OPTIMIZATION OF BEST MANAGEMENT PRACTICES FOR BEEF CATTLE RANCHING IN THE LAKE OKEECHOBEE BASIN

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Sponsor: Florida Department of Environmental Protection, Taufiqul Aziz , Contract Manager

FINAL REPORT

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May 20, 1999

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This project and the preparation of this report was funded in part by a Section 319 Nonpoint Source Management Program grant from the U.S. Environmental Protection Agency through a contract with the Stormwater / Nonpoint Management Section of Florida Department of Environmental Protection. The total cost of the project was $934,000, of which $150,000 or 16 percent was provided by the U.S. E.P.A

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1. Executive Summary

In 1994, three organizations (Archbold Biological Station, University of Florida Institute of Food and Agricultural Sciences, and South Florida Water Management District) initiated a multi-disciplinary BMP development program at the Buck Island Ranch. In 1996 the Florida Cattlemen's Association joined the group. These four organizations work together at MAERC in long-term monitoring of water quality, wildlife biology, and landscape ecology in relation to agriculture.

Buck Island Ranch is located near Lake Placid, Florida. In November 1988, Archbold Biological Station became manager of the 10,300-acre (4,170 ha) Buck Island Ranch, under a long-term lease from the John D. and Catherine T. MacArthur Foundation. This established the MacArthur Agroecology Research Center (MAERC) at Buck Island Ranch. The primary mission of MAERC is to conduct and stimulate long-term investigation of the relationships between cattle ranching, citrus production, and the native ecological systems of central and southern Florida. The Ranch is maintained as a full-scale working ranch and grove. Cattle herds and citrus groves are managed at full production levels for project purposes. This provides staff and visiting scientists a unique opportunity in Florida: to measure and monitor ecological effects of agricultural practices at real world scales of space and numbers. They can also evaluate BMP's on a large scale as a way of testing how agriculture and the ecosystem interact over the long term.

In 1996 this group initiated planning for a demonstration project to document water quality BMPs for south Florida cattle ranches. This project seeks to develop BMPs that will help reduce phosphorus runoff loading into Lake Okeechobee while maintaining the economic viability of Florida cattle ranches. The cattle stocking rate optimization project infrastructure consists of multiple, field-scale plots that are realistic in size, yet are fenced and ditched separately from each other, and are instrumented so that all surface water runoff can be captured and analyzed. The design for the improved pasture project is a completely randomized block employing four (4) stocking rate BMP's on eight pastures. Stocking rate BMP's on the improved pasture plots are 0, 1.4, 2.5, and 3.3 acres/cow-calf unit. The design for the native rangeland evaluation is also a completely randomized design employing four (4) stocking rates on eight plots, with the stocking rates being different than those used on the improved pasture plots. Native rangeland stocking rates are 0, 2.3, 4.0, and 5.3 acres/cow-calf unit. The difference in animal densities in the summer and winter array is necessitated by differences in potential biomass production between these areas. Each study animal was assigned to a stocking rate at the beginning of the demonstration project and remains at this same stocking rate for the life of the project.

These grazing blocks reflect the two principal pasturing regimes of a typical central Florida ranch. One array site is located on a wetter range area containing a mixture of native grasses, along with some bahiagrass. This range area is used for winter and spring (dry season) grazing by cows immediately after calving and during breeding. The other array site is on well drained and improved pasture with bahiagrass, which is used for summertime (wet season) grazing of cow-calf pairs. The two arrays are similar in design and instrumentation. The winter range array consists of a 700-acre area. Within this array eight 80-acre range plots are delineated. The winter range plots are 30 acres larger than the summer pasture plots because, in general, cattle are kept on winter range in lower densities than on summer pastures. The 80-acre plot size allows the number of cows within a grazing herd to be kept at a level that provides greater statistical significance when evaluating animal characteristics. The 500-acre summer array consists of eight 50-acre plots.

Construction of the pasture plots infrastructure was completed in 1998. Implementation of the cattle stocking rate BMP's in late 1998 was preceded by a year-long equilibration period during which the effects of the construction were allowed to dissipate. Data collection began in 1998 and continued through the end of 1999. Measurements included runoff flow rates and water quality. Water quality parameters measured included TP, ortho-P, NH_3, NO_x and TKN. Samples were taken by both manual grab techniques and automatic water samplers.

Initial statistical analysis of both the concentration and load results show only a block effect reflecting differences between the winter and summer pasture blocks. The summer improved pastures show much greater total phosphorus concentrations and loads as compared to the winter native range areas. This difference may be an artifact of prior land use history. The summer pastures were used as clover fields many years ago and thus subject to intense fertilization. Total phosphorus concentrations and loads were five times higher on the summer pastures than on the winter pastures.

Statistical differences resulting from the different cattle stocking rates would not be expected to be evident this early in the project. 1998 represented an equilibration period and 1999 represents the first year of grazing density BMP's. With an impressive monitoring infrastructure currently in place at Buck Island Ranch, the next two years (2000-2001) of the project should yield good results towards quantifying the water quality impacts of grazing density.

In addition to observing differences between the quantity of phosphorus in the runoff waters between the two sites, a notable difference was also observed in the proportion of ortho-P contained in the runoff. For the winter pastures the ortho-P to Total P ratio was approximately 0.23 while for the summer pastures the ratio was 0.72. Not only did the summer pastures export more phosphorus but they also exported a more biologically available form of phosphorus.

Meaningful results were also found in the soils data. On both the summer and winter pastures the highest concentration of soil phosphorus is located within the first 5 cm of the pasture soils. The high TP content in the summer pasture runoff water was matched by correspondingly high water soluble P concentration in the summer pasture soils. This apparent relationship between soil P and runoff P warrants further investigation.

The success of the next two years will depend greatly on the ability of the project team to properly maintain the pasture ditches and the measurement instruments. With over 20 dataloggers and over 100 sensors in operation, the task of keeping up with equipment failures will be a challenge. Also important to the project will be the timely review of incoming data, reliability of controller software, and the strict adherence to SOP requirements for runoff sample collection and handling. The frequency of grab samples will also need to be increased while the extent of autosamples may be decreased or at least reduced by implementing sample compositing schemes.

2. Introduction

In an effort to restore the Everglades/Lake Okeechobee ecosystem, the South Florida Water Management District (SFWMD) developed a Surface Water Improvement and Management (SWIM) program for the Kissimmee River Basin and Lake Okeechobee watershed. The SWIM rule was intended to obtain phosphorus load reductions beyond what had already been realized from the Rural Clean Water Protection Program (1980-1990), the dairy buy-out program and the other related programs. Despite reduction in phosphorus loads from Lake Okeechobee watershed, the SWIM mandated targets have not been met, and in-lake total phosphorus concentrations have not begun to decline. Although the SWIM plan is now fully operational, additional phosphorus load reduction due to its implementation has not occurred. Nondairy sources of P in the Lake Okeechobee drainage basin are primarily from beef cattle pastures (improved pasture and native range). Although animal densities and runoff phosphorus concentrations associated with beef cattle pastures are relatively low, the vast acreage (approximately 470,000 acres) of this land use makes them a major contributor of phosphorus. In order to achieve the phosphorus load target and to hasten Lake Okeechobee's recovery, it is necessary to find ways to reduce phosphorus in runoff from beef cattle pastures. This optimization project seeks to do so proactively, not through the regulatory framework, but through a collaborative program that seeks and includes input from the stakeholder community. A guiding principle is to protect and enhance Lake Okeechobee, while minimizing negative economic impacts on the agricultural industry.

2.1. Project Objectives

The specific objectives of this BMP optimization project are to:

i. Demonstrate and quantify how modification of cattle grazing density affects runoff water nutrient loads.
ii. Demonstrate and quantify how pasture type (winter and summer) affects runoff water nutrient loads
iii. Demonstrate and quantify how cattle grazing densities affect cattle growth characteristics and subsequent ranch economics.
iv. Communicate results of the demonstration project to South Florida ranchers and land managers.

2.2. Background

The practice of grazing wetland prairies is a particularly interesting aspect of the system since those wetlands may be important areas for additional phosphorus assimilation from adjacent pastures. In order to meet phosphorus load reduction goals it will be necessary to increase the wetland area available for nutrient assimilation. Grazing of native range may be compatible with this need or it may act to negate the benefits of wetland assimilation of phosphorus. For example, if grazing pressure is low to moderate, grazing may increase nutrient assimilation by stimulating new growth (Steinman, 1996). This can be the result of a change in species composition, the formation of new tissue with higher phosphorus quotas, or over compensatory growth (Paige and Whitham, 1987). However, grazing may reduce P assimilation if the grazing pressure is too intense (Steinman et al., 1991). If grazer density is very high, then the overall biomass will be reduced and less P will be taken up. Grazing may also promote the growth of species with less P requirement. Thus, the role of native range (wetland prairies) and improved pasture (introduced grasses) is a target of attention in the drive to accomplish additional nutrient load reduction. Ranchers may be required to adjust their management (grazing density, fertilization, etc.) to help reach the P reduction goals. Additionally, grazing of wetlands is being scrutinized by the water management districts with respect to water quality issues and habitat destruction. Therefore, it becomes a regional priority to conduct BMP investigations and establish the relationship between range management practices and the ecosystem impacts.

While water quality is the primary driving force for BMP development and implementation, wildlife habitat and ranch economics are equally important to the overall goal of sustainable ecosystem restoration. Thus, the issues of nutrient dynamics, water quality, wildlife habitat, and ranch profitability must be treated as a single system (Figure 2.1).

Florida ranks tenth among all states and second among states east of the Mississippi in beef production (Graetz and Nair, 1996). In 1995, Florida maintained 1.15 million beef cows, and total cash receipts from cattle and calves were $290 million (FDCAS, 1996). Florida's cattle production is dominated by cow-calf operations, so the industry has a significant impact on cattle production in other states.

The vast majority of Florida's cattle are located in south and central Florida, south of a line between Daytona Beach, Orlando and Tampa. Much of what was once native subtropical wet prairie ecosystem in this region is now managed for grazing. Land use changes within these ecosystems have resulted in dramatic changes in the wildlife habitat characteristics and the patterns of nutrient flow for upland, marsh and lake ecosystems. For example, total P concentration in Lake Okeechobee has almost doubled since 1970's and chlorophyll a level significantly increased between early 1970's and 1990 (James et al., 1995a,b). Coincidental with this general area of south Florida is one of the nations fastest growing urban populations and one of the nation's most sensitive ecosystems. This region of Florida is home to many endangered plants and animals making it a "national hotspot" for endangered species (Cox et al., 1994). Also, water from this cattle production region feeds into Lake Okeechobee and the Florida Everglades. Preservation and restoration of this unique ecosystem ranks at the top of our national environmental priority list.

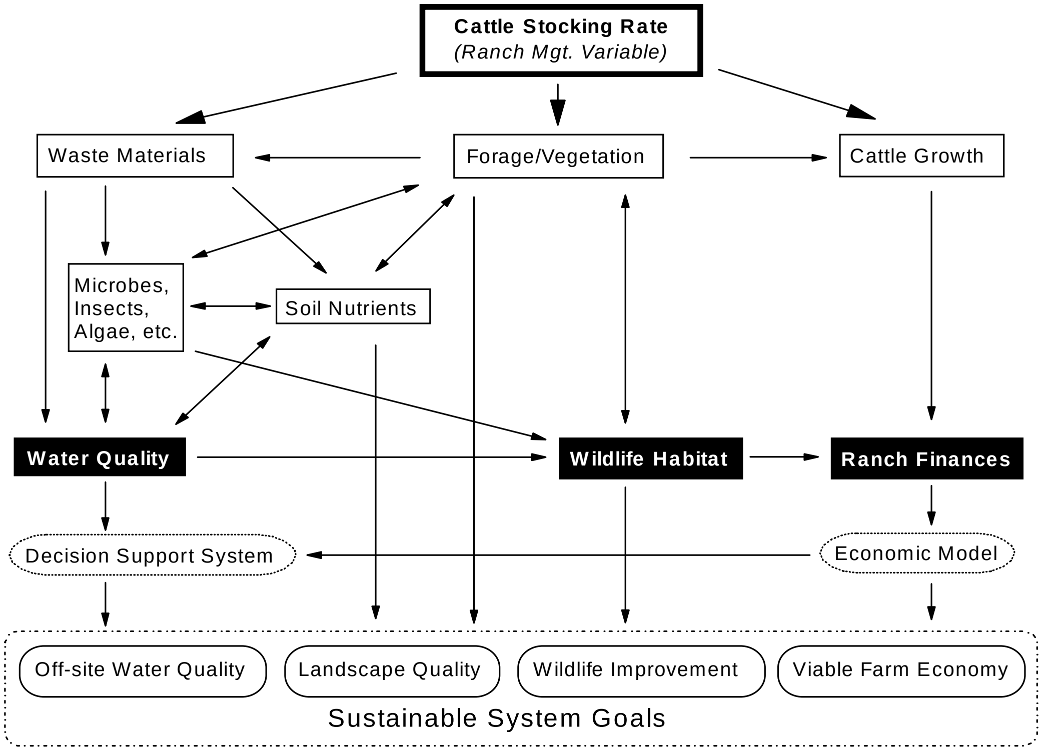


Figure 3.1. Ranch agro-ecosystem components and linkages.

3. Demonstration Project Design

The cattle stocking rate optimization project infrastructure consists of multiple, field-scale pasture plots that are realistic in size, yet are fenced and ditched separately from each other, and are instrumented so that all surface water runoff can be captured and analyzed. The design for the improved pasture study is a completely randomized block employing four (4) stocking rate treatments on eight pastures as described in Table 3.1. Stocking rate treatments on the improved pasture plots are 0, 1.4, 2.5, and 3.3 acres/cow-calf unit. The design for the native rangeland evaluation is also completely randomized, employing four (4) stocking rates on eight plots, with the stocking rates being different than those used on the improved pasture plots. Native rangeland stocking rates are 0, 2.3, 4.0, and 5.3 acres/cow-calf unit. The difference in animal densities in the summer and winter array is necessitated by differences in potential biomass production between these areas. Each study animal was assigned to a stocking rate at the beginning of the study and remains at this same stocking rate for the life of the project.

Table 3.1. Demonstration project treatments assignments (control plots highlighted).

Block	Plot ID	Treatment		
		Description	Cow-Calf Units	Acres/Unit
Winter	W4 & W7	Control	0	N/A
	W1 & W6	Low	15	5.3
	W2 & W8	Medium	20	4.0
	W3 & W5	High	35	2.3
Summer	S1 & S8	Control	0	N/A
	S4 & S6	Low	15	3.3
	S2 & S7	Medium	20	2.5
	S3 & S5	High	35	1.4

These grazing blocks reflect the two principal pasturing regimes of a typical central Florida ranch. One array site is located on a wetter range area containing a mixture of native grasses, along with some bahiagrass. This range area is used for winter and spring (dry season) grazing by cows immediately after calving and during breeding. The other array site is on well-drained and improved pasture with bahiagrass, which is used for summer time (wet season) grazing of cow-calf pairs. The two arrays will be similar in design and instrumentation. The winter range array consists of a 700-acre area. Within this array eight 80-acre range plots are delineated. The winter range plots are 30 acres larger than the summer pasture plots because, in general, cattle are kept on winter range in lower densities than on summer pastures. The 80-acre plot size allows the number of cows within a grazing herd to be kept at a level that provides greater statistical significance when evaluating animal characteristics. The 500-acre summer array consists of eight 50-acre plots.

The project was carried out in two stages in order to separate the effects due to site disturbances from those due to stocking rate treatments. The first stage of the project was an equilibration period lasting almost two years (1997-1998). In stage two, the test herds were introduced to the grazing plots at the specified treatment stocking densities. Water quality data was collected during both phases.

3.1. Location

The project is located at Buck Island Ranch located near Lake Placid, Florida (See Figure 3.1) In November 1988, Archbold Biological Station became manager of the 10,300-acre (4,170 ha) Buck Island Ranch, under a long-term lease from the John D. and Catherine T. MacArthur Foundation. This established the MacArthur Agroecology Research Center (MAERC) at Buck Island Ranch. The primary mission of MAERC is to conduct and stimulate long-term investigation on the relationships between cattle ranching, citrus production, and the native ecological systems of central and southern Florida. The Ranch is maintained as a full-scale working ranch and grove. Cattle herds and citrus groves are managed at full production levels for project purposes. This provides staff and visiting scientists a unique opportunity in Florida: to measure and monitor ecological effects of agricultural practices at real world scales of space and numbers. They can also evaluate BMP's on a large scale as a way of testing how agriculture and the ecosystem interact over the long term.

Figure 3.1. Buck Island Ranch location map.

In 1994, three organizations (MAERC, University of Florida's Institute of Food and Agricultural Sciences (IFAS), South Florida Water Management District) created a cooperative group to initiate a multi-disciplinary program at the Buck Island Ranch. In 1996 the Florida Cattlemen's Association joined the group. These four organizations work together at MAERC in long-term monitoring of water quality, wildlife biology, and landscape ecology in relation to agriculture.

Both the winter and summer pasture blocks are located on the south half of the ranch, adjacent to Harney Pond Canal, a major regional conveyance linking Lake Istopoga and Lake Okeechobee. The summer pasture plots are to the north of the canal (see Figure 3.2) while the winter pasture plots are to the south of the canal (see Figure 3.3).

