume the organic material in the water. Sources of organic material in the water include decomposing plants, leaf or crop litter, animal waste, sewage and fertilizers. High levels of BOD indicate that the oxygen in the water is taken up by bacteria and is less available to other life forms. Low levels of BOD indicate higher water quality. BOD levels in Little Salt Creek were consistently at or below the detection limit of 3 mg/L. These results indicate that these samples did not have high levels of organic pollutants.

Total suspended solids tests measure the concentration of solids entrained in the water column. The test is conducted by passing a known quantity of sample water through a filter of standardized pore size. The filter is then dried to remove the water. The difference in the weight of the filter before and after the sample was pored through it is the weight of the suspended solids. Suspended solids are both organic and inorganic. Typical sources for TSS in streams include silt from bed, banks and overland runoff, animal waste, algae, plankton and agricultural or industrial waste. High concentrations of TSS clog fish gills and interfere with growth and reproduction of stream organisms. High TSS levels also absorb light and contribute to excessive warming of stream water. The results of these tests are presented in Figure 6-3. The TSS tests produced far more variable results than the TDS evaluations. Generally the samples taken in November had higher TSS levels particularly in the mid-basin reaches. Given the erodible soils in the watershed, even small variations in flow rates on the sample days may account for these differences. However, in all cases, the levels were relatively low.

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[1] Greene, D.L. Harvey, F. E., Gilbert, J. M., Coke, G. R., and Winter,
J. R., Seasonal Variations In Stream Salinity In Eastern Nebraska's Salt Creek Watershed – Implications for the Survival of the Endangered Salt Creek Tiger Beetle**.** 2008 Joint Meeting of The Geological Society of America, Soil Science Society of America, American Society of Agronomy, Crop Science Society of America, Gulf Coast Association of Geological Societies with the Gulf Coast Section of SEPM

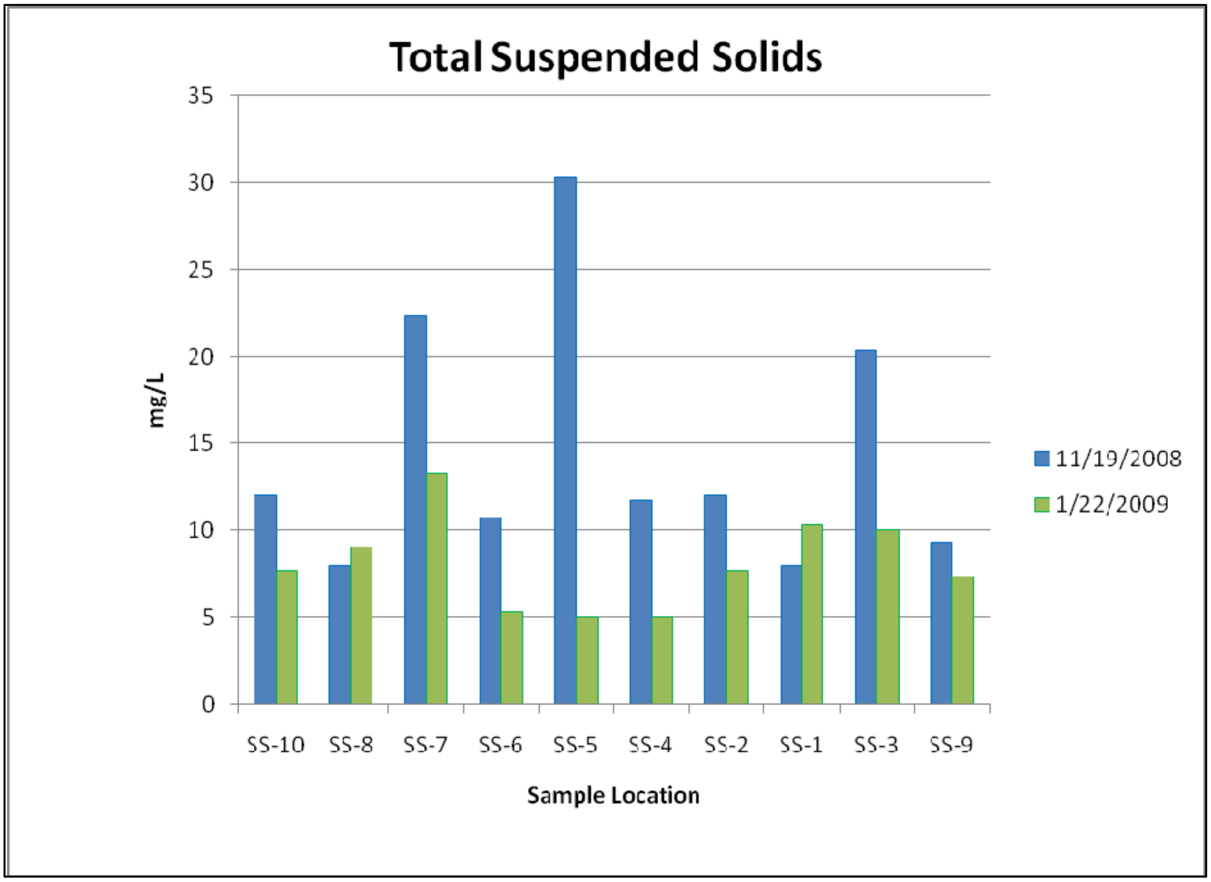

Figure 6-3: Total Suspended Solids Results

6.1.1 Water Quality Discussion

Streams dominated by saline wetlands will necessarily have different water quality profiles than their freshwater counterparts. For example high TDS levels that would be a cause for grave concern in a fresh water stream may simply reflect the rare but normal conditions of the surrounding saline wetlands.

These tests were conducted in the midst of winter, a period when dissolved oxygen would be at its highest (cold water dissolves more oxygen than warm water) and when agricultural activities are at a minimum. The samples were taken at the same time of year under similar flow conditions and when land disturbance due to farming or other activities is dormant. Achieving a more balanced and accurate understanding of the water quality requires repeated sampling during the full range of flow conditions, agricultural activity and seasons.

6.2 Stream Bio-Assessment

Unlike the water quality tests described above, measures of living organisms such as macro invertebrates and algae give an indication of water quality over a period of time. For example, peak summer water temperatures may still influence populations in late fall. Similarly, a pollutant spill or erosion event may still leave its mark on stream organisms long after TDS or TSS levels have returned to baseline.

The stream bio-assessment conducted here conformed to the USEPA Rapid Bio-Assessment for Use in Streams and Rivers: Benthic Macro invertebrates and Fish. The species sampled included macro invertebrates and periphyton but not fish. The index and scoring criteria developed by the Nebraska Department of Environmental Quality (NDEQ) for invertebrates were used in the evaluation and classification of biological integrity. NDEQ has not established analogous criteria for the classification of periphyton assemblages. The sampling locations are depicted in Figure 6-1. Water quality samples were also taken at each bio-assessment site. The sites were selected in part to allow comparison with testing conducted previously. The complete report including details of sample processing and quality control procedures is included in Appendix O**.**

Briefly, the evaluation uses the number of individual organisms and the species richness as well as the attributes of each type of organism to make reasonable inferences about the habitat and likely water quality supporting these populations. The Nebraska Invertebrate Community Index (ICI) uses a range of factors including species richness and percentage of pollution sensitive organisms to assign a score on a test stream relative to the same evaluation on reference streams in this ecoregion. An ICI score of 25 or higher is classified as excellent while a score of less than 16 is classified as poor. It is important to note that this index, while from the same ecoregion, was not prepared for saline streams. However, attributes of stream organisms that are not related to salt-tolerance should be comparable throughout the region. These other attributes may not be reflected in the index. The ICI index is directly applicable to the non-saline reaches of the stream.

6.2.1 Stream Bio-Assessment Results

All of the sample sites had ICI scores in the poor range and ranged from 12 at the Rock Creek Road site to 4 at the Arbor and N. 14th sites. The ICI score of each site is presented in Table 6.1.

Table 6.1 Nebraska ICI Rating by Sample Site

Nebraska ICI rating	
Sample site	**ICI Rating**
Rock Creek Road	12
LPSNRD	6
Game & Parks	6
Waverly Road	8
Arbor	4
N. 14th	4

The salinity of some reaches of the stream most likely has a major influence on the low species richness and low population of pollution intolerant organisms. However, the Rock Creek Road, LPSNRD and N. 14th sites scored poorly where TDS (presumably correlating to saline conditions) concentrations were not excessive. Moreover, Figure 6-4, the Rock Creek Road site facing upstream suggests that the natural salt in the stream may not be the only factor depressing stream organism populations. The detailed report indicates nutrients such as from fertilizers or livestock waste, pesticides and other factors such as poor habitat diversity may also play a role. All of the sites had high percentages of salt-tolerant algae and diatoms ranging from 30% at the upstream-most site (Rock Creek Road) to 68% at the Waverly Road site. At no sample site did the concentration of species that are strictly intolerant to salt exceed 2%. Generally the relative abundance of salt-tolerant organisms (both macroinvertebrates and algae) increased from upstream to downstream on the main stem; however, salt-tolerant organisms are abundant even high in the watershed at the Rock Creek Road site.

Figure 6-4: Rock Creek Road sample site facing upstream

6.2.1.1 Rock Creek Road Site

This site had higher macro invertebrate diversity than the others and included some pollution sensitive organisms. The site includes a rocky substrate that has not silted in and is supportive of these animals. However, the site also includes a high percentage (26%) of hemoglobin bearing species. This is indicative of hypoxic substrates. The cause of oxygen depletion in the sediment is not clear and may be due to the persistent influence of summertime high temperatures or nutrient enrichment. The possibility of high nutrient loading at the site is further suggested by the high concentrations of eutraphentic diatoms. Seventy-six percent of the diatoms sampled here require eutrophic, or nutrient enriched conditions.

6.2.1.2 LPSNRD Site

This site, located between W. Branched Oak and Raymond Roads was dominated by hemoglobin-bearing taxa indicating hypoxic conditions in the channel substrate. The flora at the site also suggests low oxygen, nutrient enriched condition; 69% of the periphyton assemblage was eutraphentic. Both macro invertebrate and diatom populations had high concentrations of salt tolerant members indicating a saline environment.

6.2.1.3 Game and Parks Site

The species diversity of macro invertebrates was lower at this site than in the upstream reaches and the fauna that was present was particularly pollution-tolerant. The low species diversity often indicates that the stream bed is not heterogeneous enough to support a broad range of organisms. This is a characteristic of silted-in streams. The diatoms however, had a higher species richness relative to the upstream reaches. Of the diatoms, 49% were salt-tolerant and additionally 61% favored a nutrient-rich environment.

6.2.1.4 Waverly Road Site

This site appears to include some stony substrates that have not silted in based on the presence of caddis fly. However, the abundance of hemoglobin-bearing taxa indicates that where sediments were present, they were oxygen depleted. This site had the highest concentration (68%) of salt-tolerant diatom taxa of any sampled. Taxa that favor nutrient-enriched substrates were also dominant. Filamentous algae were sampled here further suggesting that nutrient enrichment may impair water quality.

6.2.1.5 Arbor Site

This site was overwhelmingly dominated by midges associated with filamentous algae and hypoxic substrates. High levels of filamentous algae suggest severe nutrient enrichment. Here there was also a near-complete absence of the most prominent pollution-intolerant taxa. Sixty-nine percent of the diatom taxa favored nutrient-enriched habitats. This site is depicted in Figure 6-5.

Figure 6-5: Arbor sample site facing upstream

6.2.1.6 N. 14th Site

Located on a tributary, this site had a lower concentration of salt-tolerant macro invertebrates than the other sites. The site was dominated by pollution tolerant organisms associated with stagnant water. Salt-tolerant diatoms comprised 51% of the taxa sampled while eutraphentic taxa were 81% of the sampled diatoms.

6.3 Water Quality and Bio-assessment Summary

The water quality in Little Salt Creek is poor. The bio-assessment revealed that organisms associated with high nutrient loads and oxygen depletion occur throughout the basin. The chemical water quality tests did not indicate a problem but were not performed at a time of year when such problems are likely to be detected.

Assuming that concentration of Total Dissolved Solids is a rough proxy for natural salinity, then the chemical water quality tests do not indicate serious water quality problems. The high levels of TDS in reaches of the stream bounded by salt seeps are to be expected while the 5-day BOD and Total Suspended Solids concentrations are unexceptional. However, the tests were conducted only in winter at approximately base flow with no recent run-off inducing events. At this time of year there is very little land disturbance or other agricultural activity.

Moreover, the tests did not include analysis of the nutrients nitrogen and phosphorous or of fecal coliform. All of these tests are important for determining the degree of nutrient enrichment and the likely causes. In designing future protocols it would also be helpful to map the areas most heavily grazed by livestock and the times of year the animals are present. Other water quality data from UNL or other sources will likely include these parameters.

The results of the stream bio-assessment tell a different story because measures of living organisms necessarily provide a longer-term perspective on stream health. The natural saline wetlands profoundly influence the flora and fauna of this stream. Even if there were no anthropogenic influences in the watershed, the saltier reaches would most likely be different from and less diverse than those used in the ICI reference set. Ideally, there would be a reference stream bounded by salt seeps in pristine condition for comparison. The absence of such a perfect reference complicates the interpretation of the bio-assessment but does not eliminate its usefulness. Even allowing for an influence of the natural saline conditions, there are strong indicators of water quality problems in the stream. These merit a more detailed examination. Species that are indicators of nutrient enrichment and hypoxia possibly associated with high water temperatures are consistent throughout the basin and occur in both the saline and non-saline reaches. This suggests that factors beyond saline wetlands are influencing water quality and habitat. Poor water quality is indicated by high nutrient levels and oxygen depletion regardless of other natural factors. It is necessary to test directly for nitrogen, phosphorus, fecal coliform and dissolved oxygen to gain a more quantitative understanding of the extent of water quality degradation in this stream.

6.4 Water Quality Future Land Use Hydrology

Urbanization of watersheds can lead to significant impacts due to increased flooding and to water quality issues from increased heavy metals and oil loadings from the addition of parking lots, driveways, and road surfaces as well as potential increased nutrient loadings from residential lawns. While the majority of the Little Salt Creek watershed is in an agricultural land use today, there are approximately 1,200 acres within Lincoln's Future Service Limit where urban services and inclusion in the City limits are anticipated by 2030. Approximately 675 acres are within the Priority A area designated to be served with utilities in the next six years. In addition, there are some unique and special water resource considerations in this watershed, including the Eastern Nebraska Saline Wetlands, which are notably rare and form the habitat for the endangered Salt Creek Tiger Beetle (federally-listed), and the Saltwort plant (state-listed). Thus, it is still important to address the potential water quality impacts of future urbanization.

6.4.1 Hydrologic Modeling of Future Land Use

To assess the potential impacts to future land use changes, the hydrologic model was modified to reflect future conditions. The description of the hydrologic model modification is presented in Section 3.7, above. Within Section 3.7.3, guidelines are provided to adjust the hydrologic model initial storage based on type of land use changes within the subbasins. Within Section 3.7.4, multiplication factors are provided to adjust the lag times of subbasins having changed future land uses. These guidelines were applied to the Tier 1 and Tier 2 projected changes. The hydrologic model was then executed for both future conditions scenarios (Tier 1 only, then Tier 1 and Tier 2 changes) for low flow conditions.