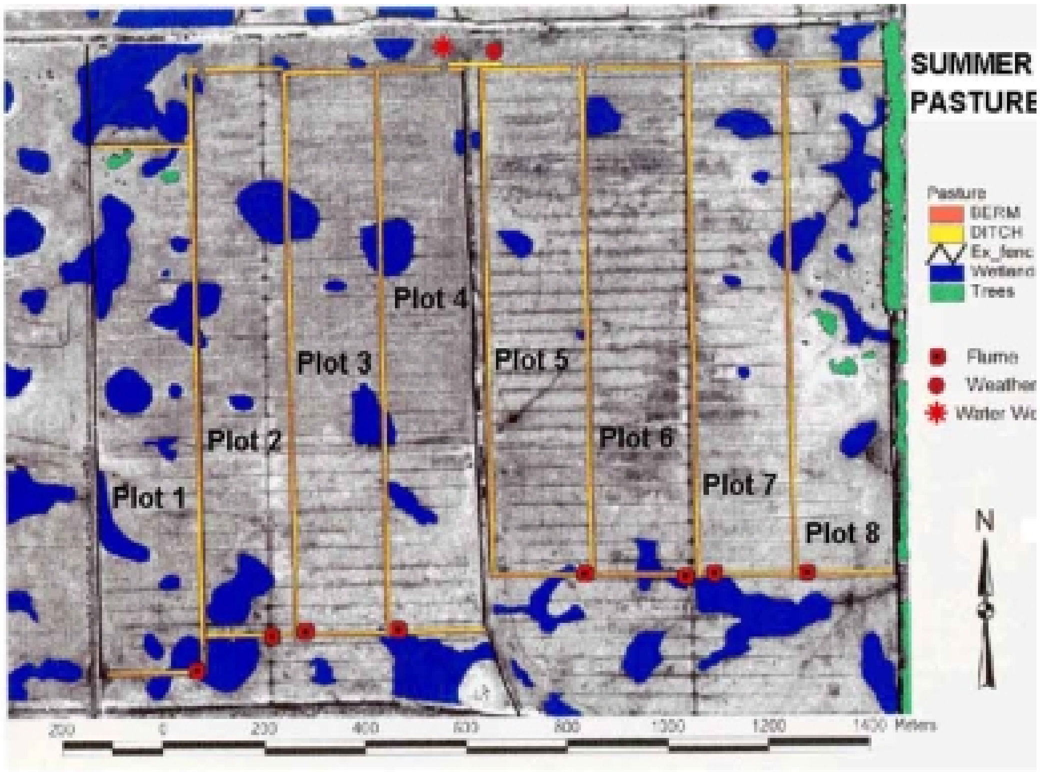


Figure 3.2. Summer pasture block.

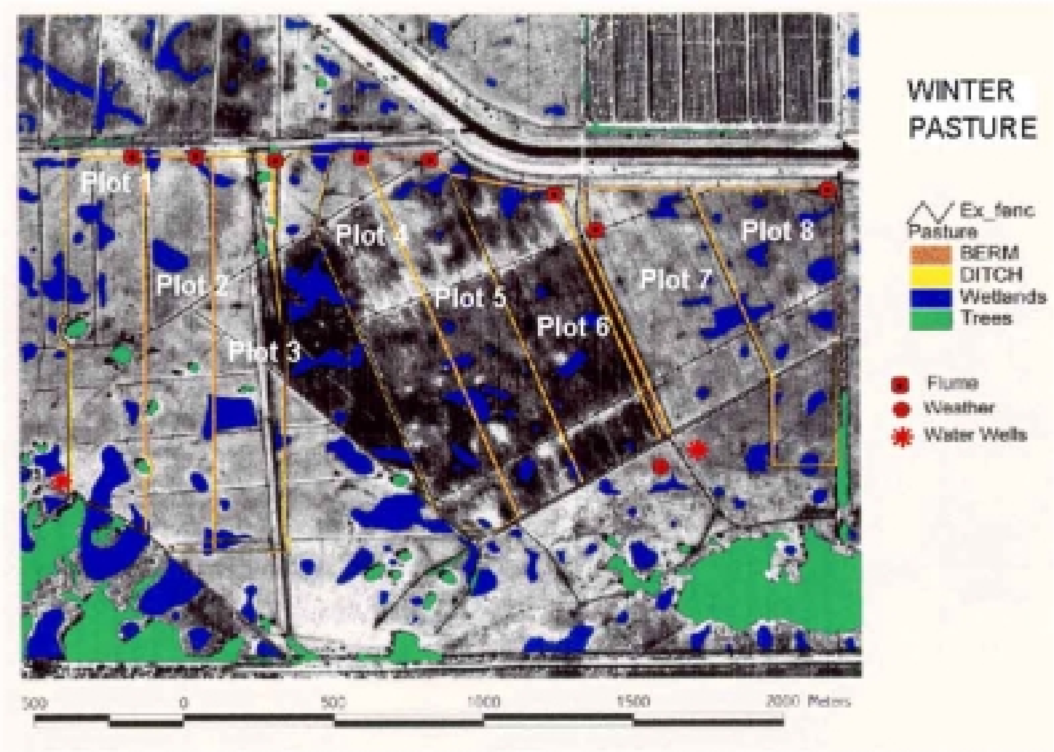


Figure 3.3. Winter pasture block.

3.2. *Surface Water Measurements*

Flumes for collection of surface water runoff from each pasture were constructed at the downstream end of each pasture plot. The flumes and their construction are shown in Figures 3.4 to 3.11. The plots are hydrologically isolated from each other by the construction of ditches and berms along their margins. Livestock are isolated within each plot by pasture fencing. Trapezoidal flumes collect all surface drainage leaving a plot. Trapezoidal flumes are hydrologically unobtrusive and do not significantly alter water table levels or surface runoff. Peak capacity for the flumes is seven cubic feet per second; a capacity dictated by funding limitations but consistent with prior investigations conducted on similar sites by IFAS. Stilling wells, floats and digital encoders monitor flume upstream and downstream water depth. Digital encoders are connected to dataloggers/controllers, which record data and activate automatic water samples based upon instantaneous flow calculations. An example datalogger program is provided in Appendix E.

3.3. *Water Quality Sampling*

Surface drainage water leaving each pasture plot is directed to a trapezoidal flume. Each flume is equipped with an automatic water sampler as shown in Figures 3.12 to 3.14. Programmable dataloggers trigger the samplers based upon flow volume and hydrograph geometry as shown in Table 3.2.

Table 3.2. Automatic sampler schedule.

Sample Number	Accum. Depth inches	Increm. Depth feet	Trigger Value	Bottle Number	QA/QC Code
				1	EB
1	0.02	0.002	**0.00167**	2	FD1
	0.02	0.002	0	3	FD2
2	0.04	0.003	0.00167	4	SS
3	0.08	0.007	**0.00334**	**5**	
4	0.12	0.010	0.00334	6	
5	0.16	0.013	0.00334	7	
6	0.24	0.020	**0.00668**	**8**	
7	0.32	0.027	0.00668	9	
8	0.40	0.033	0.00668	10	
9	0.56	0.047	**0.01336**	**11**	
10	0.72	0.060	0.01336	12	FD1
	0.72	0.060	0	13	FD2
11	1.04	0.087	**0.02672**	**14**	
12	1.36	0.114	0.02672	15	
13	1.68	0.140	0.02672	16	
14	2.32	0.194	**0.05344**	**17**	
15	2.97	0.247	0.05344	18	
16	3.61	0.301	0.05344	19	
17	4.89	0.407	**0.10688**	**20**	
18	6.17	0.514	0.10688	21	
19	7.45	0.621	0.10688	22	FD1
	7.45	0.621	**0**	**23**	FD2
20	**10.02**	0.835	**0.21376**	24	SS

Water samples are analyzed for total phosphorus, nitrate/nitrite, ammonia and total nitrogen, according to DEP approved methods. Grab samples are also taken at each site and tested for soluble reactive phosphorus in addition to the other nutrient parameters. In 1998, Harbor Branch Environmental Laboratory in Ft. Pierce performed chemical analysis of runoff water samples. In 1999, chemical analysis of runoff water samples was performed by Tennessee Valley Authority Environmental Laboratory in Chattanoga, Tennessee. Field parameters (dissolved oxygen, temperature, electrical conductivity, and pH) were measured at each flume by personnel supervised by the IFAS laboratory in Immokalee and by MAERC technicians. Both the Harbor Branch and the IFAS Immokalee laboratories hold quality assurance quality control certification from the DEP.

Flow data from the flumes are combined with nutrient concentration data to determine loading rates for total phosphorus, nitrate, ammonia and total nitrogen. Water level and nutrient concentration data collected at each flume were subdivided into identifiable flow events to evaluate the effect of stocking rates on nutrient concentration and loads. Nutrient mass loadings were computed for each plot.

3.4. Livestock and Pasture Management

The breeding females utilized for the demonstration project were randomly chosen from a breeding herd of 570 head on Buck Island Ranch. Animal selection was based upon age (ability to fulfill the 2 year project duration), pregnancy status at time of starting the project, health, conformation, and disposition. The selected animals were identified with a number tagging system. One hundred forty breeding females were chosen and stratified by age, stage of pregnancy, and frame size then randomly assigned to a stocking rate. Open females are replaced with 4-year-old pregnant cows from the replacement herd once a year at weaning time. This is the stage when a cow's offspring is separated from his mother and sold to other sectors of the industry.

Animals are maintained on winter pastures from November through May and on summer pastures from June through October. Animals continuously graze while on the pastures and nutritional supplementation are provided throughout the year, as standard management practices require. Each stocking rate herd is maintained as a unit when moved between winter and summer pastures.

The following animal data are collected: cow body weight, calf birth date, calf birth weight, calf weaning weight, calf average daily gain, and herd health schedule. Body condition score is measured, according to methods described by Kunkle et. al. (1994) to assess if the nutritional needs of animals are being met. Animal dystocia (calving difficulty) is measured since it represents a potential economic loss to the rancher. Calf weaning weight is also measured. This is the weight of an offspring when the individual is separated from his mother and sold to other sectors of the industry. This is an important economic parameter because most producers sell their calves at weaning stage and receive the income for their operation at that time.

3.5. Soil and Water Quality Assessment

Pasture construction, including ditching and fencing, was completed in spring 1997. Water quantity and water quality monitoring instrument installation was completed by June 1998. It was expected that it may take as long as one year for soil and water chemistry to equilibrate following construction-related soil disturbance. During the equilibration period the pastures were stocked at the lowest stocking rate (0.3 cows-calves per acre). During this time pasture runoff volumes, water quality, and meteorological conditions were measured continuously. These measurements serve two important purposes. First, they provide critical background information on intra and inter-pasture variation in soil and water chemistry. This knowledge is important in the eventual design of BMPs for beef cattle ranching.

At least 10 soil samples were collected from 0-5 cm depth in each of the 16 plots of the winter and summer pasture arrays on a quarterly basis. Soil samples were analyzed for P by University of Florida Analytical Research Lab in Gainesville, a DEP certified lab.

3.6. Stocking Rate Optimization Project

Following the pasture system equilibration period, the breeding females were placed into the appropriate pasture arrays and the optimization project began. Water quality, soil chemistry, meteorological, and animal data collection continued for one year, 1999. The pastures were managed according to practices that fall within or near to commonly utilized beef cattle production standards in Florida. These practices, and the corresponding optimization project data collected, are relevant to all beef cattle ranches in Florida, particularly those on low topography landscapes having relatively low soil phosphorus retention capacities.

3.7. Beef Cattle BMP Public Workshop

Public presentations and exhibits were held each year at the annual convention of the Florida Cattlemen’s Association to convey the results of the optimization project to the beef cattle ranching community. In addition a video supplement to the final report project report was prepared, reproduced and delivered to regional water managers and cattlemen. These education components increase the chances for project acceptance by the affected stakeholders, and the chances for long-term project relevance and success in promoting BMP adoption and water quality improvements.

Figure 3.4. Construction of flume station.

Figure 3.5. Construction of flume station.

Figure 3.6. View of flume station from downstream location.

Figure 3.7. Completed flume station.

Figure 3.8. Stilling well with pulley, float and counterweight.

Figure 3.9. Digital stage encoders at stilling wells.

Figure 3.10. Datalogger/controller shelter and hardware.

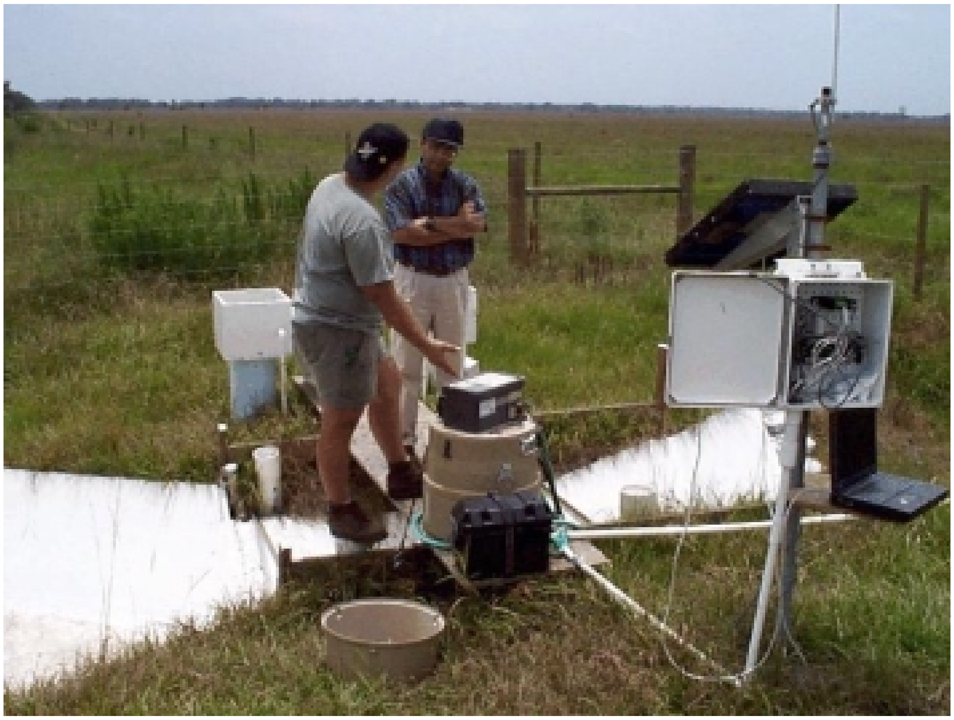


Figure 3.11. Flume instrumentation.

Figure 3.12. Autosampler intake strainer at flume approach section.

Figure 3.13. Automatic water sampler.

Figure 3.14. Automatic water sampler with plastic bottle liners.

4. Nutrient Concentrations

4.1. Autosamples

Runoff water samples were collected at each of the 16 flume stations. The vast majority of these samples were autosamples collected by the ISCO units commanded by the CR-10 dataloggers. Manual grab samples were collected periodically in 1999 to augment the autosample data. Tests conducted on the autosamples include TP, TKN, NH_3, and NO_x. Tests performed on the grab samples include NH_3, TKN, TP, NO_x, and ortho-P.

With the exception of the NO_x parameters, the summer pasture nutrient concentrations were higher than the winter pasture concentrations. Of all parameters measured, TP showed the most dramatic differences in runoff water quality between the two pasture blocks, with summer pasture concentrations exceeding winter pasture concentrations by a factor of 5 or more. Winter plot TP values were in the range of 0.10 mg/L while the summer plot TP measurements were in the range of 0.50 mg/L. TKN values for both blocks were in the 3 to 4 mg/L range, NH_3 was 0.1 to 0.3 mg/L, and NOx was less than 0.05 mg/L.

Tables 4.1.1 to 4.1.4 present results arranged by parameter. Figures 4.1.1 to 4.1.8 present monthly mean values for each parameter by pasture block. Figures 4.1.9 to 4.1.16 present all data for a given parameter in a condensed format allowing visual inspection of the variability. Figures 4.2.1 to 4.2.2 provide some indication of the grab sample data.

In some cases the summary statistics tables report standard deviations that exceed the mean concentration values. This is the result of bimodal frequency distributions observed in several cases. These sites exhibited low nutrient concentrations for the majority of the time but with periodic concentration spikes well in excess of the typical observations.

4.2. Grab Samples

Figures 4.2.3 and 4.2.4 are important graphics. They present comparisons of the frequency distribution of the ortho-P to TP ratio for the summer and winter pasture runoff. The summer runoff exhibits much higher values (0.74 average) compared to the winter runoff (0.23 average). However, the fact that many ratios exceed one brings these measurements into question. Unfortunately each new budget year has bought a new contract lab to the project. Hopefully the third lab will remain with the project through to its completion. It is not possible to determine if the source of the P concentration/ratio problem is related to laboratory issues or to sample collection and labeling problems. The ortho-P to Total P ratio is significant because it represents the proportion of phosphorus load that is in a biologically active form and thus represents a more immediate nutrient problem to the aquatic system. An effective BMP that reduces the ortho-P to TP ratio can be considered partially effective even if there is no reduction in the TP concentration.

4.3. QA/QC

Figures 4.3.1 to 4.3.20 and Tables 4.3.1 to 4.3.9 present various QA/QC measures for the nutrient concentration measurements. Results were generally good. There were some problems with high equipment blanks in some cases. Many of these occurred prior to the installation of a reliable water treatment system and an effective maintenance program at the MAERC field lab.

Table 4.1.1. Summary statistics for NH_3-N treatment results: number of samples, mean concentrations in mg/L, and standard deviation (control plots highlighted).

Year	Site	Treatment	Rep	n	NH3-N mg/L	SD
1998	w1	15	1	188	0.18	0.20
	w2	20	1	144	0.18	0.07
	w3	35	1	204	0.19	0.08
	w4	C	1	131	0.17	0.08
	w5	35	2	188	0.18	0.09
	w6	15	2	183	0.16	0.07
	w7	C	2	158	0.22	0.10
	w8	20	2	217	0.20	0.16
	Average			177	0.19	0.11
	s1	C	1	97	0.23	0.08
	s2	20	1	41	0.27	0.05
	s3	35	1	7	0.33	0.15
	s4	15	1	91	0.20	0.05
	s5	35	2	69	0.35	0.24
	s6	15	2	112	0.21	0.17
	s7	20	2	125	0.28	0.25
	s8	C	2	83	0.33	0.46
	Average			78	0.28	0.18
1999	w1	15	1	51	0.16	0.09
	w2	20	1	39	0.18	0.06
	w3	35	1	31	0.20	0.10
	w4	C	1	74	0.21	0.09
	w5	35	2	43	0.24	0.07
	w6	15	2	51	0.19	0.07
	w7	C	2	35	0.20	0.06
	w8	20	2	22	0.24	0.07
	Average			43	0.20	0.08
	s1	C	1	49	0.32	0.16
	s2	20	1	44	0.35	0.13
	s3	35	1	29	0.39	0.40
	s4	15	1	45	0.30	0.23
	s5	35	2	42	0.25	0.07
	s6	15	2	53	0.23	0.08
	s7	20	2	68	0.28	0.09
	s8	C	2	49	0.25	0.09
	Average			47	0.30	0.16

Table 4.1.2. Summary statistics for NOx-N treatment results: number of samples, mean concentrations in mg/L, and standard deviation (control plots highlighted).

Year	Site	Treatment	Rep	n	NOx mg/L	SD
1998	w1	15	1	188	0.02	0.02
	w2	20	1	144	0.02	0.02
	w3	35	1	204	0.05	0.10
	w4	C	1	131	0.02	0.01
	w5	35	2	188	0.02	0.02
	w6	15	2	183	0.02	0.01
	w7	C	2	158	0.03	0.04
	w8	20	2	217	0.02	0.02
	Average			177	0.03	0.03
	s1	C	1	97	0.01	0.01
	s2	20	1	41	0.01	0.01
	s3	35	1	7	0.02	0.03
	s4	15	1	91	0.01	0.01
	s5	35	2	69	0.02	0.03
	s6	15	2	112	0.01	0.01
	s7	20	2	125	0.01	0.01
	s8	C	2	83	0.01	0.01
	Average			78	0.01	0.02
1999	w1	15	1	51	0.09	0.26
	w2	20	1	39	0.02	0.04
	w3	35	1	31	0.01	0.01
	w4	C	1	74	0.01	0.02
	w5	35	2	43	0.02	0.02
	w6	15	2	51	0.01	0.01
	w7	C	2	36	0.01	0.01
	w8	20	2	22	0.03	0.04
	Average			43	0.03	0.05
	s1	C	1	49	0.02	0.02
	s2	20	1	44	0.02	0.02
	s3	35	1	29	0.01	0.003
	s4	15	1	45	0.01	0.01
	s5	35	2	42	0.01	0.01
	s6	15	2	53	0.01	0.02
	s7	20	2	68	0.02	0.02
	s8	C	2	52	0.01	0.01
	Average			48	0.01	0.01

Table 4.1.3. Summary statistics for TKN treatment results: number of samples, mean concentrations in mg/L, and standard deviation (control plots highlighted).

Year	Site	Treatment	Rep	n	TKN mg/L	SD
1998	w1	15	1	188	3.61	1.03
	w2	20	1	144	3.60	0.88
	w3	35	1	204	3.29	1.09
	w4	C	1	131	3.42	0.87
	w5	35	2	188	3.90	0.71
	w6	15	2	183	3.38	0.85
	w7	C	2	158	3.92	1.36
	w8	20	2	217	3.42	1.00
	Average			177	3.57	0.97
	s1	C	1	97	3.21	0.91
	s2	20	1	41	3.05	1.40
	s3	35	1	7	3.86	1.70
	s4	15	1	91	3.25	1.09
	s5	35	2	69	3.82	1.19
	s6	15	2	112	4.01	1.31
	s7	20	2	125	3.17	1.27
	s8	C	2	83	3.65	1.16
	Average			78	3.50	1.25
1999	w1	15	1	51	3.25	0.94
	w2	20	1	39	3.04	1.33
	w3	35	1	31	3.70	0.92
	w4	C	1	74	3.76	1.65
	w5	35	2	43	3.65	1.13
	w6	15	2	51	9.94	1.58
	w7	C	2	36	3.81	1.51
	w8	20	2	22	3.04	0.78
	Average			43	4.27	1.23
	s1	C	1	49	5.74	9.05
	s2	20	1	44	4.95	1.12
	s3	35	1	29	4.24	1.45
	s4	15	1	45	4.10	1.43
	s5	35	2	42	4.49	1.44
	s6	15	2	53	4.67	1.79
	s7	20	2	68	4.58	2.06
	s8	C	2	48	4.22	1.36
	Average			47	4.62	2.46

Table 4.1.4. Summary statistics for Total P treatment results: number of samples, mean concentrations in mg/L, and standard deviation (control plots highlighted).

Year	Site	Treatment	Rep	n	Total P mg/L	SD
1998	w1	15	1	188	0.06	0.05
	w2	20	1	144	0.06	0.08
	w3	35	1	204	0.10	0.08
	w4	C	1	131	0.06	0.06
	w5	35	2	188	0.06	0.03
	w6	15	2	183	0.08	0.07
	w7	C	2	158	0.13	0.21
	w8	20	2	217	0.07	0.07
	Average			177	0.08	0.08
	s1	C	1	97	0.35	0.27
	s2	20	1	41	0.19	0.09
	s3	35	1	7	0.76	0.29
	s4	15	1	91	0.47	0.40
	s5	35	2	69	0.62	0.37
	s6	15	2	112	0.33	0.15
	s7	20	2	125	0.22	0.12
	s8	C	2	83	0.76	0.52
	Average			78	0.46	0.28
1999	w1	15	1	51	0.13	0.27
	w2	20	1	38	0.19	0.69
	w3	35	1	31	0.08	0.04
	w4	C	1	74	0.07	0.03
	w5	35	2	43	0.10	0.09
	w6	15	2	51	0.07	0.03
	w7	C	2	36	0.22	0.67
	w8	20	2	22	0.10	0.11
	Average			43	0.12	0.24
	s1	C	1	49	0.51	0.29
	s2	20	1	44	0.56	0.28
	s3	35	1	29	0.48	0.48
	s4	15	1	45	0.58	0.45
	s5	35	2	42	0.65	0.42
	s6	15	2	53	0.58	0.34
	s7	20	2	68	0.60	0.44
	s8	C	2	52	0.65	0.29
	Average			48	0.58	0.37

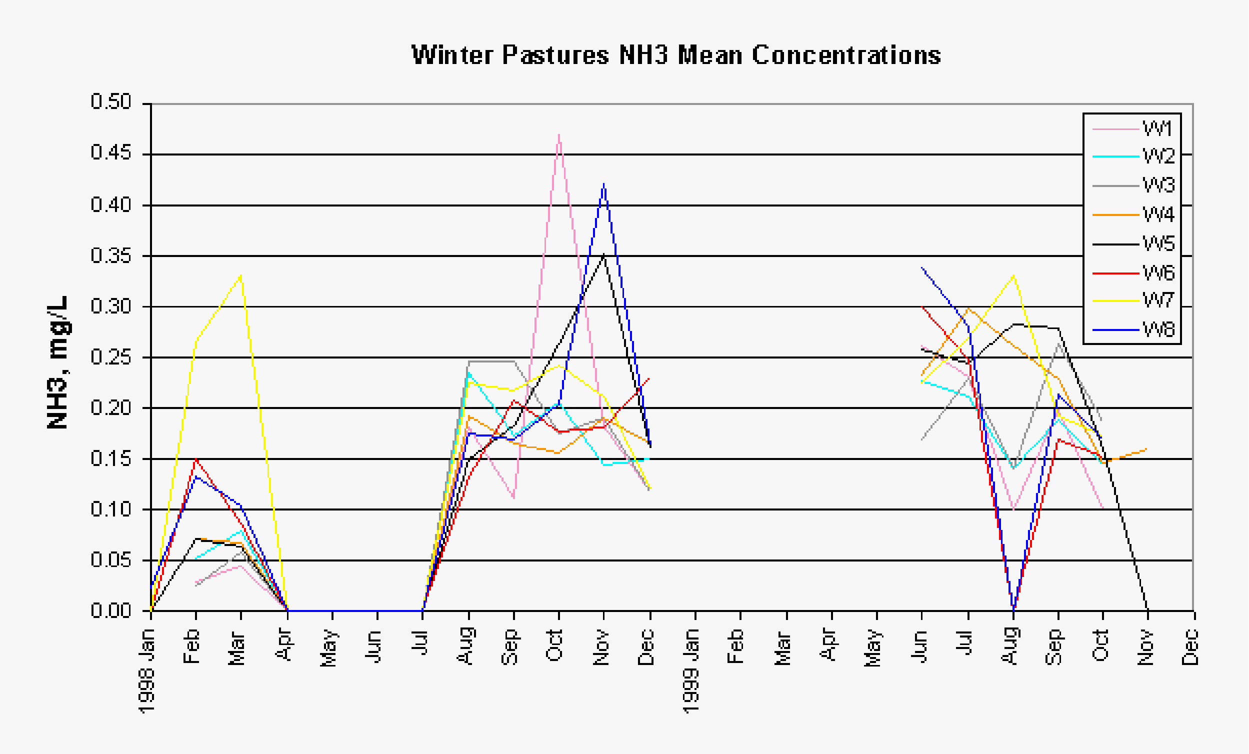


Figure 4.1.1. Monthly mean concentration of NH3 as elemental nitrogen for autosamples collection from winter pasture plot.

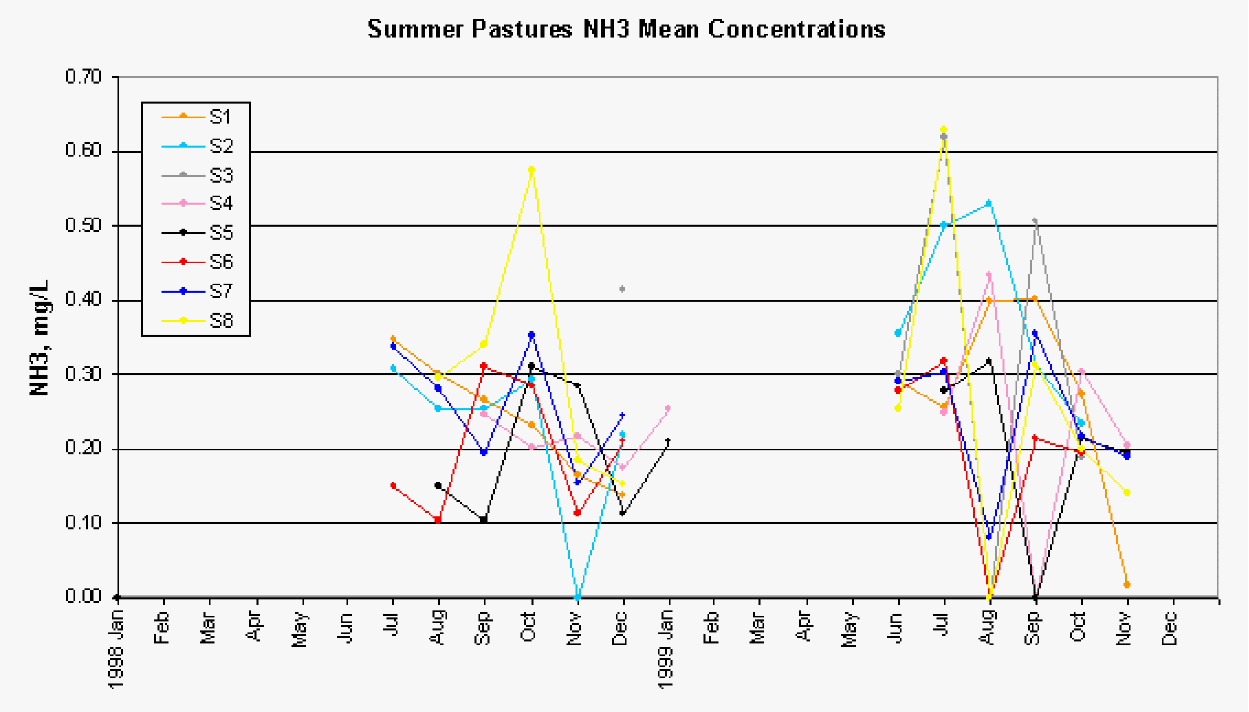


Figure 4.1.2. Monthly mean concentration of NH3 as elemental nitrogen for autosamples collection from summer pasture plot.

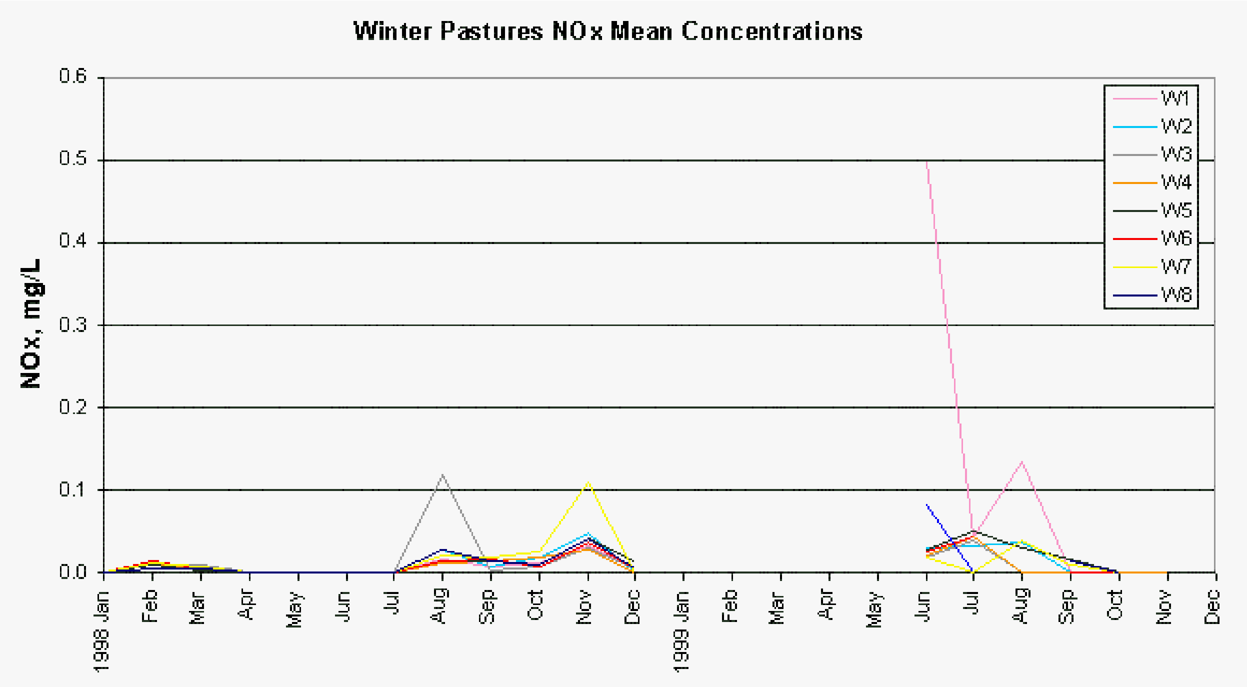


Figure 4.1.3 Monthly mean concentration of N0x as elemental nitrogen for autosamples collection from winter pasture plot.