The purpose of the low flow conditions was to assess volume of increased runoff containing the first flush from parking lots and such. To assess low flows, the rainfall producing a half-inch basin-wide runoff volume under existing conditions was analyzed.

6.4.2 Low Flow Analysis

Since low flows peak discharges and volumes may be more influenced by watershed base flows, the first step in assessing low flows was to obtain an estimate for the average annual base flow for Little Salt Creek. Average daily flows for the period of record were obtained from the USGS stream gauge located at 27th and Arbor Street. These flows were then arranged from highest to lowest on a Weibull Chart. It was found that 95% of the flows were at or less than 32 cfs. Therefore a chart was developed showing the flow rankings for flows less than 100 cfs (see Figure 6-6). For the low flow analysis the flow which is approximately exceeded 50% of the time was adopted. This flow is 5.4 cfs. This flow was assumed to be distributed throughout the conveyance system based on a ratio to the contributing drainage area. At the gauge site the drainage area is 43.6 square miles. Therefore, the base flow was assumed to have a rate of 0.124 cfs/square mile of drainage area.

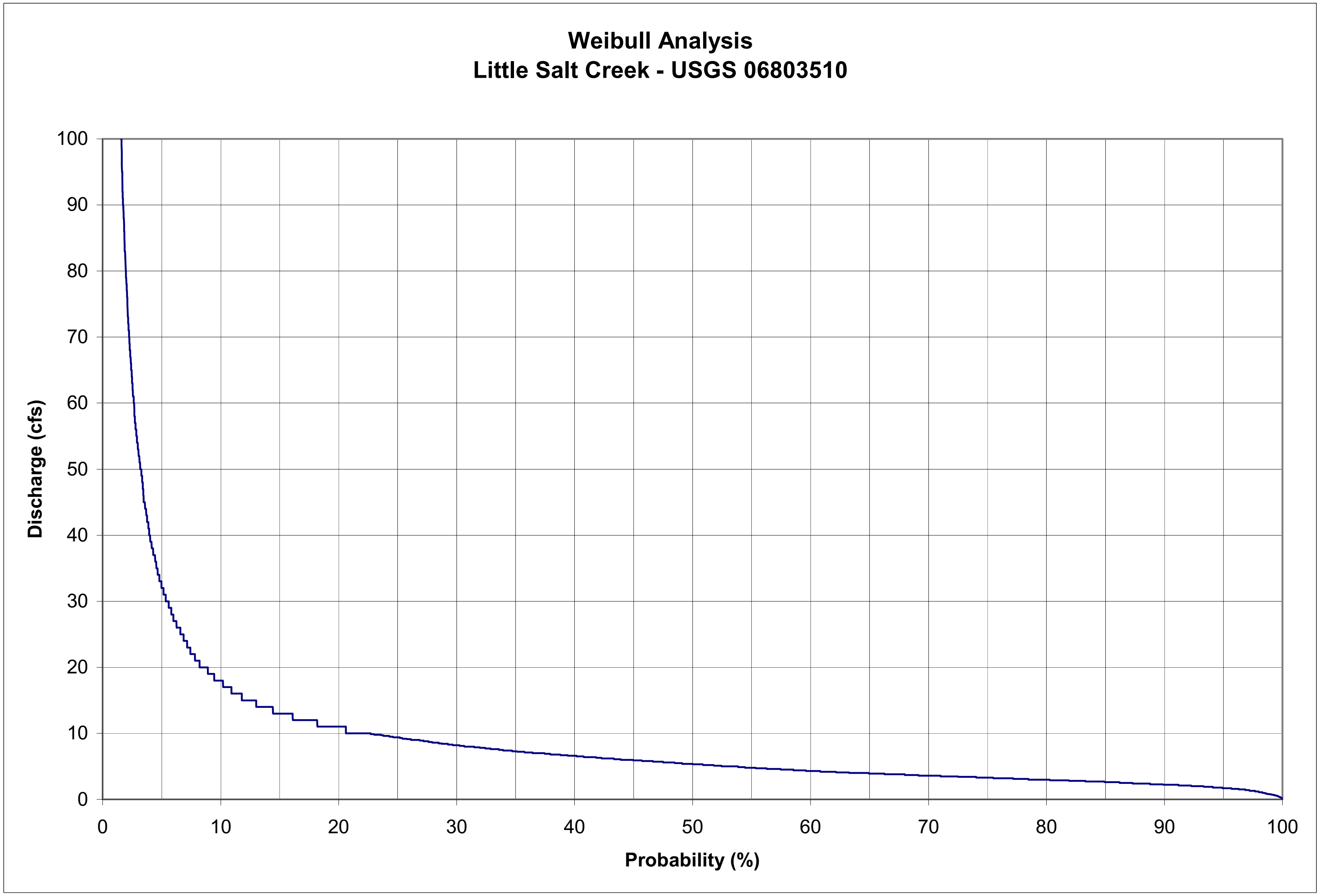

Figure 6-6: Weibull analysis of Little Salt Creek average daily flows at N 27th St and Arbor Rd