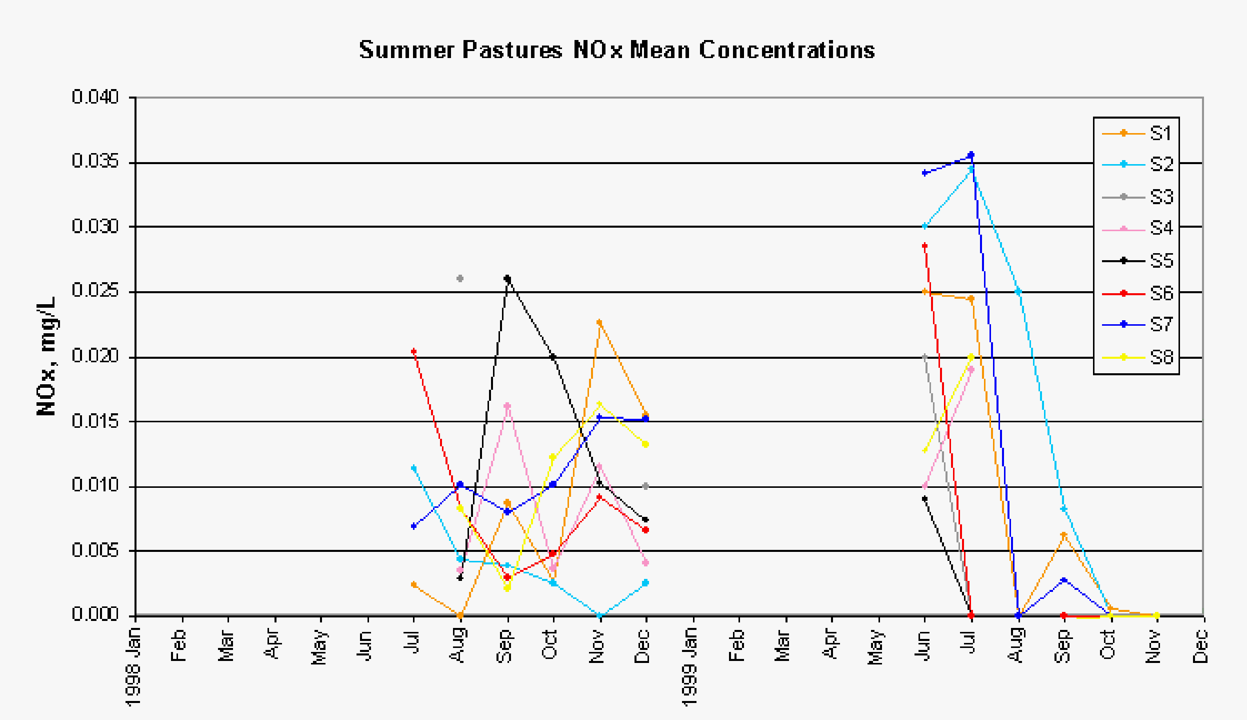


Figure 4.1.4. Monthly mean concentration of N0x as elemental nitrogen for autosamples collection from summer pasture plot.

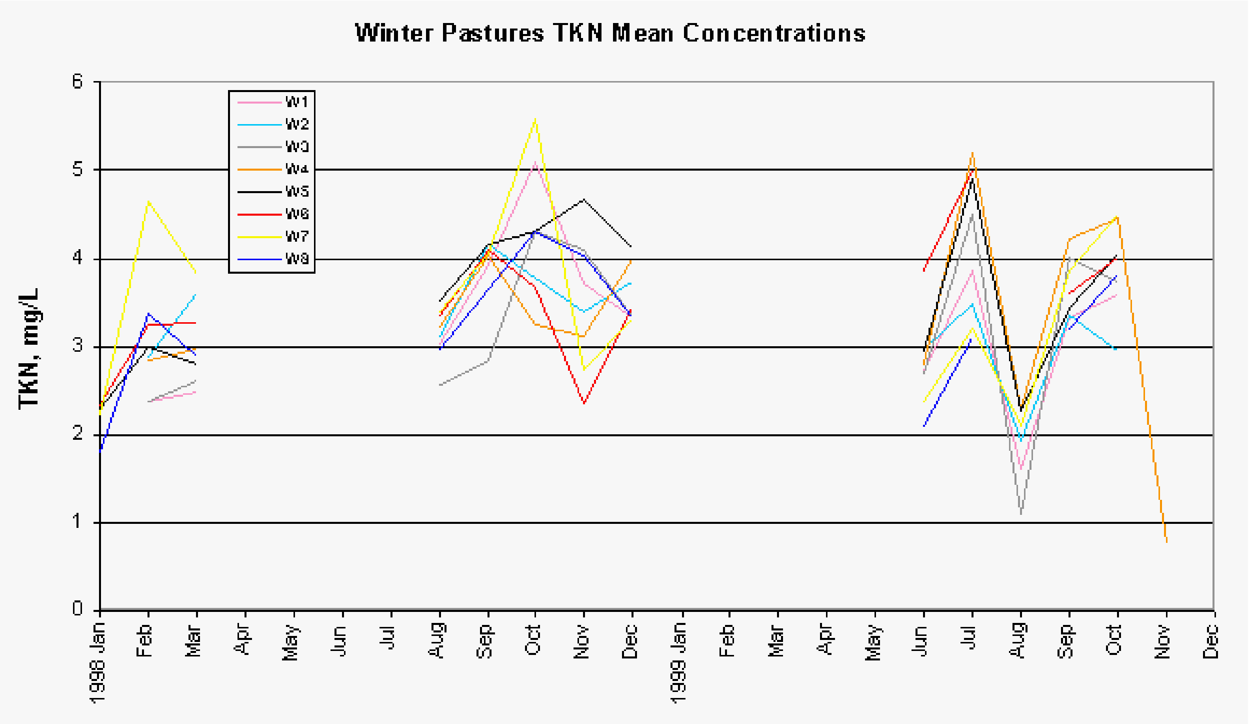


Figure 4.1.5. Monthly mean concentration of TKN as elemental nitrogen for autosamples collection from winter pasture plot.

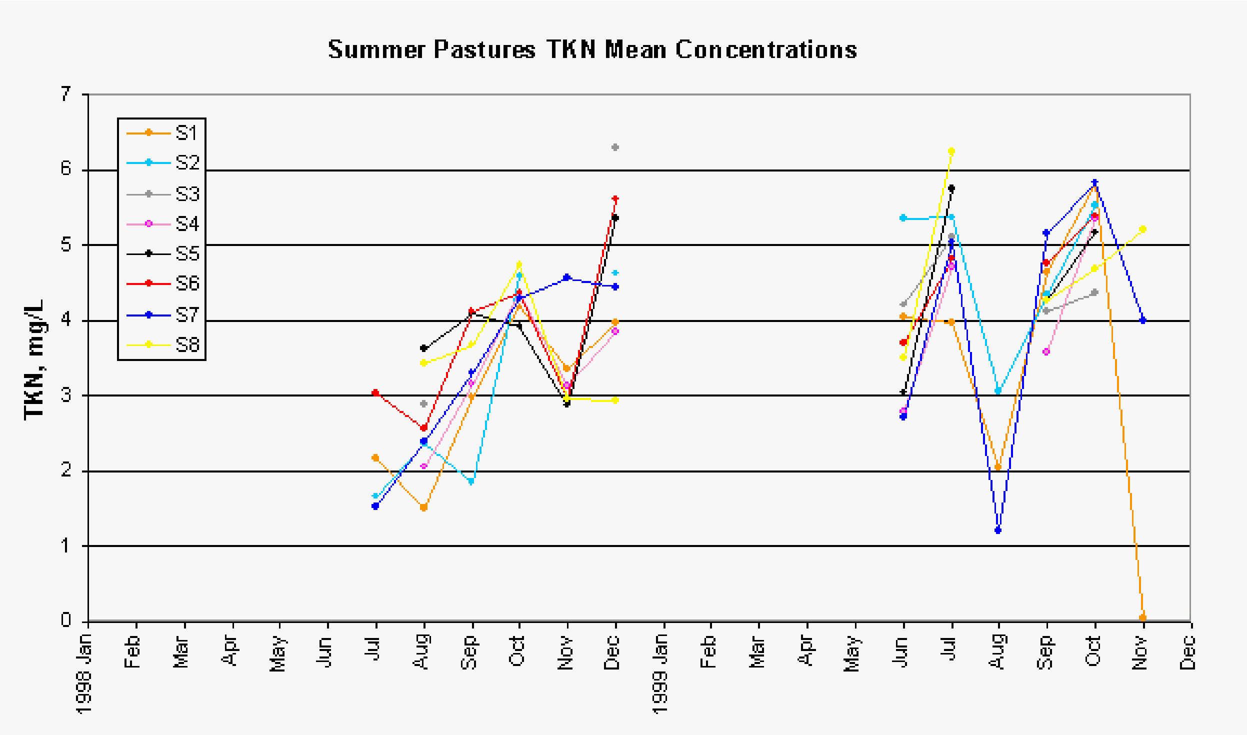


Figure 4.1.6. Monthly mean concentration of TKN as elemental nitrogen for autosamples collection from summer pasture plot.

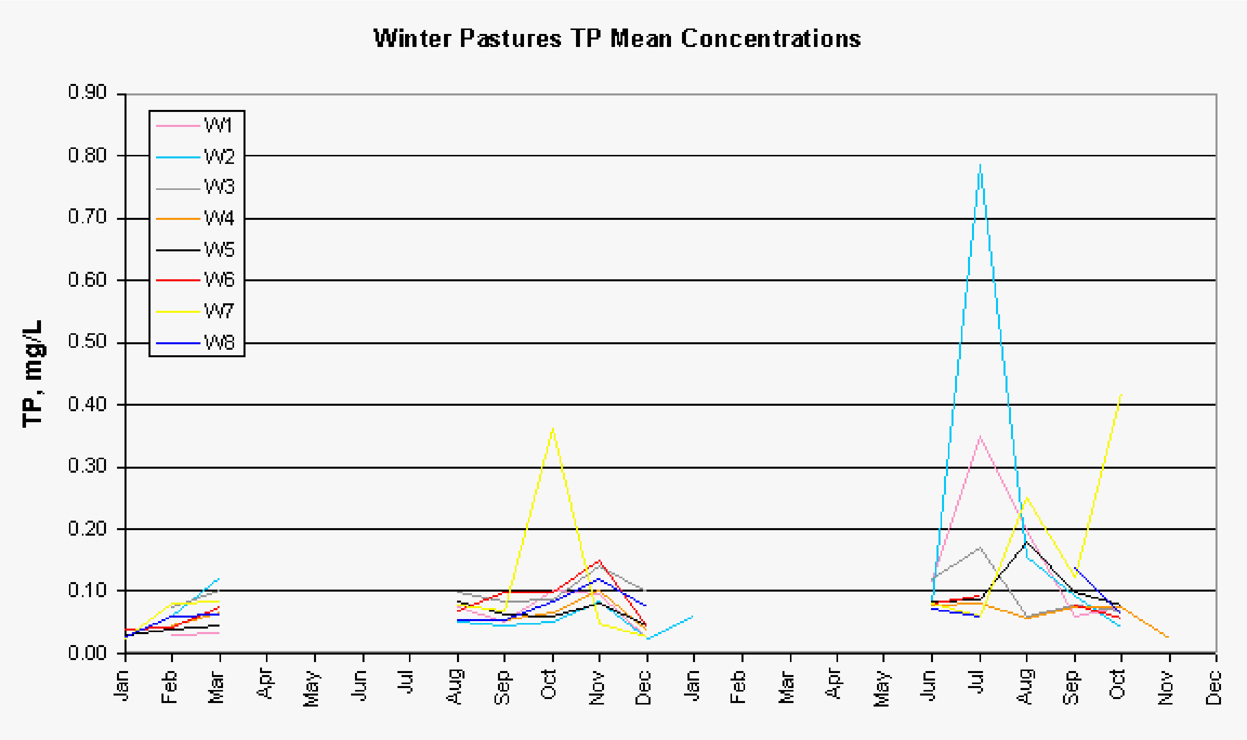


Figure 4.1.7. Monthly mean concentration of TP as elemental phosphorus for autosamples collection from winter pasture plot.

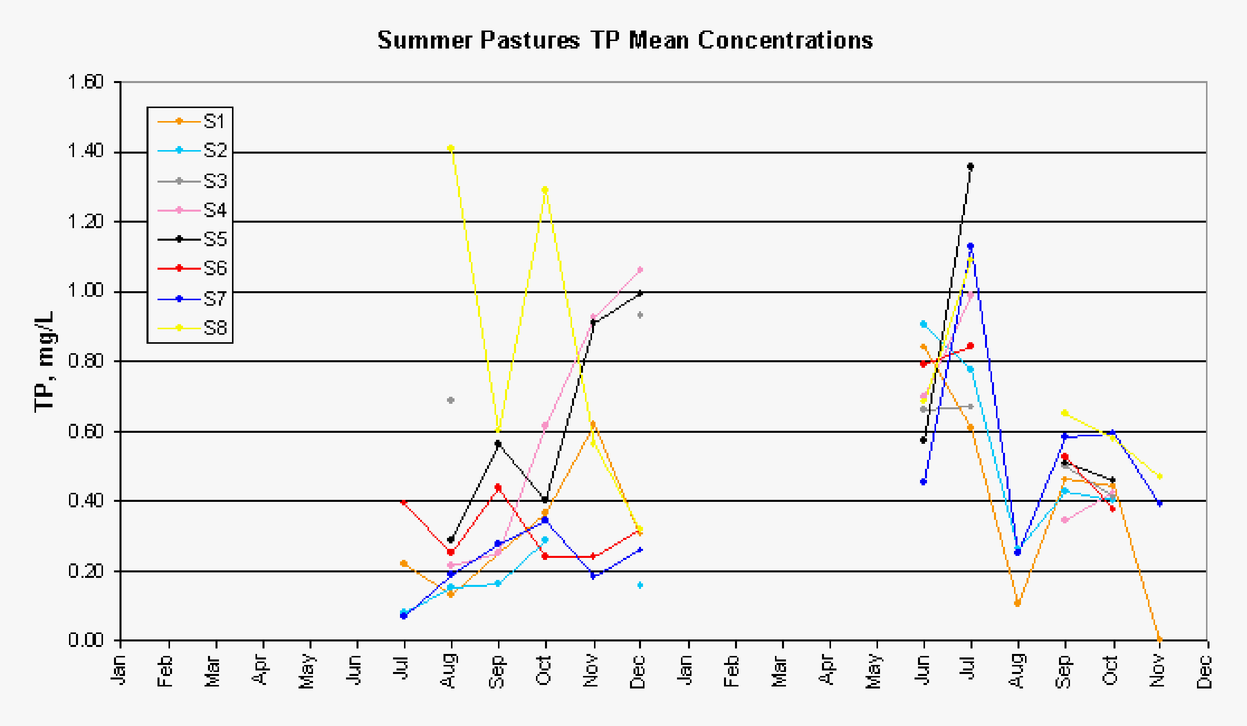


Figure 4.1.8. Monthly mean concentration of TP as elemental phosphorus for autosamples collection from summer pasture plot.

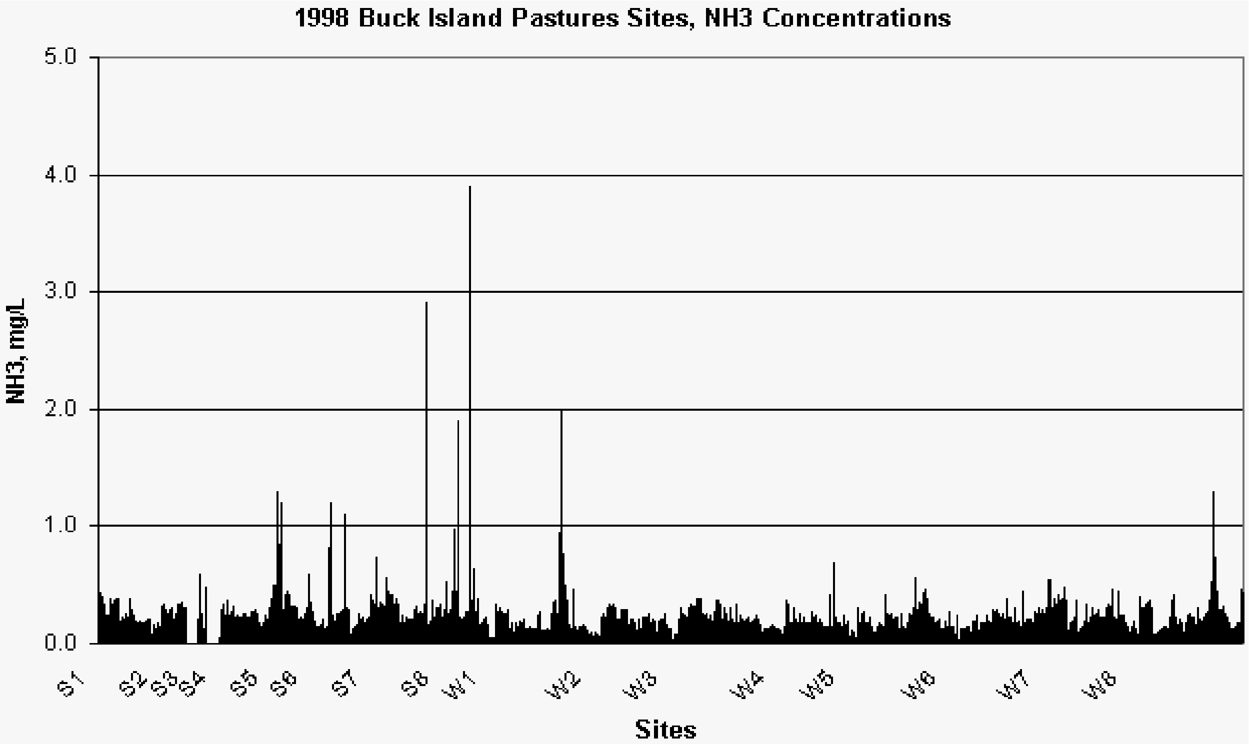


Figure 4.1.9. Individual autosample concentrations of NH3 as elemental nitrogen for each pasture plot for full period of record.

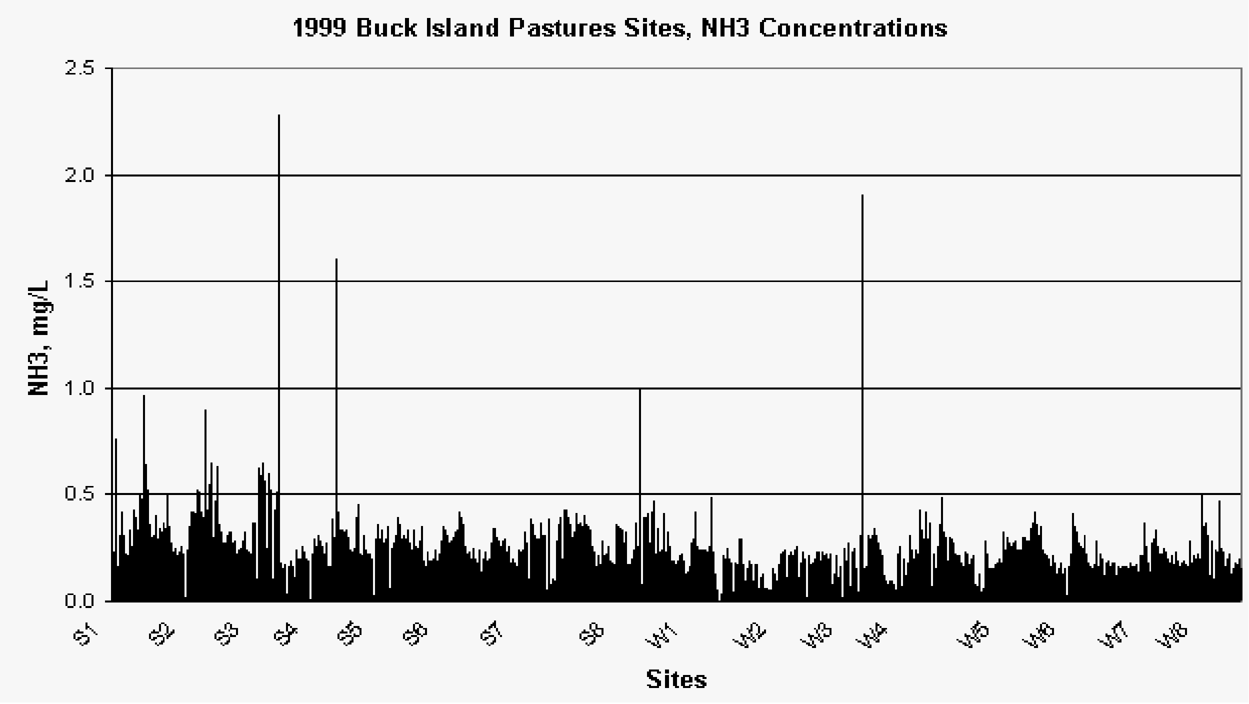


Figure 4.1.10. Individual autosample concentrations of NH3 as elemental nitrogen for each pasture plot for full period of record.

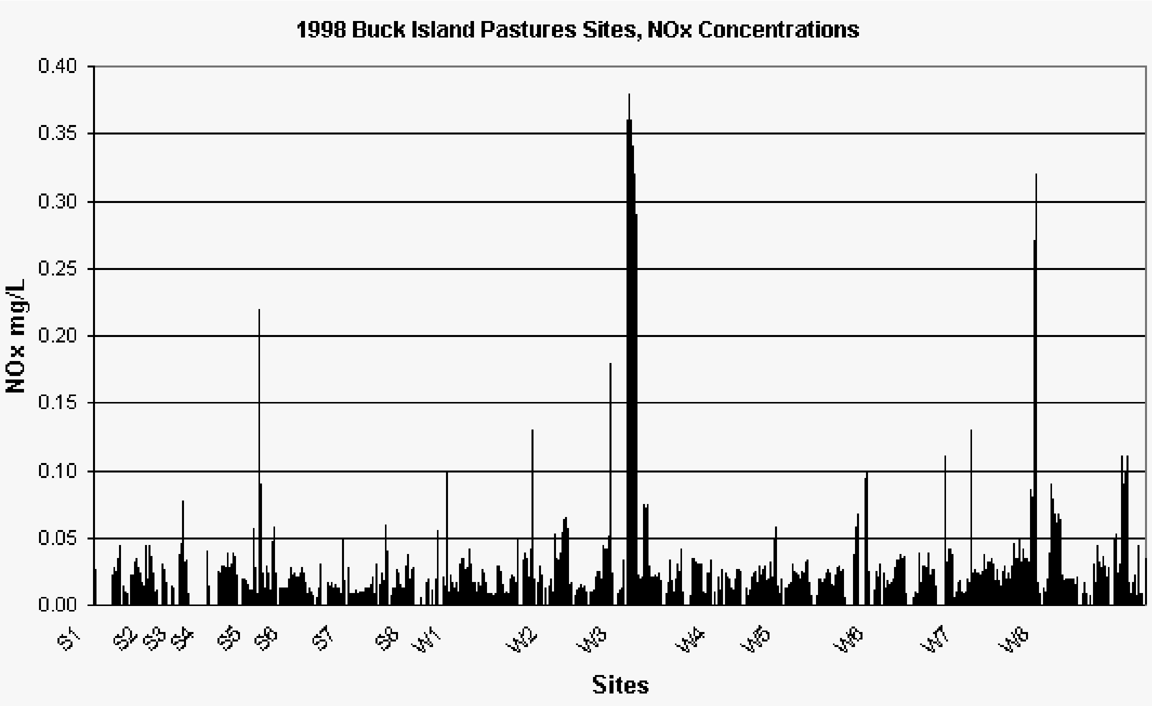


Figure 4.1.11. Individual autosample concentrations of N0x as elemental nitrogen for each pasture plot for full period of record.

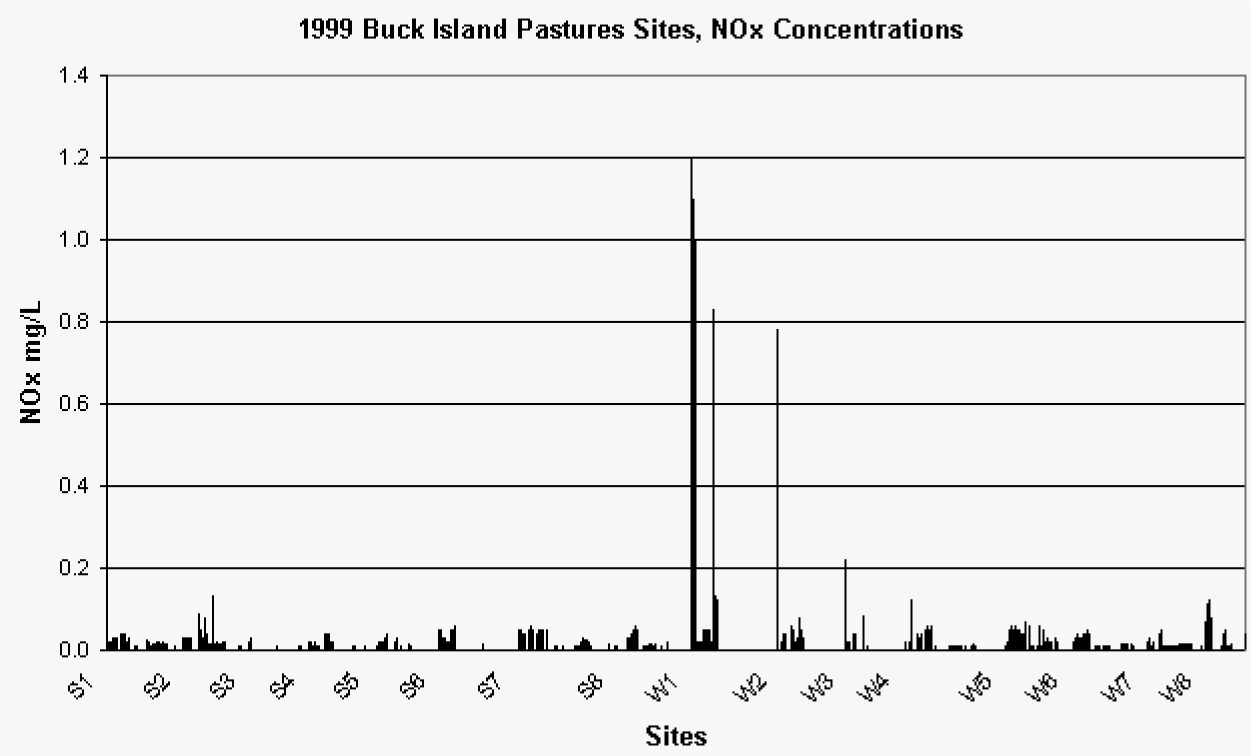


Figure 4.1.12. Individual autosample concentrations of N0x as elemental nitrogen for each pasture plot for full period of record.

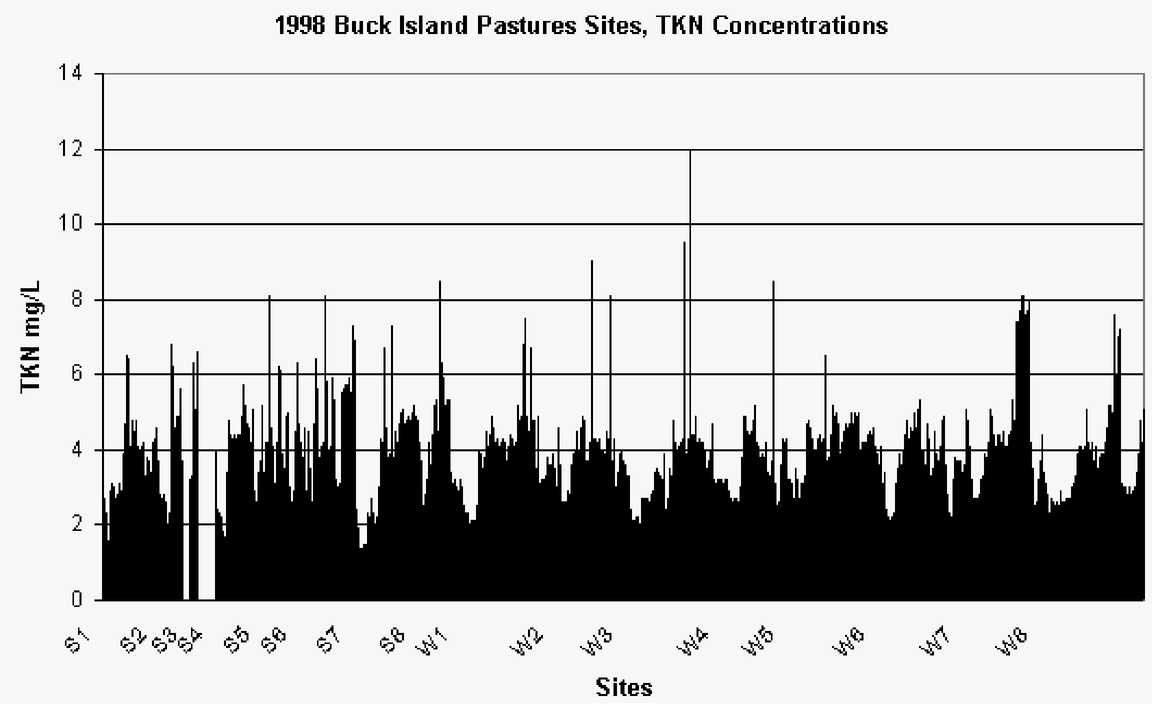


Figure 4.1.13. Individual autosample concentrations of TKN as elemental nitrogen for each pasture plot for full period of record.

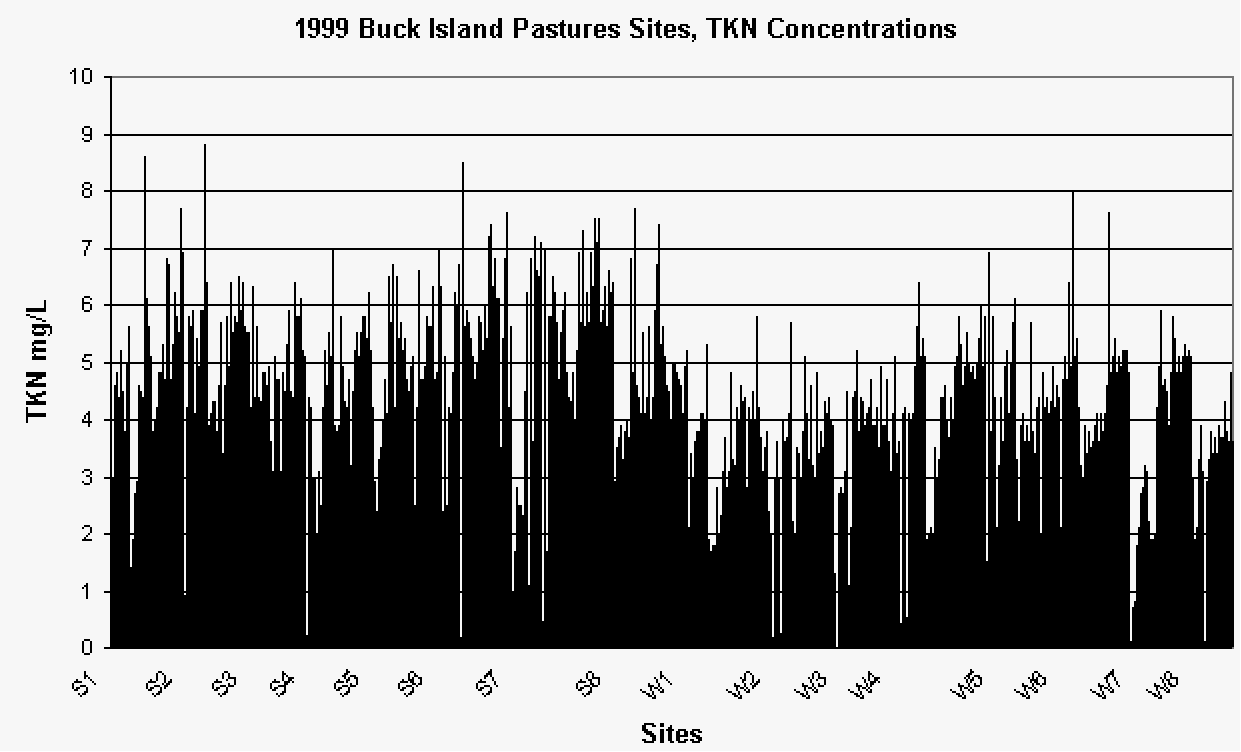


Figure 4.1.14. Individual autosample concentrations of TKN as elemental nitrogen for each pasture plot for full period of record.

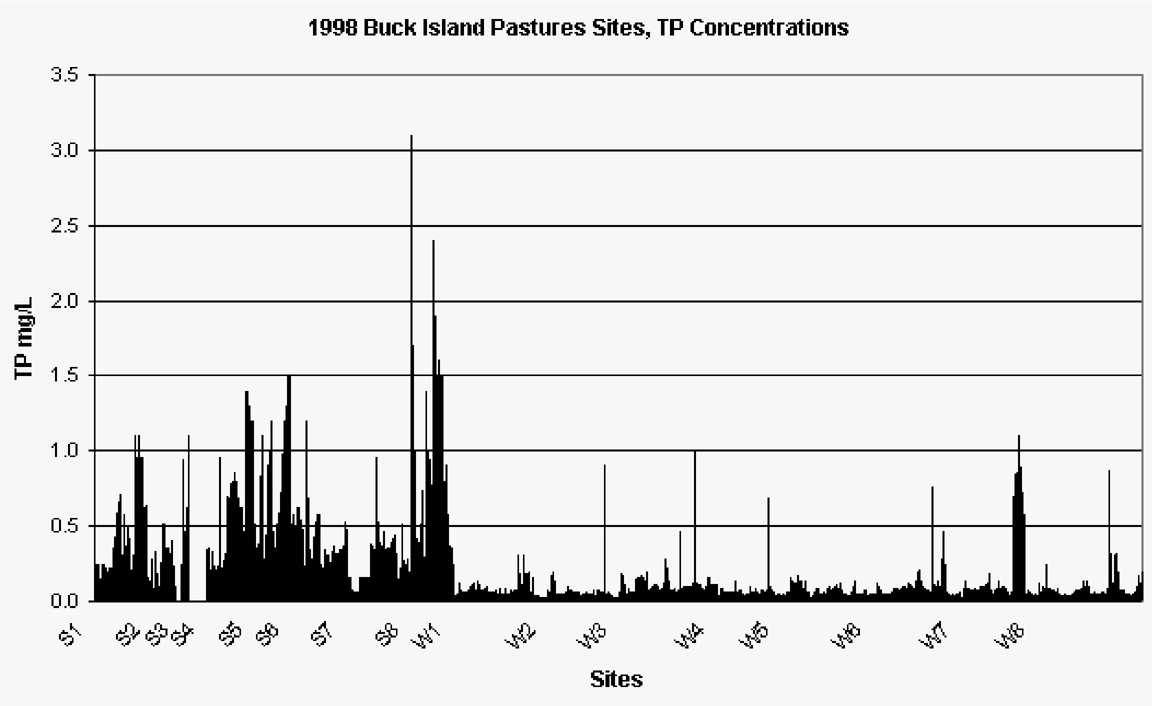


Figure 4.1.15. Individual autosample concentrations of TP as elemental phosphorus for each pasture plot for full period of record.