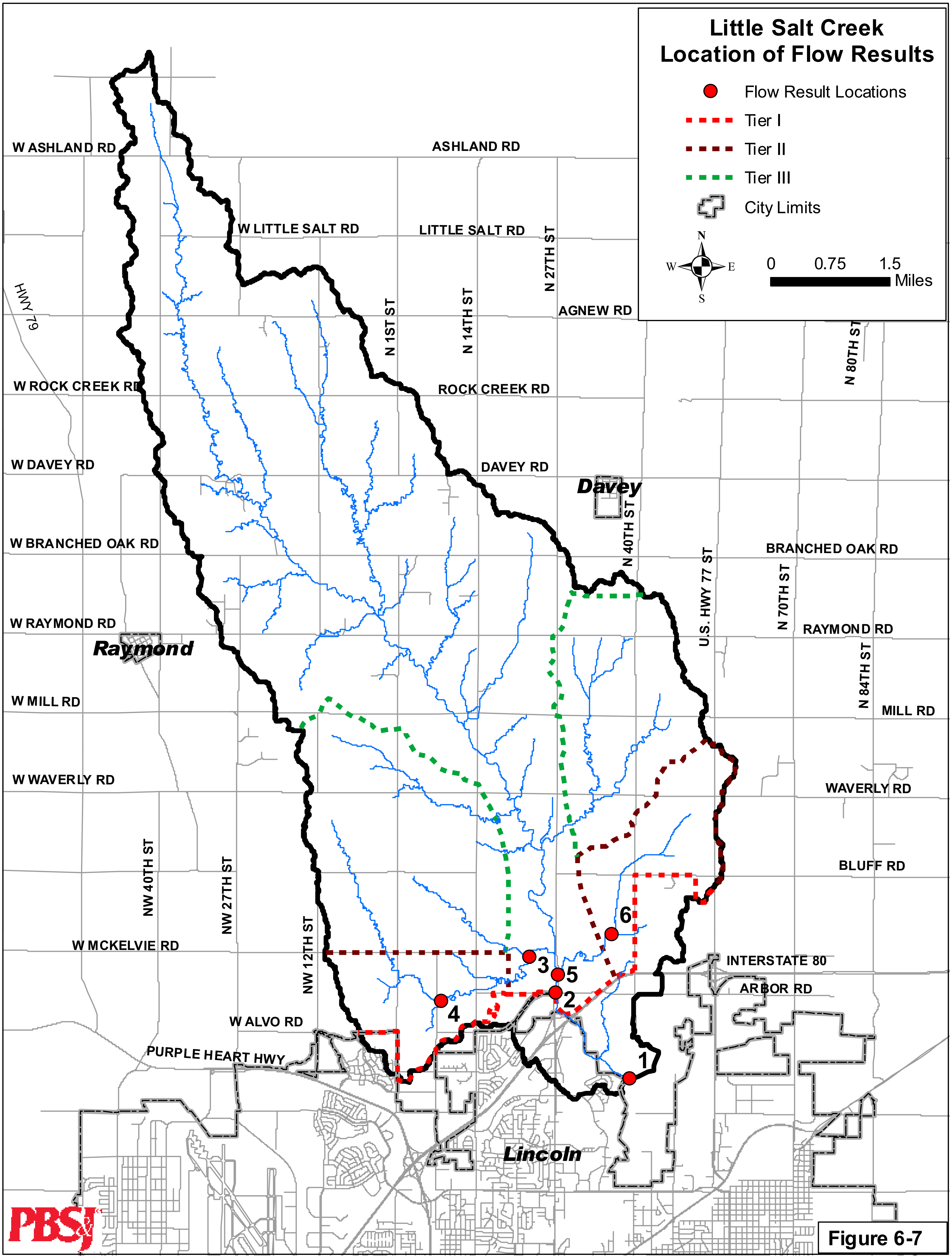
Little Salt Creek
Location of Flow Results
● Flow Result Locations
Tier I
Tier II
Tier III
City Limits
N
W
E
S
0
0.75
1.5
Miles
W ASHLAND RD
ASHLAND RD
W LITTLE SALT RD
LITTLE SALT RD
N 27TH ST
HWY 79
AGNEW RD
N 1ST ST
N 14TH ST
N 80TH ST
W ROCK CREEK RD
ROCK CREEK RD
W DAVEY RD
DAVEY RD
Davey
N 40TH ST
W BRANCHED OAK RD
BRANCHED OAK RD
U.S. HWY 77 ST
N 70TH ST
W RAYMOND RD
RAYMOND RD
Raymond
N 84TH ST
W MILL RD
MILL RD
W WAVERLY RD
WAVERLY RD
NW 40TH ST
NW 27TH ST
BLUFF RD
NW 12TH ST
W MCKELVIE RD
6
3
5
2
4
1
INTERSTATE 80
ARBOR RD
W ALVO RD
PURPLE HEART HWY
Lincoln
PBSJ

Figure 6-7

The rainfall depth required to produce an average half inch runoff from the watershed was found to be 3.30 inches over a twenty-four hour period. This rainfall depth was distributed based on an SCS Type II rainfall pattern. This event corresponds to a 2.5-year frequency (40% probability of exceedance). The resultant runoff volume plots within the computed probabilities of the 1-day and 2-day volumes for the 40% probability of exceedance as described in Section 3.3.1 of this report (see Figure 3-7). Table 6.2 through Table 6.4 displays the comparison between existing conditions and future conditions for the Tier 1 and Tier 2 scenarios for the half inch runoff event. The locations at which the results were taken are displayed above in Figure 6-7. For this rainfall event the percentage increase in peak discharge is substantial in the smaller tributaries undergoing changes from agriculture to fully developed. However, the percentage increase in total volume of runoff is more moderate. Figures 6-8 through 6-15, located at the conclusion of this section, provide the hydrograph results for the three conditions (existing, Tier 1, and combined Tier 1 & 2) for the half inch runoff event. These hydrographs again reflect the effects urbanization on the lower portion of the watershed has on the main channel.

Table 6.2 Comparison of peak flows under existing and future conditions for the 0.5" runoff event

	Existing	Tier 1		Tiers 1 and 2	
Location	Peak Flow (cfs)	Peak Flow (cfs)	% Increase	Peak Flow (cfs)	% Increase
1	2036	2013	-1.13	2203	8.20
2	2011	2087	3.78	2309	14.8
3	483	556	15.1	740	53.2
4	337	423	25.5	678	101
5	383	454	18.5	440	14.9
6	298	396	32.9	366	22.8

Table 6.3 Comparison of total volumes under existing and future conditions for the 0.5" runoff event

	Existing	Tier 1		Tiers 1 and 2	
Location	Volume (ac-ft)	Volume (ac-ft)	% Increase	Volume (ac-ft)	% Increase
1	1249	1313	5.12	1334	6.81
2	1157	1172	1.30	1194	3.20
3	135	141	4.44	159	17.8
4	60.0	64.7	7.83	81.6	36.0
5	69.7	79.6	14.2	82.7	18.7
6	35.7	46.5	30.3	48.5	35.9

Table 6.4 Comparison of volumes within the first six hours of runoff under existing and future conditions for the 0.5" runoff event

	Existing	Tier 1		Tiers 1 and 2	
Location	Volume (ac-ft)	Volume (ac-ft)	% Increase	Volume (ac-ft)	% Increase
1	580	643	10.9	664	14.5
2	549	565	2.91	586	6.74
3	96.2	102	6.03	120	24.7
4	54.6	59.4	8.79	75.7	38.6
5	68.8	78.8	14.5	81.8	18.9
6	35.7	46.5	30.3	48.5	35.9

Within these smaller subbasins the increase in volume could be controlled through watershed management such that the peak discharge could be maintained by use of retention cells, with the volume distributed over a longer period of time. Therefore, with watershed management control, such as implementing the site specific structural and non-structural best management practice (BMP) recommendations of Section 7.2, oils and nutrients could also be more easily controlled.

It is noted that the main channel of Little Salt Creek is predicted to have a very slight lowering of peak discharge during an event producing a half inch runoff. In looking at the modeling results this was due to the peak runoff from the lower fifth of the basin becoming quicker, thus entering and leaving the main channel prior to the upper watershed contributing. This is reflected in the comparative tables above as well as displayed in Figures 6-8 and 6-9, which shows the multiple peaks due to timing differences between the upper and lower portions of the watershed for the half inch of watershed runoff. In review of Tables 6.2 and 6.4 above, the increase in future conditions storm volumes are much larger for the first six hours of runoff, with the percentage of increase dropping for the entire storm volume.

This is indeed possible, but it is noted that the design storm utilized is stationary. Storm systems that cause flooding frequently tend to be moving systems. Any storm system that would move from northwest to southeast within this watershed would allow the upper watershed to develop first, with the lower basin developing and contributing later. In this case, which is common, the predicted peak discharge at the confluence of the watershed would become higher.