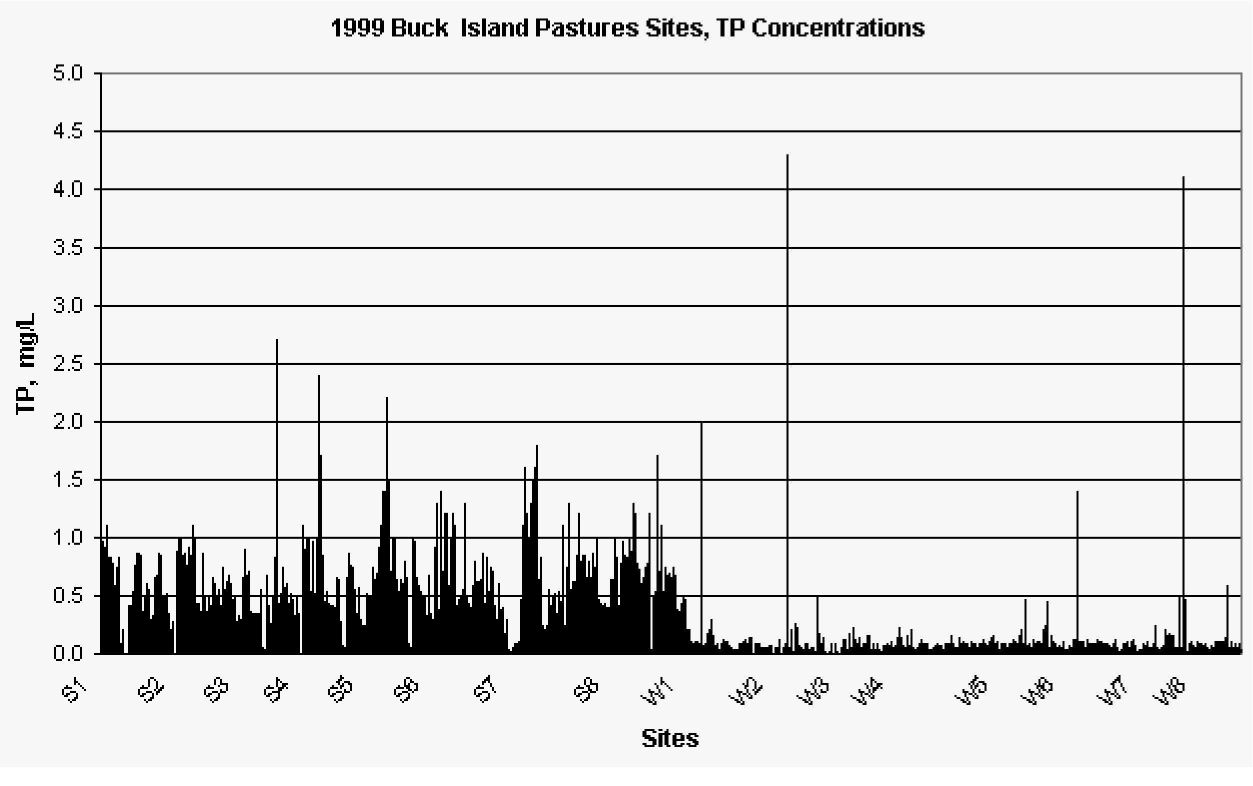


Figure 4.1.16. Individual autosample concentrations of TP as elemental phosphorus for each pasture plot for full period of record.

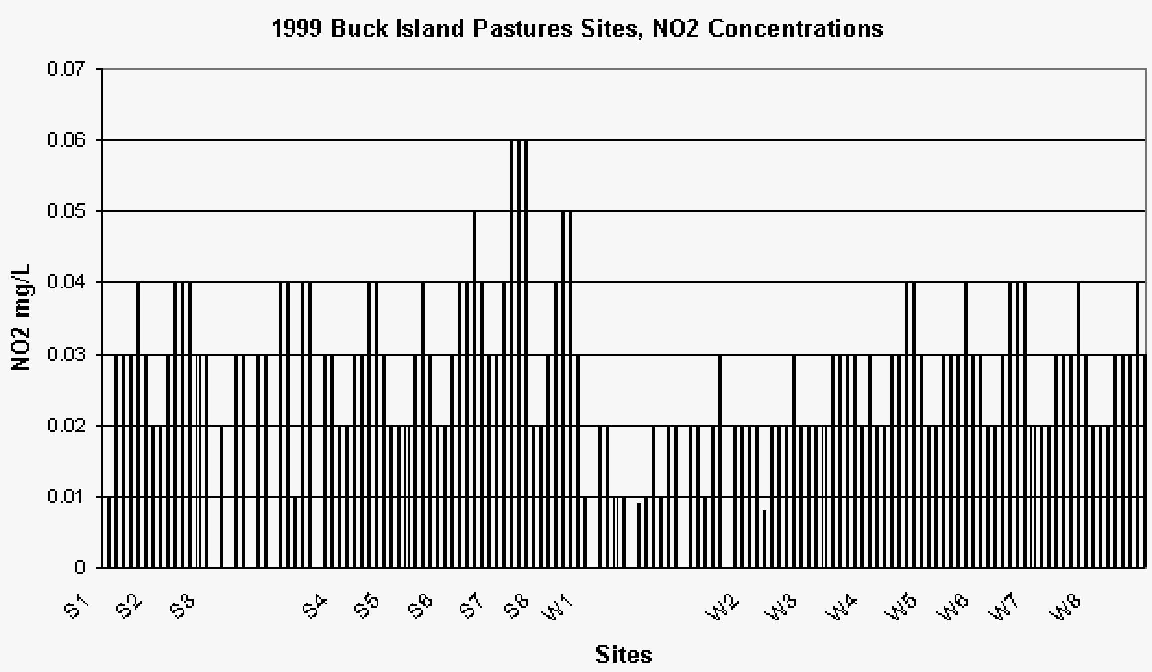


Figure 4.2.1. Individual grab sample concentrations of N02 as elemental nitrogen for each pasture plot for full period of record.

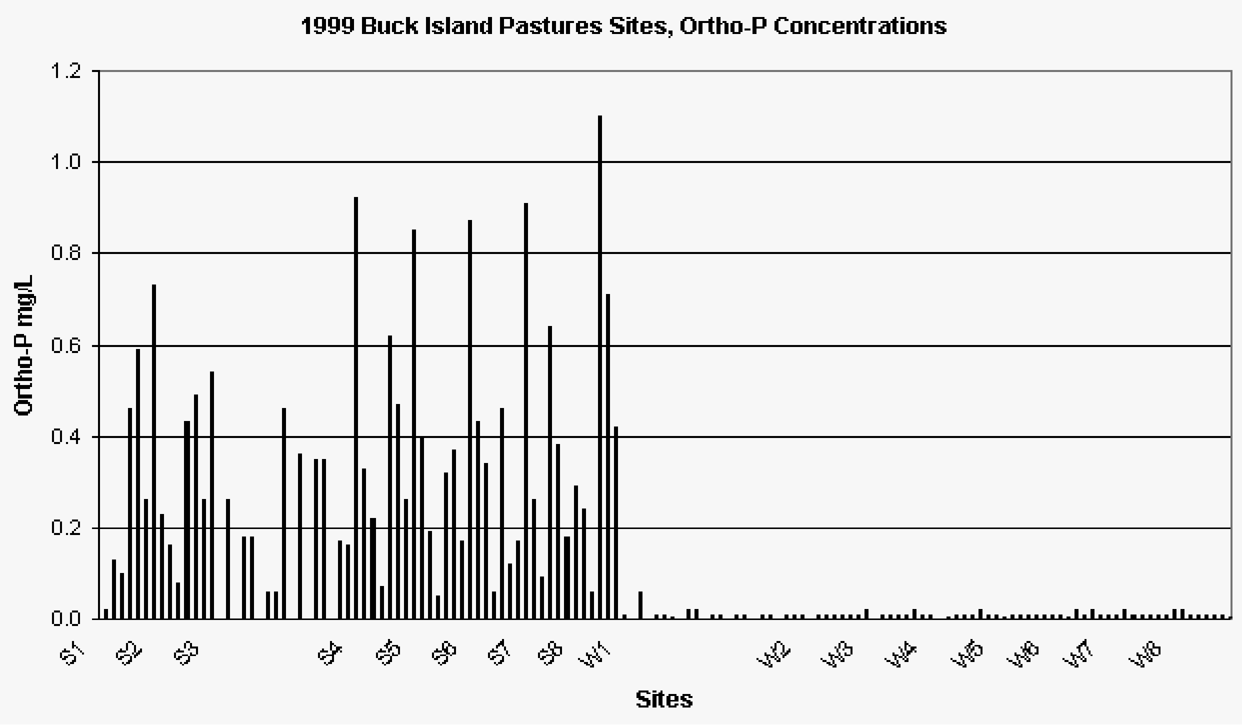


Figure 4.2.2. Individual grab sample concentrations of P04 as elemental phosphorus for each pasture plot for full period of record.

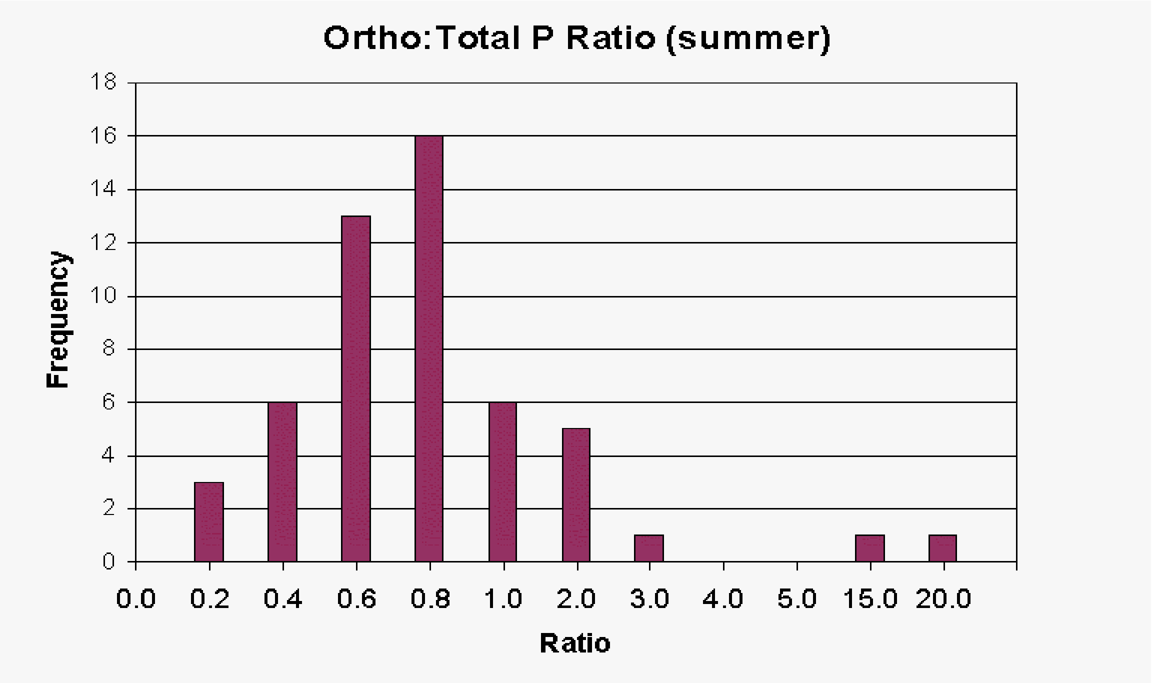


Figure 4.2.3. Frequency histogram for ratio of soluble reactive phosphorus (ortho-P) to total P for summer pastures grab samples.

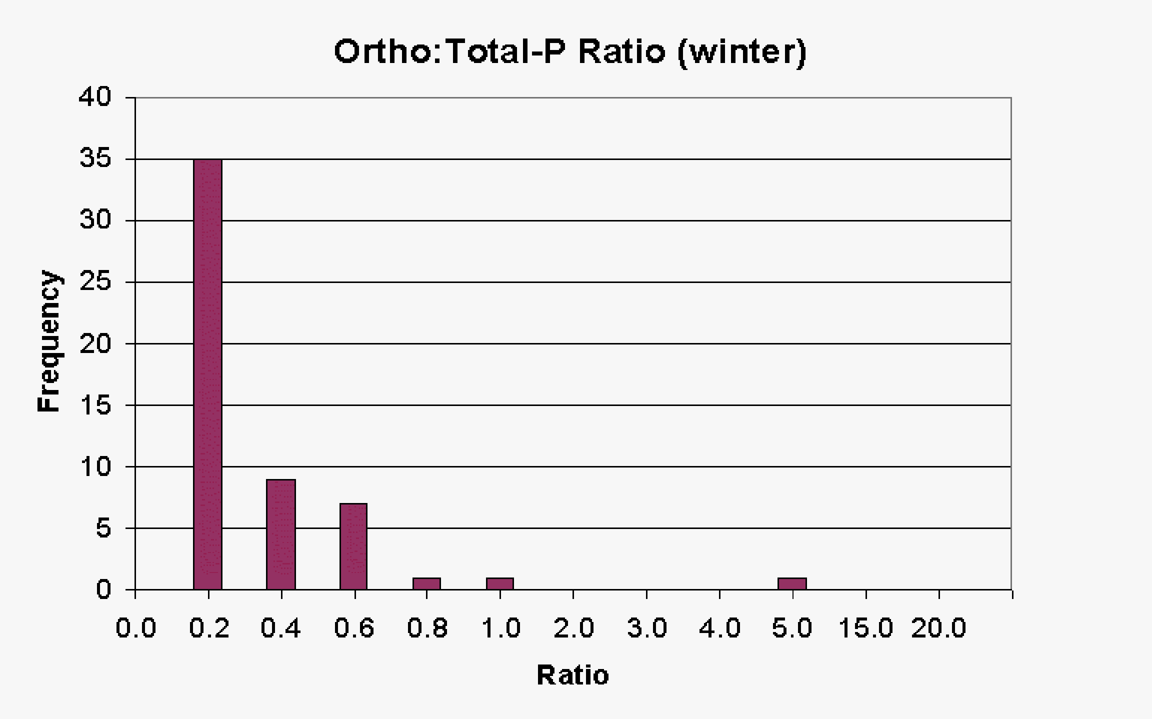


Figure 4.2.4. Frequency histogram for ratio of soluble reactive phosphorus (ortho-P) to total P for winter pastures grab samples.

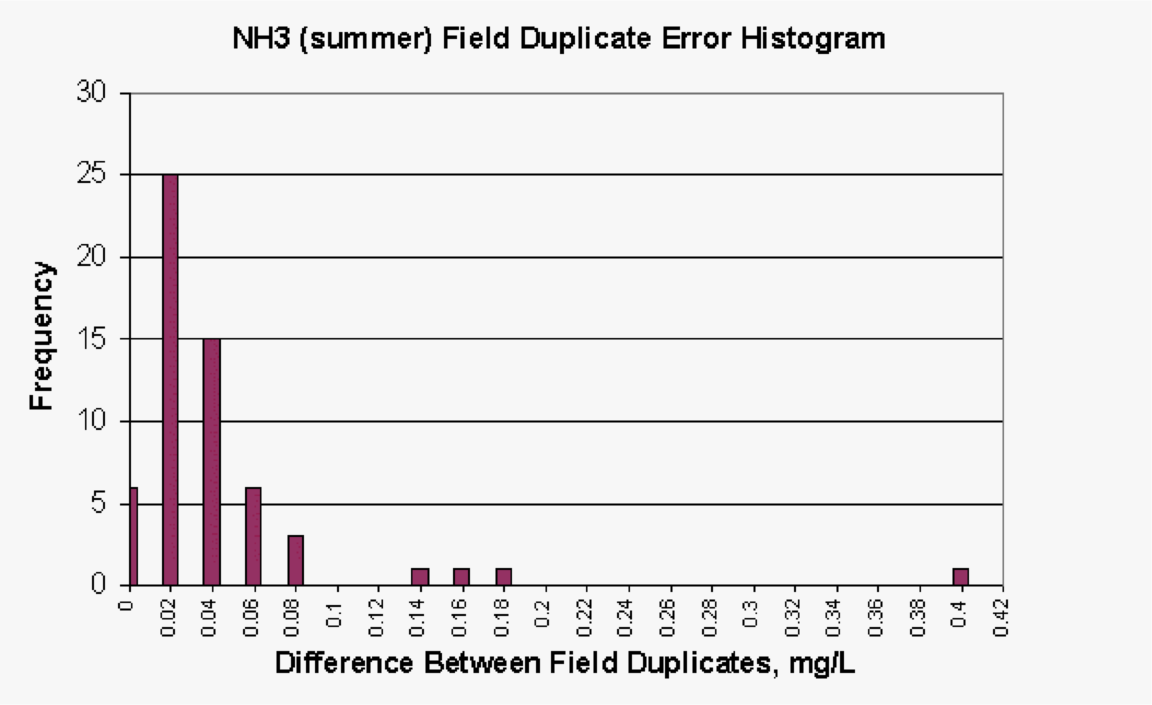


Figure 4.3.1. Frequency histogram of NH3 concentration differences, between autosamples, for all summer sites over full period of record.