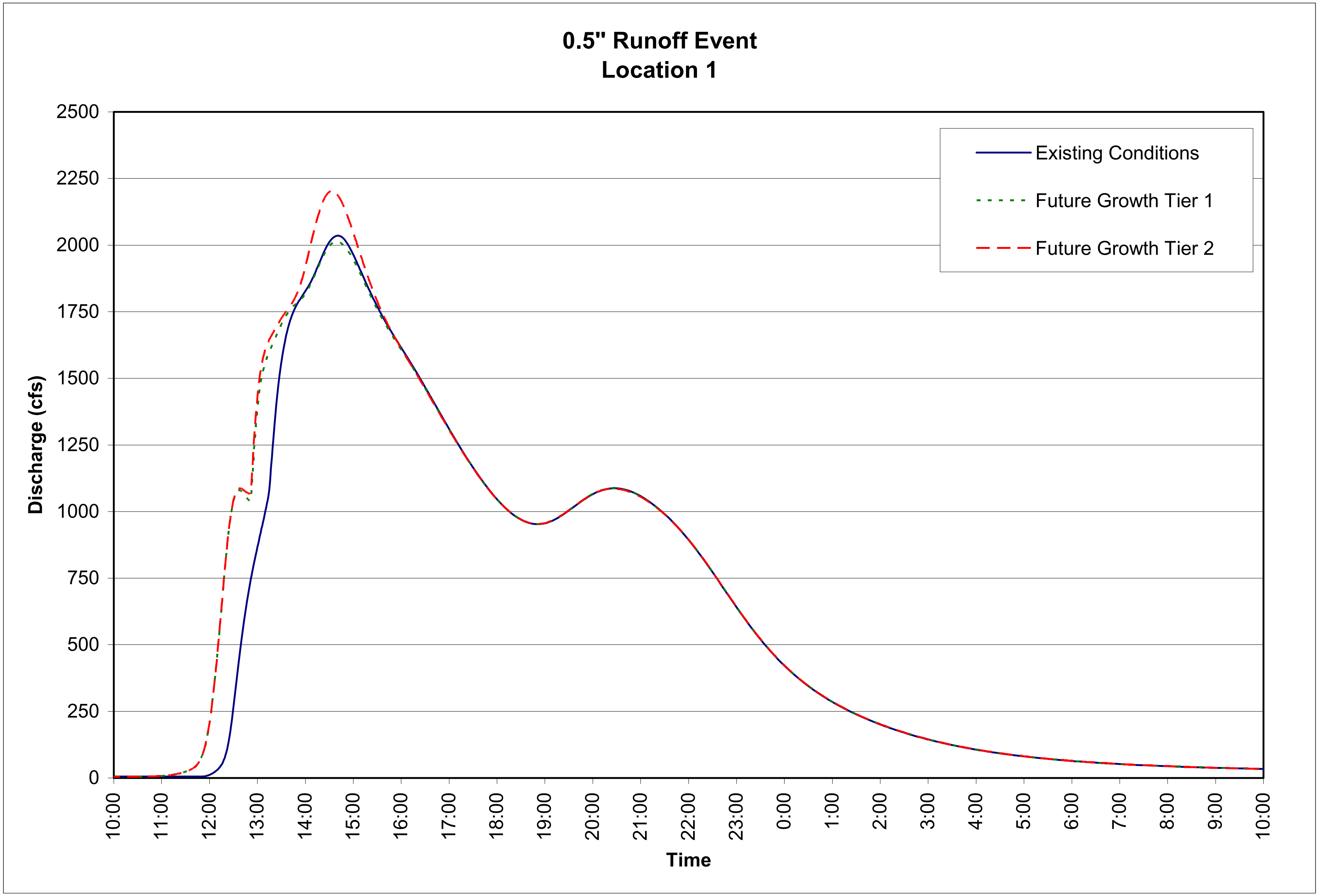

Figure 6-8: 0.5" runoff event resultant hydrographs of existing and future conditions scenarios at Location 1

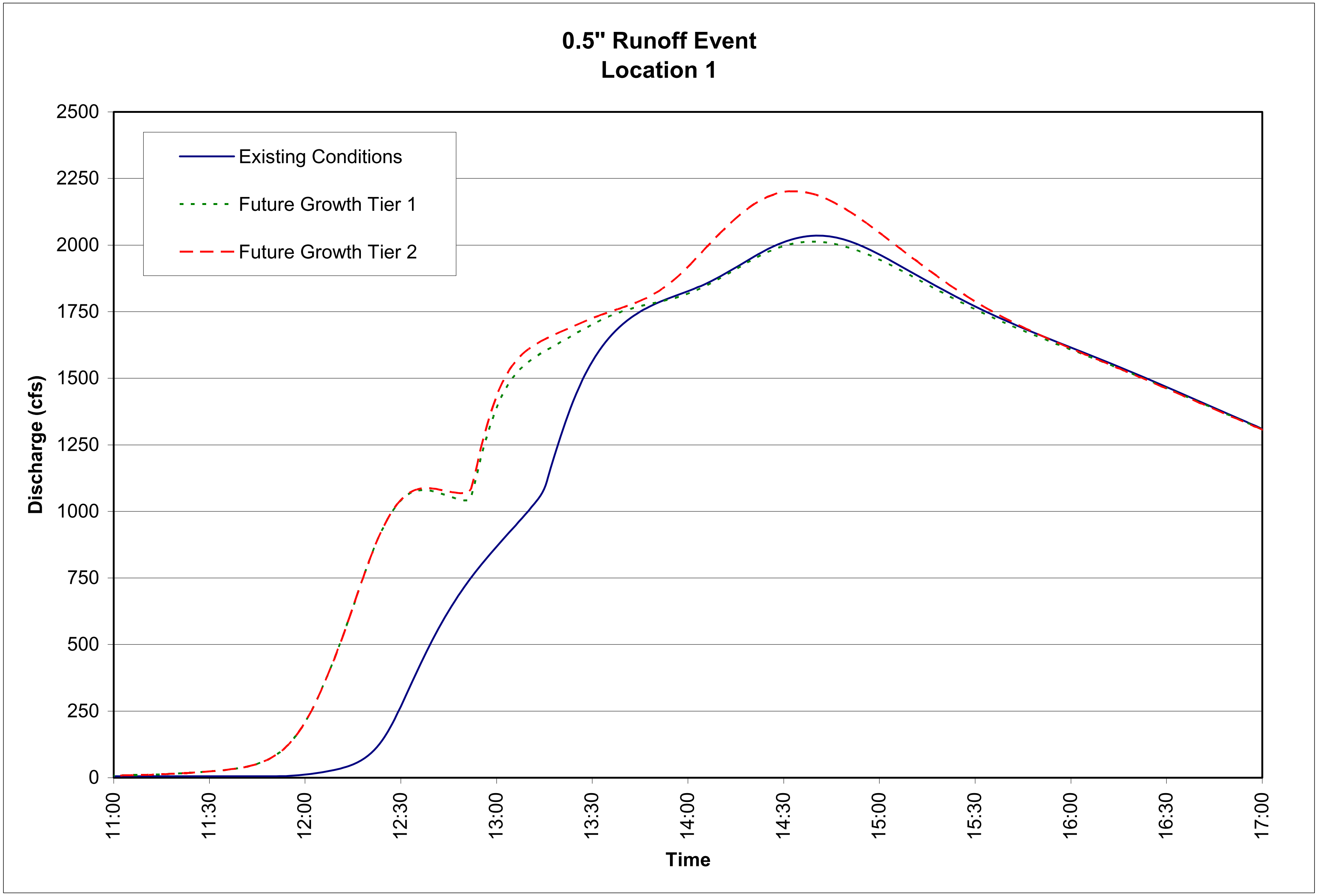

Figure 6-9: 0.5" runoff event resultant hydrographs of existing and future conditions scenarios at Location 1 (first 6 hours of runoff)

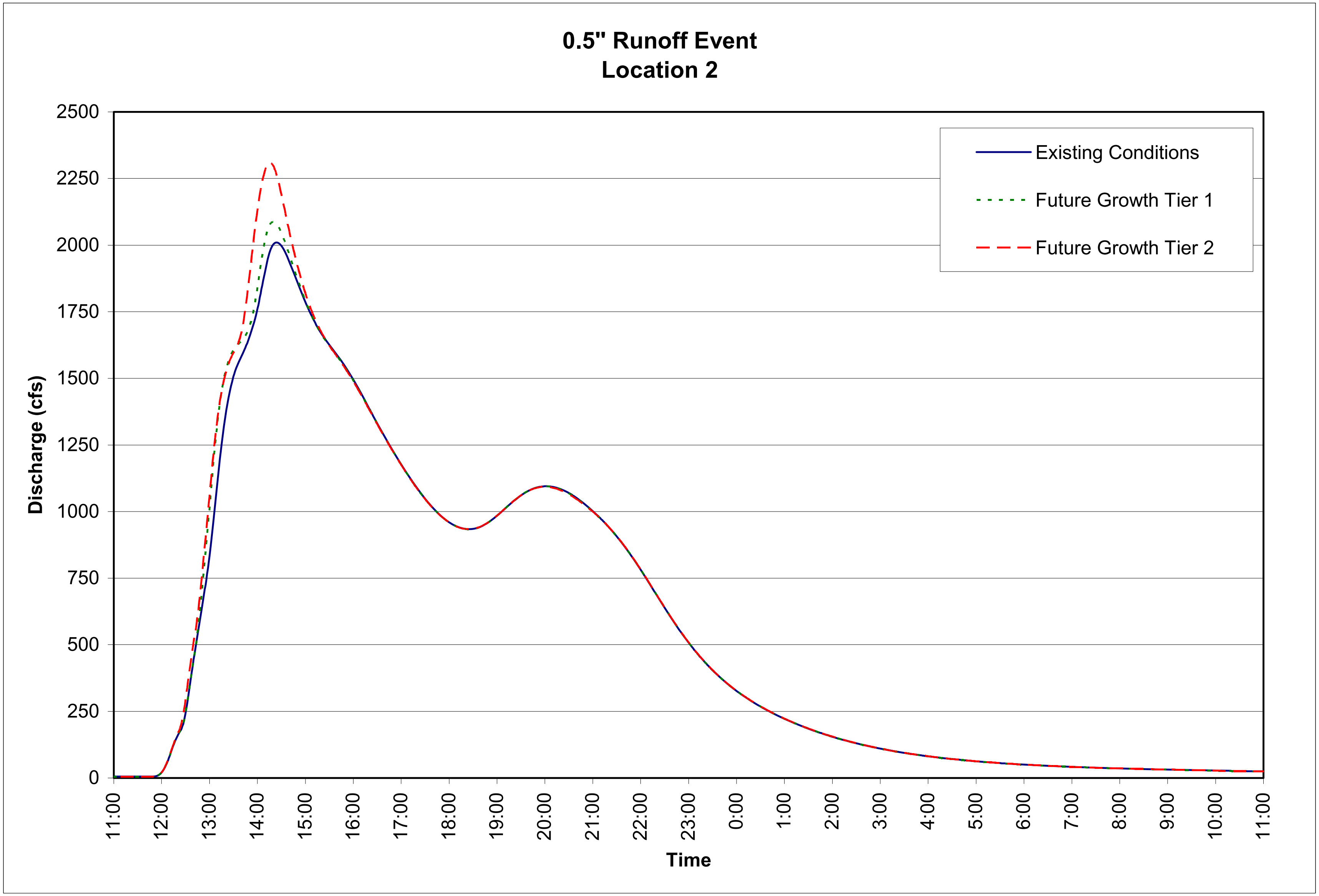

Figure 6-10: 0.5" runoff event resultant hydrographs of existing and future conditions scenarios at Location 2

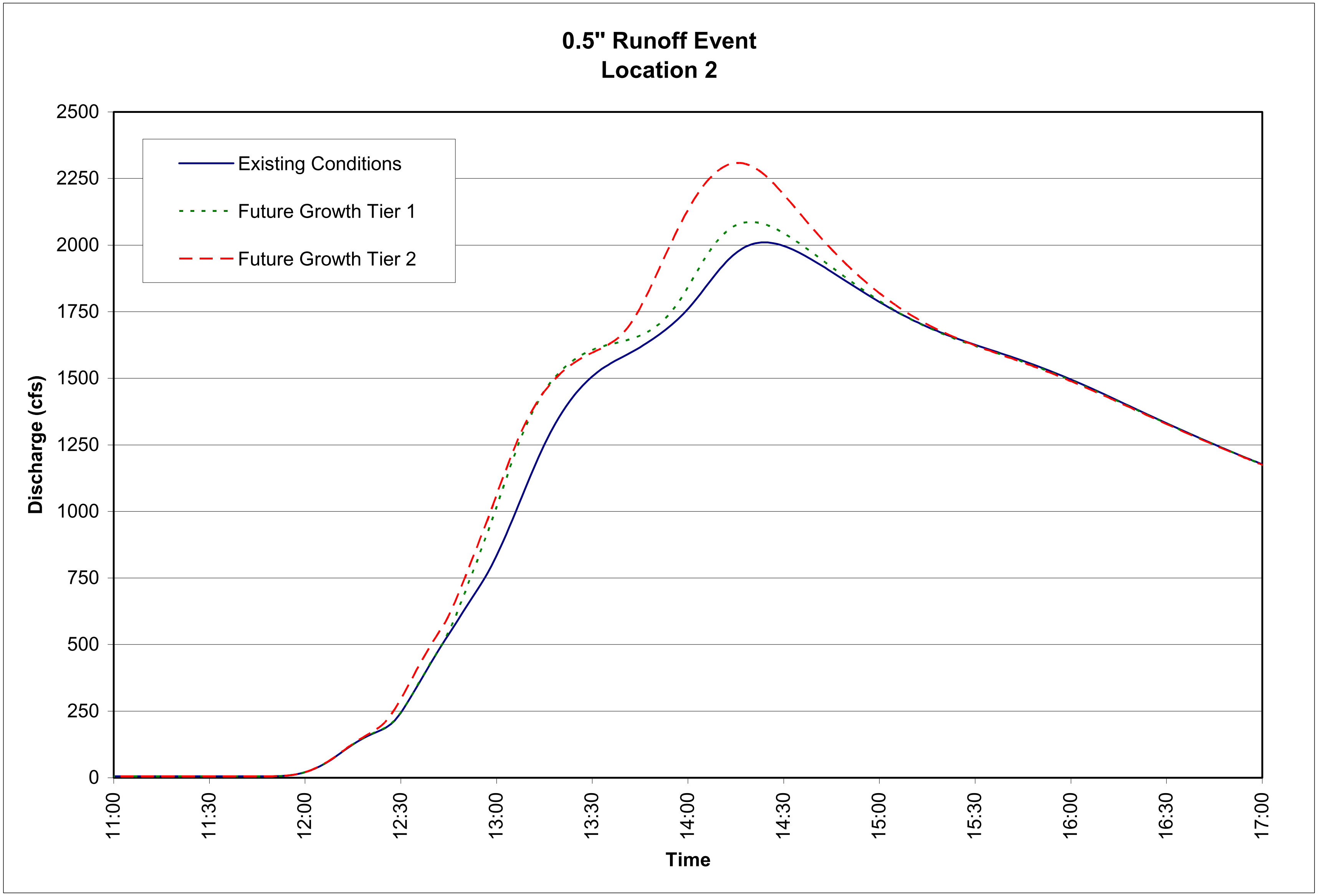

Figure 6-11: 0.5" runoff event resultant hydrographs of existing and future conditions scenarios at Location 2 (first 6 hours of runoff)