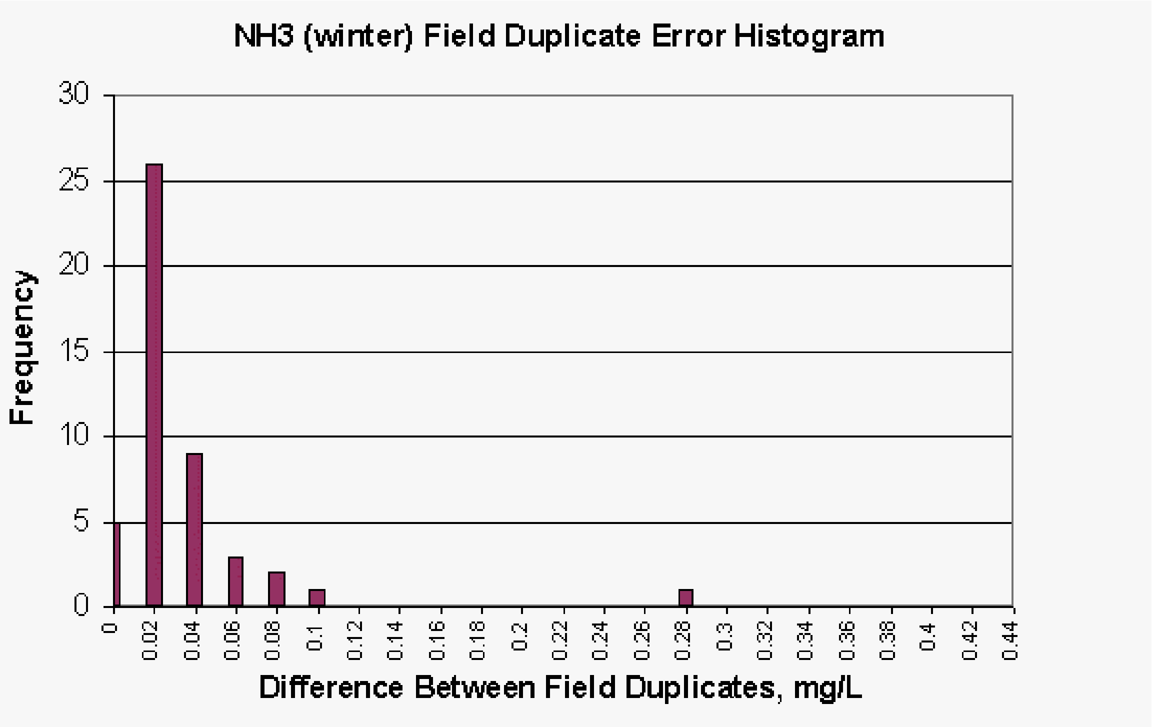


Figure 4.3.2. Frequency histogram of NH3 concentration differences, between autosamples, for all winter sites over full period of record.

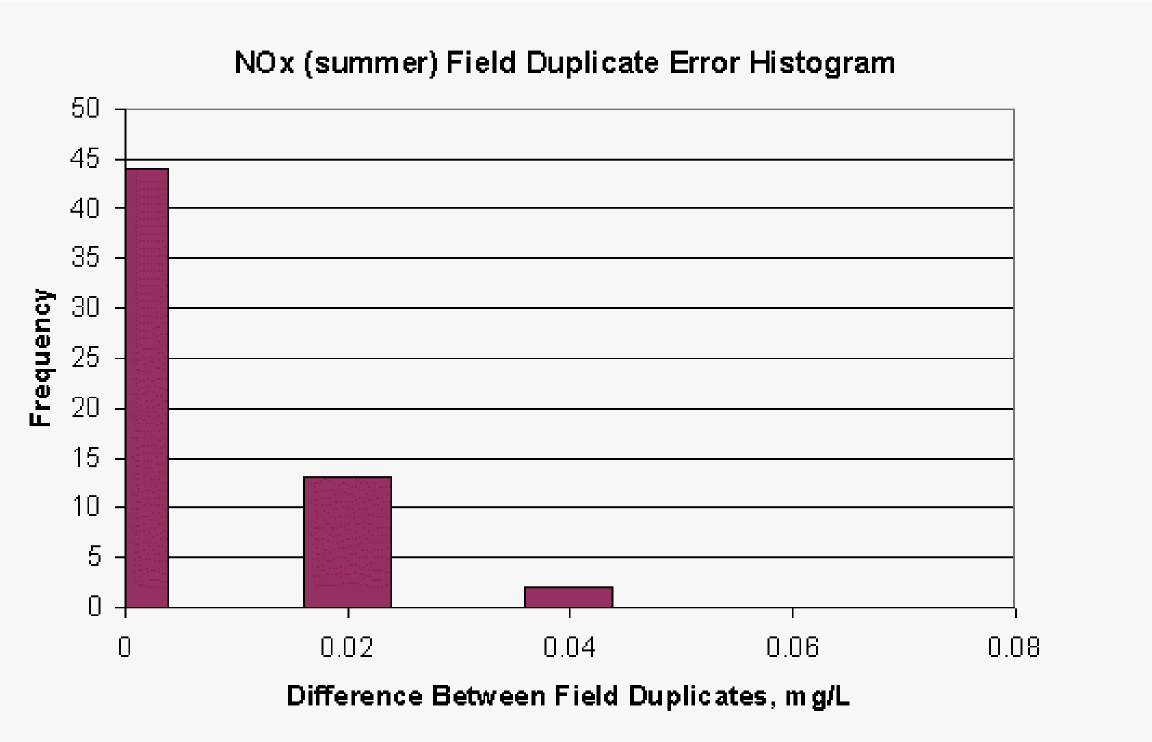


Figure 4.3.3. Frequency histogram of N0x concentration differences, between autosamples, for all summer sites over full period of record.

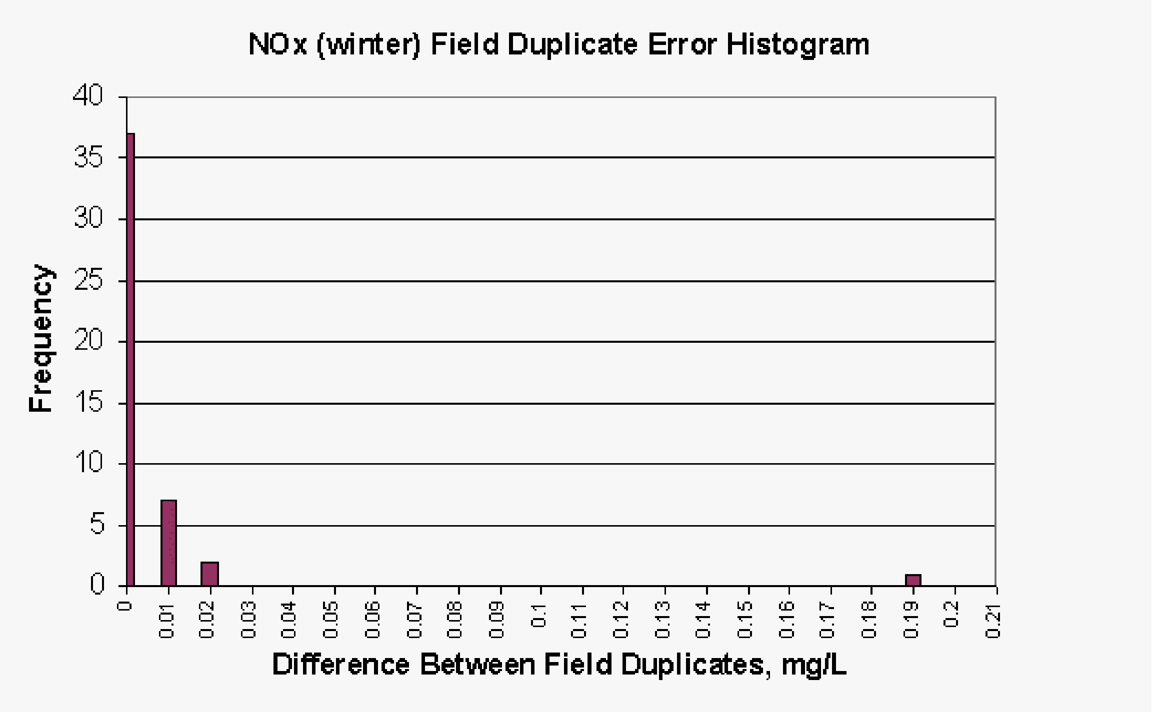


Figure 4.3.4. Frequency histogram of N0x concentration differences, between autosamples, for all winter sites over full period of record.

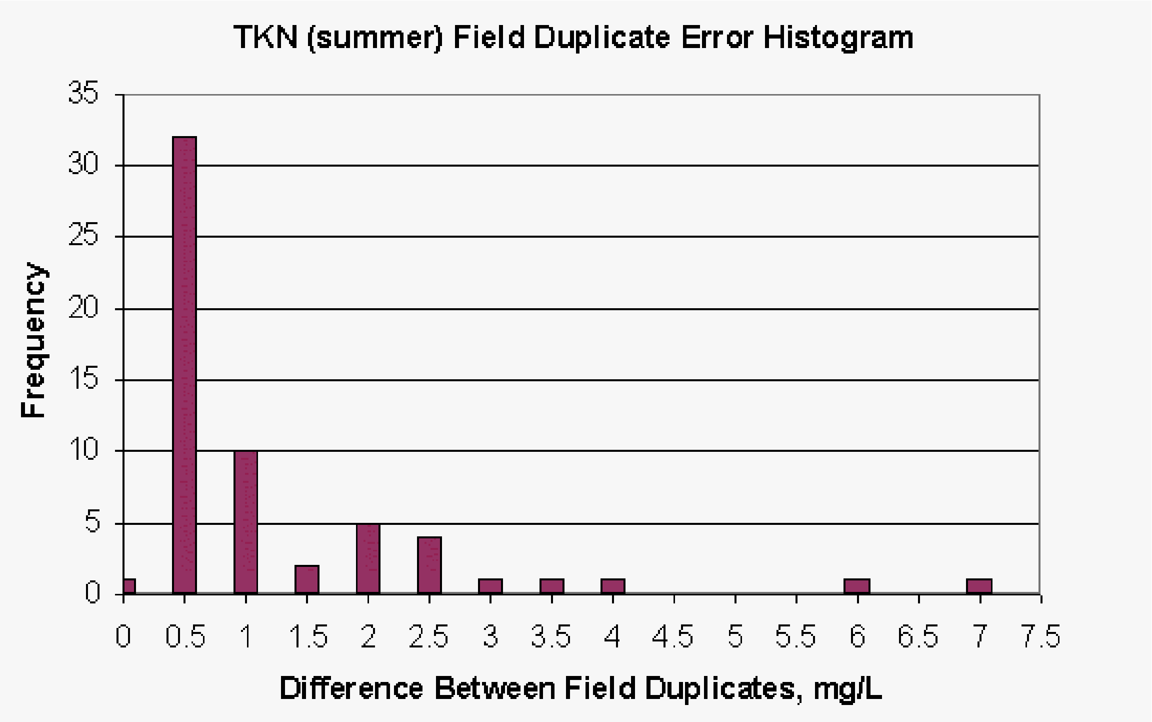


Figure 4.3.5. Frequency histogram of TKN concentration differences, between autosamples, for all summer sites over full period of record.

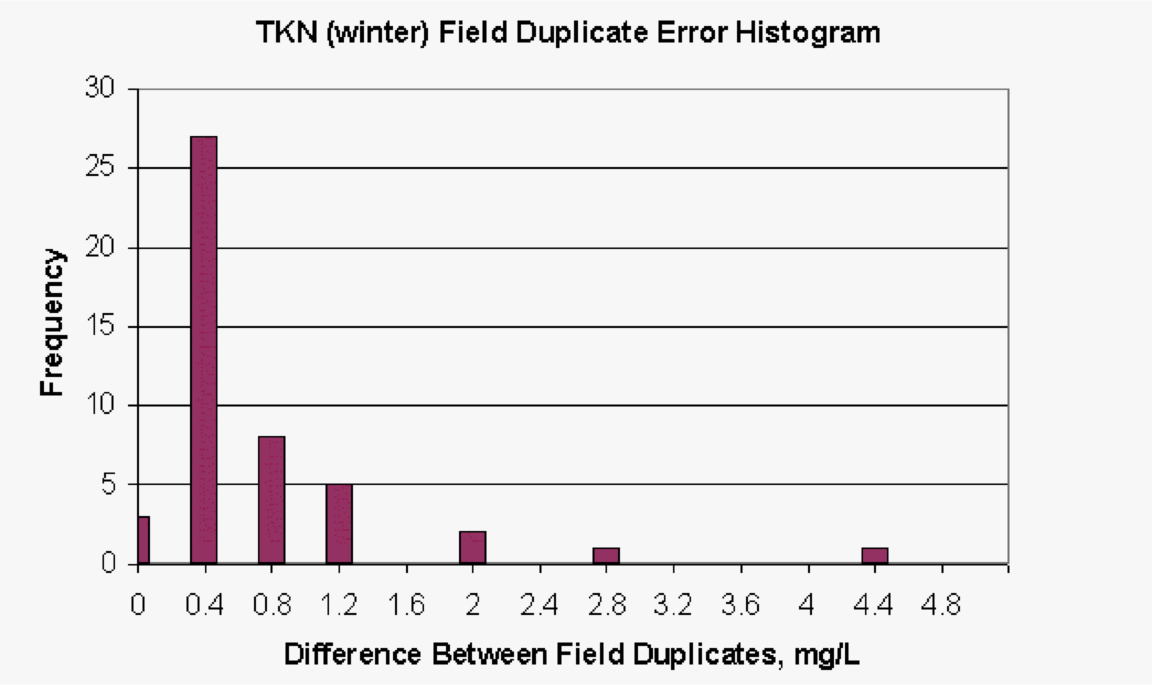


Figure 4.3.6. Frequency histogram of TKN concentration differences, between autosamples, for all winter sites over full period of record.

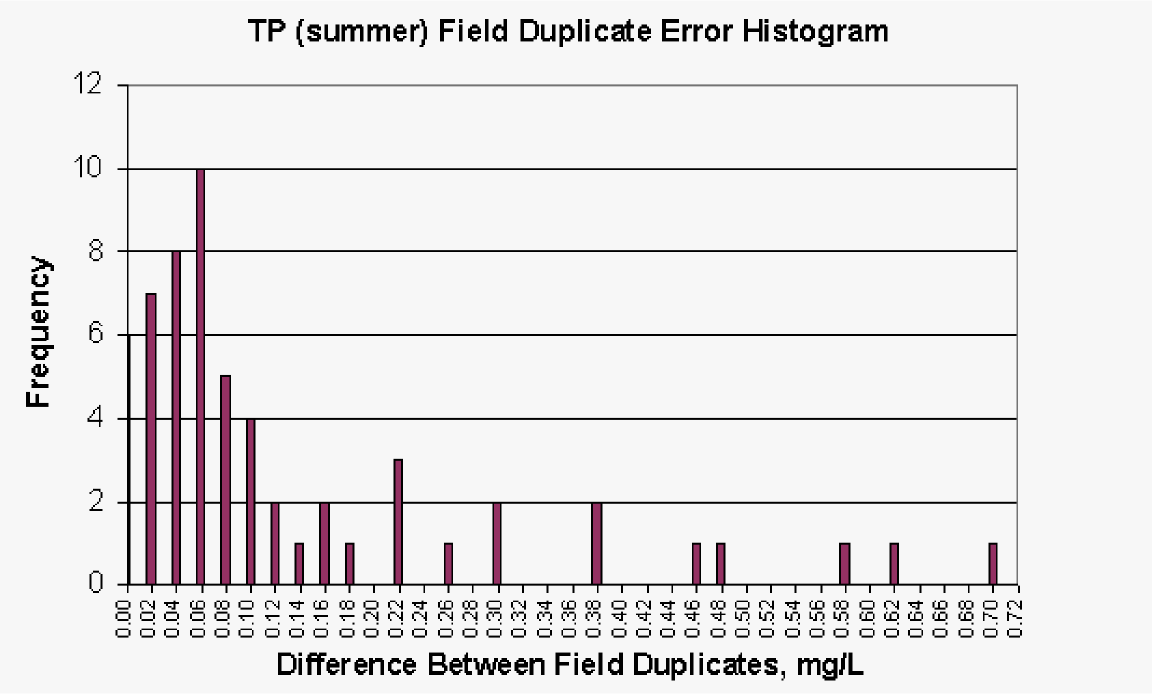


Figure 4.3.7. Frequency histogram of TP concentration differences, between autosamples, for all summer sites over full period of record.