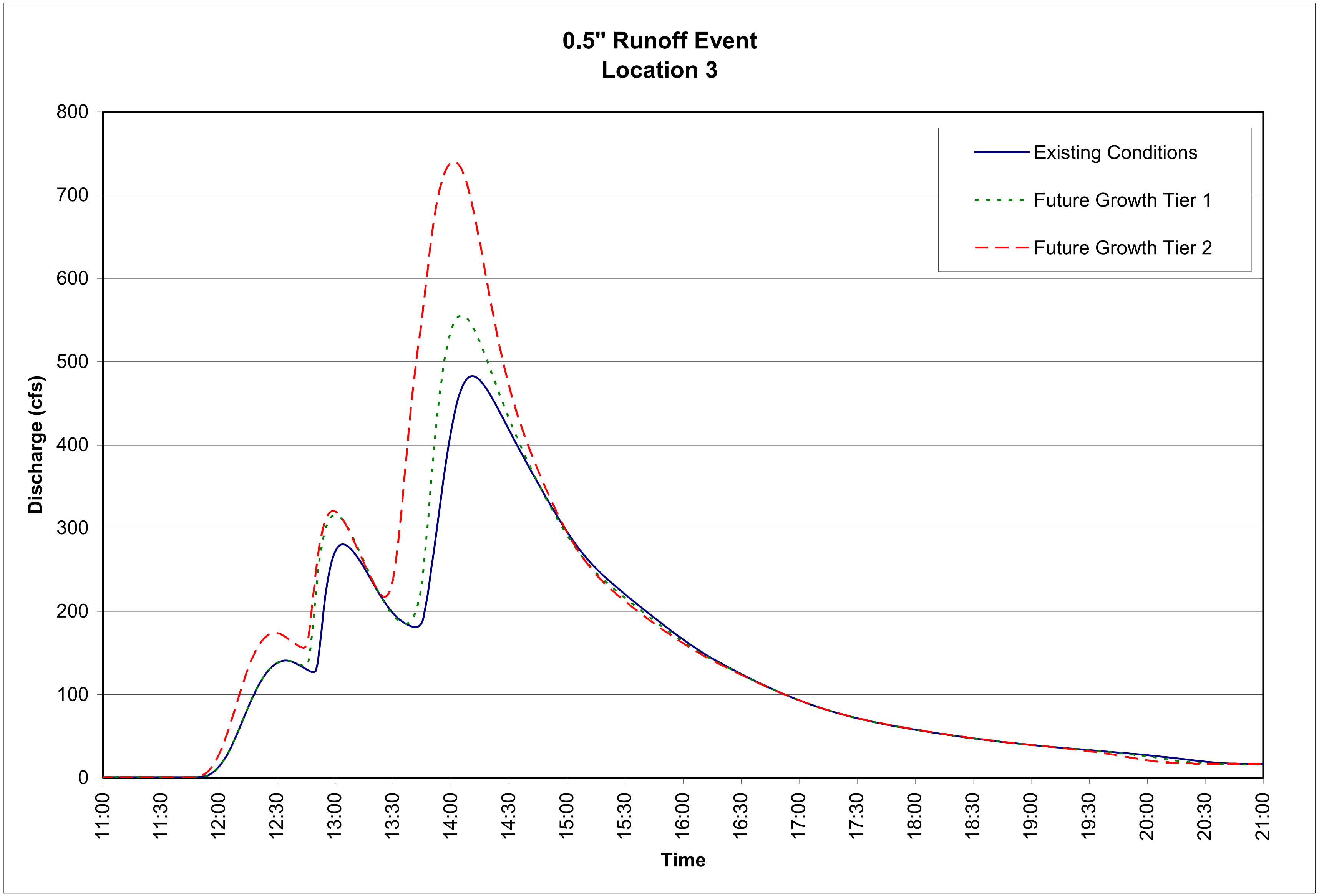

Figure 6-12: 0.5" runoff event resultant hydrographs of existing and future conditions scenarios at Location 3

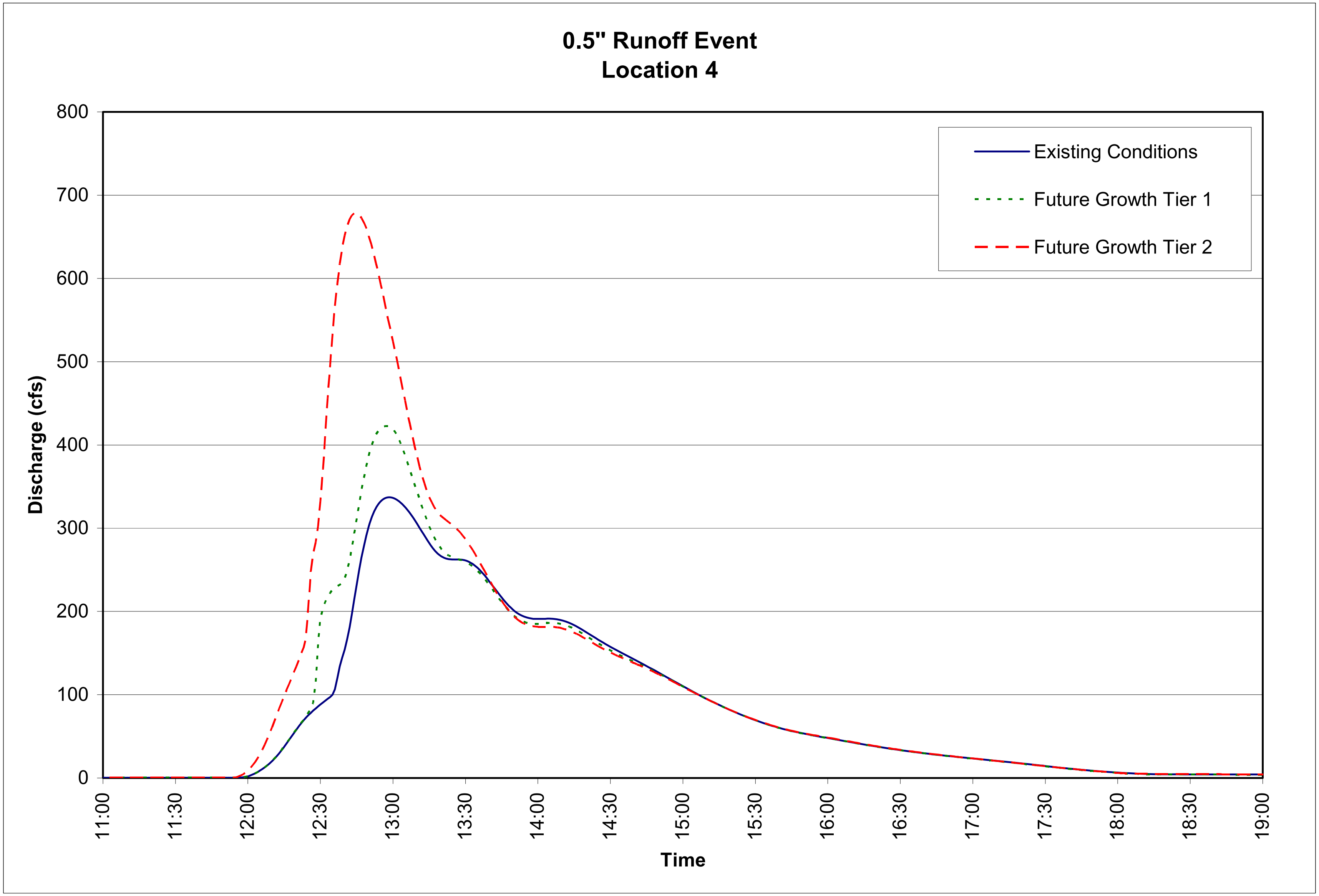

Figure 6-13: 0.5" runoff event resultant hydrographs of existing and future conditions scenarios at Location 4

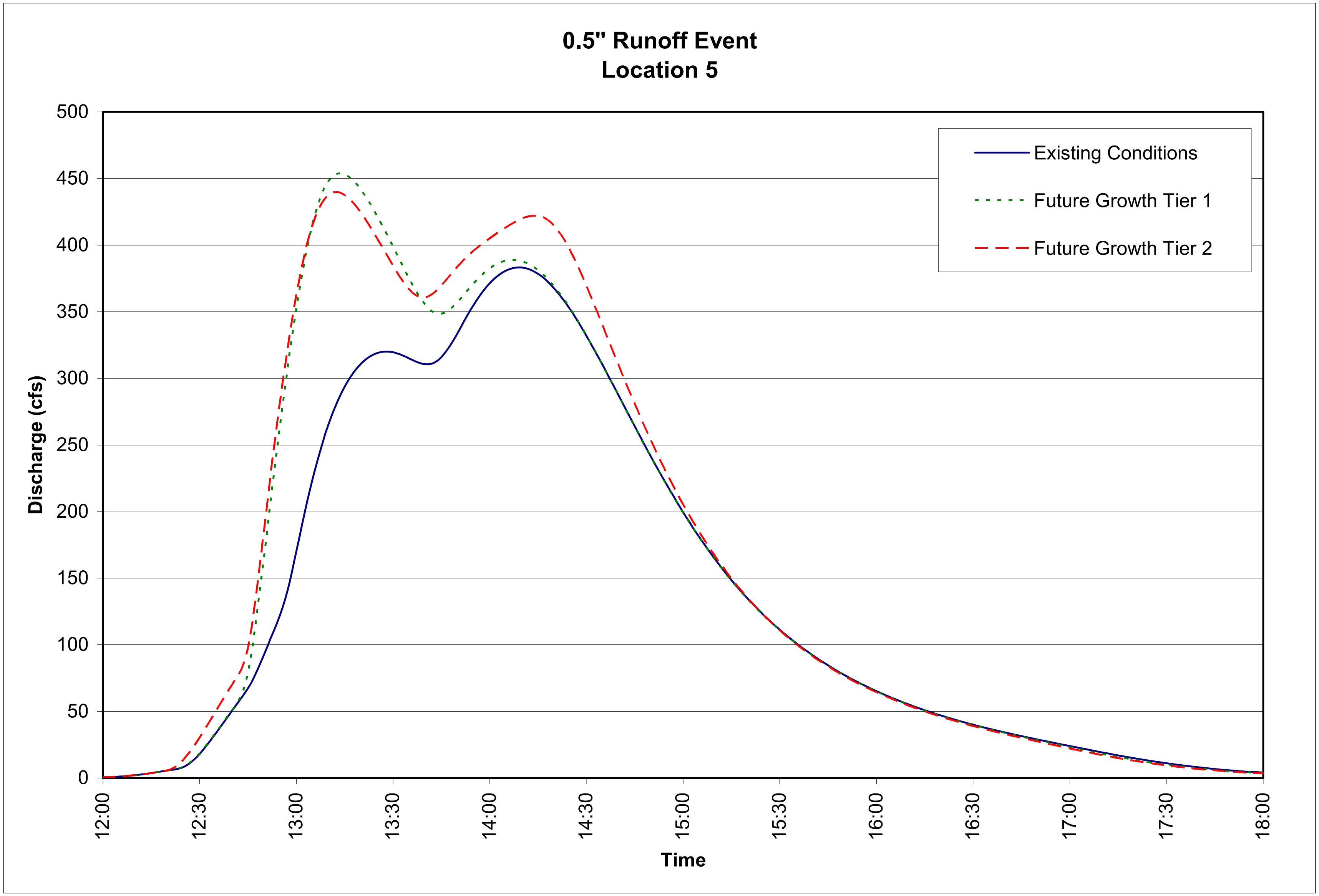

Figure 6-14: 0.5" runoff event resultant hydrographs of existing and future conditions scenarios at Location 5

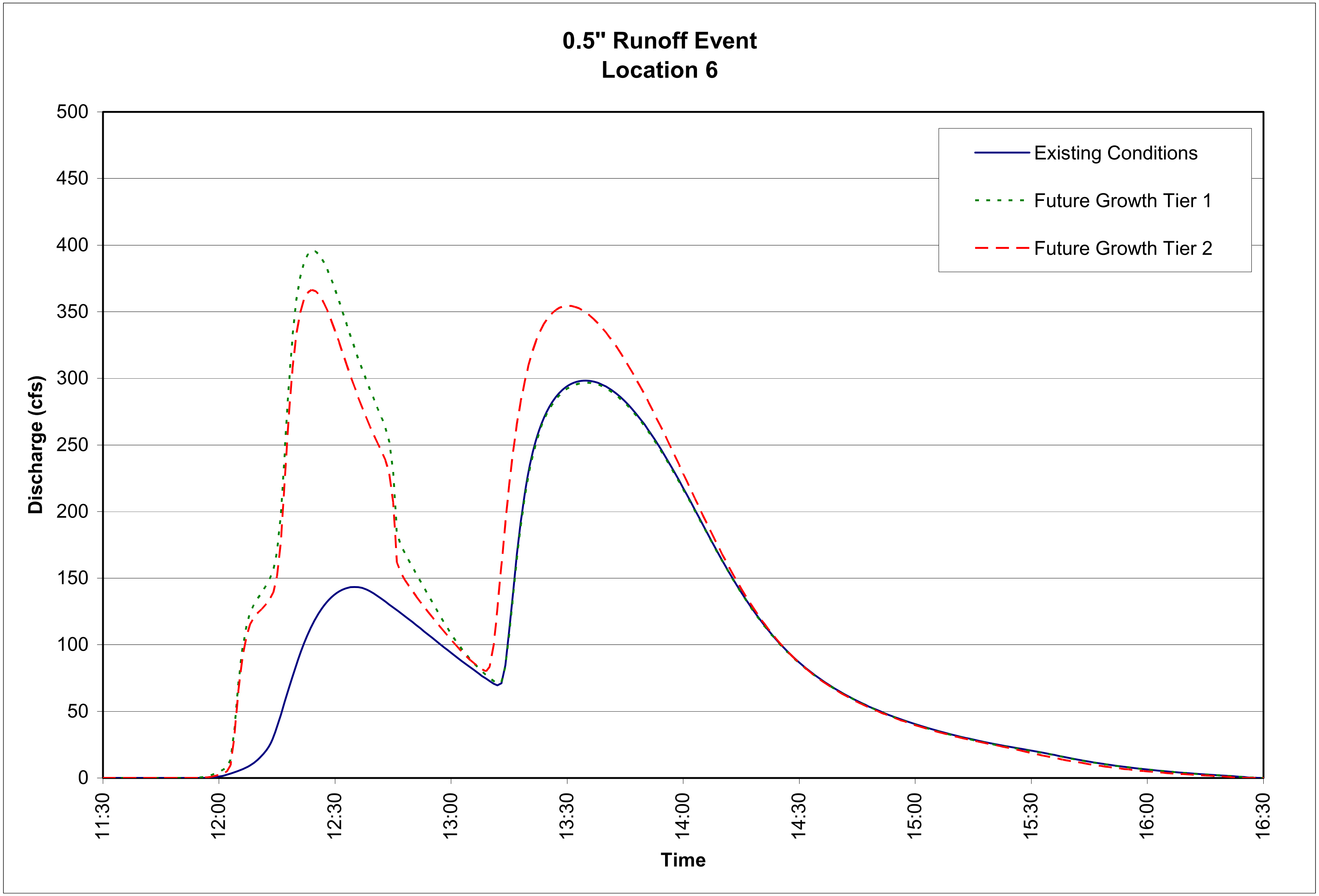

Figure 6-15: 0.5" runoff event resultant hydrographs of existing and future conditions scenarios at Location 6