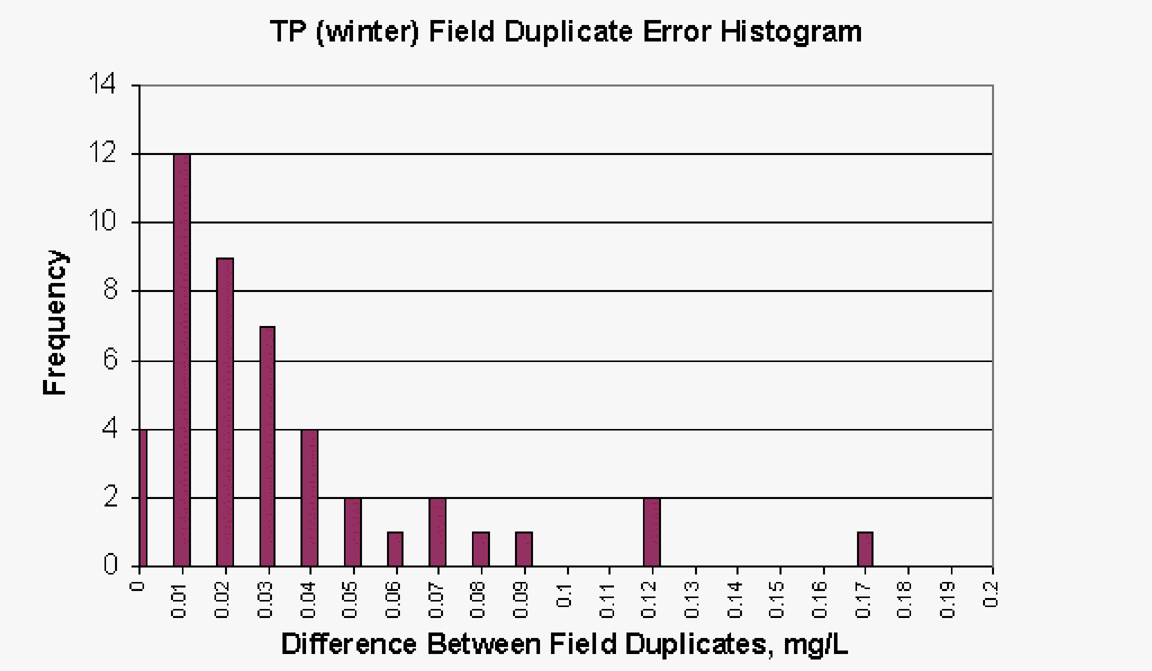


Figure 4.3.8. Frequency histogram of TP concentration differences, between autosamples, for all winter sites over full period of record.

Table 4.3.1. Coefficient of variation of NH3-N concentrations for autosample duplicates (control plots highlighted).

1999 Site	Sampling Date	NH3 FD1	NH3 FD2	CV
S1	2-Jul	0.31	0.25	15%
	20-Jul	0.26	0.43	35%
	16-Aug	0.39	0.33	12%
	13-Sep	0.50	0.43	11%
	22-Sep	0.44	0.36	14%
	27-Sep	0.34	0.32	4%
	12-Oct	0.23	0.24	3%
	25-Oct	0.20	0.22	7%
S2	14-Jun	0.20	0.26	18%
	2-Jul	0.52	0.51	1%
	20-Jul	0.43	0.46	5%
	14-Sep	0.29	0.30	2%
	21-Sep	0.26	0.27	3%
	27-Sep	0.31	0.32	2%
	12-Oct	0.25	0.28	8%
S3	14-Jun	0.30	0.28	5%
	2-Jul	0.62	0.58	5%
	27-Sep	0.16	0.18	8%
	12-Oct	0.20	0.18	7%
S4	2-Apr	0.22	0.21	3%
	21-Jun	0.28	0.31	7%
	20-Jul	0.30	0.30	0%
	27-Sep	0.24	0.23	3%
	12-Oct	0.21	0.24	9%
S5	2-Jul	0.25	0.25	0%
	27-Jul	0.36	0.39	6%
	14-Sep	0.29	0.31	5%
	27-Sep	0.25	0.28	8%
	12-Oct	0.19	0.19	0%
S6	18-Jun	0.28	0.34	14%
	1-Jul	0.30	0.32	5%
	1-Jul	0.42	0.38	7%
	28-Sep	0.27	0.24	8%
	12-Oct	0.28	0.29	2%
	25-Oct	0.02	0.18	112%
S7	18-Jun	0.24	0.21	9%
	25-Jun	0.30	0.33	7%
	1-Jul	0.29	0.29	0%
	20-Jul	0.38	0.35	6%
	23-Aug	0.08	0.10	16%
	2-Sep	0.08	0.09	8%
	17-Sep	0.40	0.43	5%
	21-Sep	0.30	0.29	2%
	27-Sep	0.37	0.35	4%
	8-Oct	0.23	0.18	17%
	12-Oct	0.28	0.27	3%
	25-Oct	0.17	0.15	9%
S8	24-Jun	0.17	0.17	0%
	1-Jul	1.00	0.60	35%
	14-Sep	0.39	0.33	12%
	27-Sep	0.33	0.34	2%
	12-Oct	0.19	0.17	8%
	25-Oct	0.13	0.14	5%
Average				10%

Table 4.3.2. Coefficient of variation of NH3-N concentrations for autosample duplicates (control plots highlighted).

1999 Station	Sampling Date	NH3 FD1	 FD2	CV
W1	1-Jul	0.24	0.22	6%
	20-Jul	0.22	0.49	54%
	25-Aug	0.03	0.02	28%
	13-Sep	0.21	0.20	3%
	12-Oct	0.063	0.055	10%
	25-Oct	0.10	0.13	18%
W2	1-Jul	0.20	0.21	3%
	20-Jul	0.24	0.26	6%
	23-Aug	0.11	0.11	0%
	13-Sep	0.20	0.17	11%
	27-Sep	0.20	0.23	10%
	12-Oct	0.047	0.08	37%
W3	1-Jul	0.23	0.25	6%
	23-Aug	0.14	0.15	5%
	13-Sep	0.30	0.31	2%
	26-Oct	0.22	0.21	3%
W4	1-Jul	0.33	0.29	9%
	12-Oct	0.073	0.06	14%
	18-Oct	0.28	0.22	17%
	25-Oct	0.15	0.14	5%
W5	1-Jul	0.26	0.27	3%
	20-Jul	0.24	0.24	0%
	13-Sep	0.28	0.27	3%
	27-Sep	0.22	0.21	3%
	12-Oct	0.13	0.14	5%
W6	25-Jun	0.41	0.35	11%
	1-Jul	0.26	0.25	3%
	15-Sep	0.15	0.17	9%
	21-Sep	0.22	0.17	18%
	27-Sep	0.19	0.16	12%
	8-Oct	0.15	0.16	5%
W7	1-Jul	0.27	0.29	5%
	23-Aug	0.33	0.26	17%
	13-Sep	0.20	0.22	7%
	27-Sep	0.23	0.16	25%
	12-Oct	0.19	0.28	27%
W8	25-Jun	0.06	0.06	0%
	1-Jul	0.28	0.25	8%
	13-Sep	0.24	0.23	3%
	27-Sep	0.20	0.20	0%
Average				10%

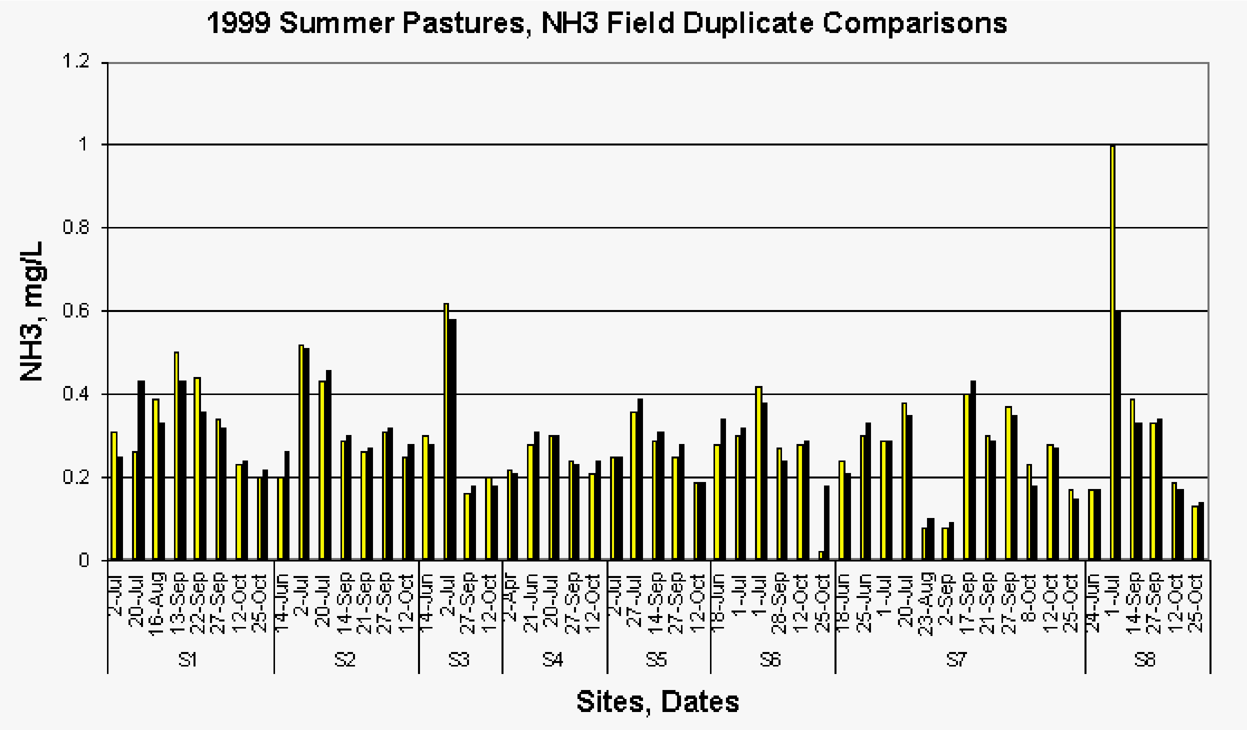


Figure 4.3.9. Visual composition of field duplicate for autosample concentration of HN3-N for summer pasture plots in 1999.

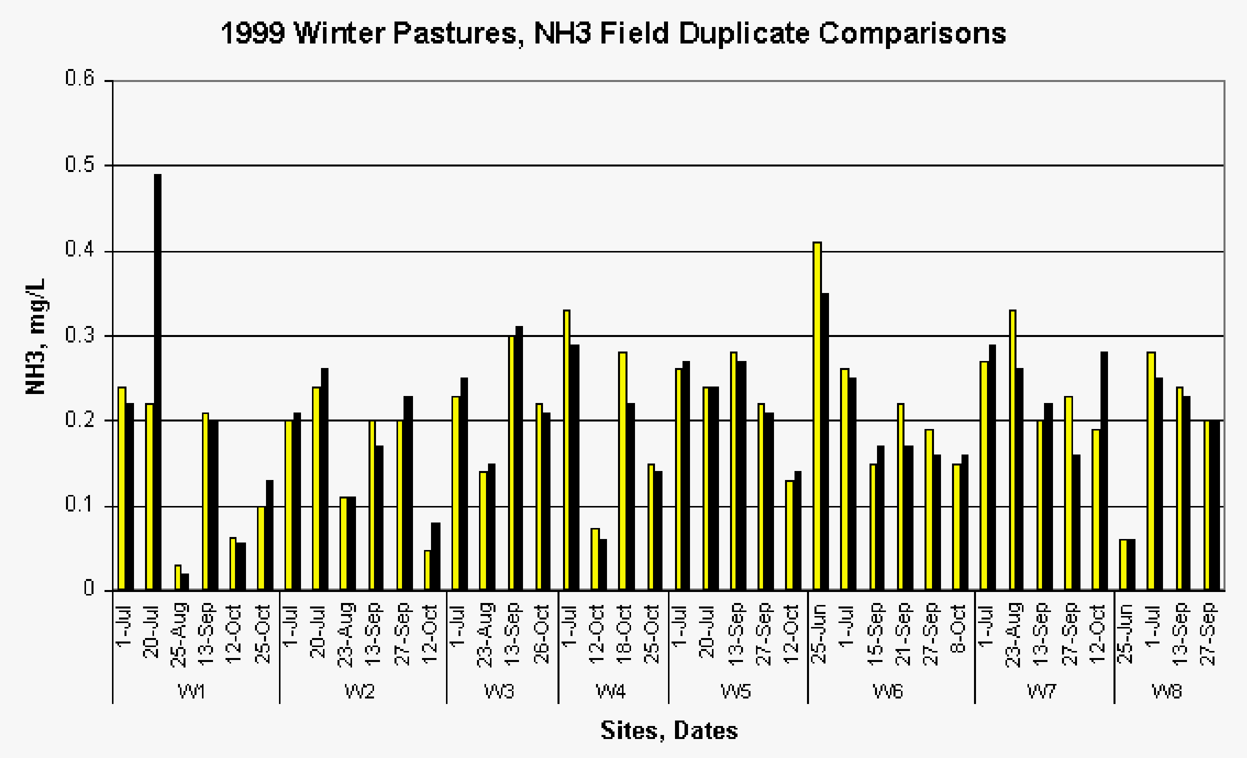


Figure 4.3.10. Visual composition of field duplicate for autosample concentration of NH3-N for winter pasture plots in 1999.

Table 4.3.3. Coefficient of variation of NOx-N concentrations for autosample duplicates (control plots highlighted). Laboratory results less than the MDL are reported as 50% of MDL level (0.005 in this case).

1999 Site	Sampling Date	NOx *		CV
		FD1	FD2	
S1	2-Jul	0.005	0.005	0%
	20-Jul	0.020	0.030	28%
	16-Aug	0.005	0.005	0%
	13-Sep	0.010	0.010	0%
	22-Sep	0.005	0.005	0%
	27-Sep	0.015	0.018	13%
	12-Oct	0.005	0.005	0%
	25-Oct	0.005	0.005	0%
S2	14-Jun	0.030	0.020	28%
	2-Jul	0.005	0.005	0%
	20-Jul	0.030	0.020	28%
	14-Sep	0.014	0.016	9%
	21-Sep	0.014	0.011	17%
	27-Sep	0.018	0.021	11%
	12-Oct	0.005	0.010	47%
S3	14-Jun	0.020	0.020	0%
	2-Jul	0.005	0.005	0%
	27-Sep	0.012	0.005	58%
	12-Oct	0.005	0.005	0%
S4	2-Apr	0.005	0.005	0%
	21-Jun	0.010	0.020	47%
	20-Jul	0.020	0.020	0%
	27-Sep	0.005	0.005	0%
	12-Oct	0.005	0.005	0%
S5	2-Jul	0.005	0.005	0%
	27-Jul	0.030	0.020	28%
	14-Sep	0.005	0.011	53%
	27-Sep	0.005	0.005	0%
	12-Oct	0.005	0.005	0%
S6	18-Jun	0.050	0.050	0%
	1-Jul	0.050	0.050	0%
	1-Jul	0.005	0.005	0%
	28-Sep	0.005	0.005	0%
	12-Oct	0.005	0.005	0%
	25-Oct	0.005	0.005	0%
S7	18-Jun	0.005	0.005	0%
	25-Jun	0.050	0.040	16%
	1-Jul	0.005	0.005	0%
	20-Jul	0.050	0.050	0%
	23-Aug	0.005	0.005	0%
	2-Sep	0.005	0.005	0%
	17-Sep	0.010	0.010	0%
	21-Sep	0.005	0.005	0%
	27-Sep	0.012	0.017	24%
	8-Oct	0.005	0.005	0%
	12-Oct	0.005	0.005	0%
	25-Oct	0.005	0.005	0%
S8	24-Jun	0.030	0.030	0%
	1-Jul	0.005	0.005	0%
	14-Sep	0.012	0.011	6%
	27-Sep	0.005	0.005	0%
	12-Oct	0.005	0.005	0%
	25-Oct	0.005	0.005	0%
Average				8%

* 0.005 represents values <MDL

Table 4.3.4. Coefficient of variation of NOx-N concentrations for autosample duplicates (control plots highlighted). Laboratory results less than the MDL are reported as 50% of MDL level (0.005 in this case).

1999	sampling	NOx *		
Station	Date	FD1	FD2	CV
W1	1-Jul	0.050	0.050	0%
	20-Jul	0.020	0.020	0%
	25-Aug	0.005	0.005	0%
	13-Sep	0.005	0.005	0%
	12-Oct	0.005	0.005	0%
	25-Oct	0.005	0.005	0%
W2	1-Jul	0.005	0.005	0%
	20-Jul	0.020	0.030	28%
	23-Aug	0.080	0.080	0%
	13-Sep	0.005	0.005	0%
	27-Sep	0.005	0.005	0%
	12-Oct	0.005	0.005	0%
W3	1-Jul	0.040	0.040	0%
	23-Aug	0.005	0.005	0%
	13-Sep	0.005	0.005	0%
	26-Oct	0.005	0.005	0%
W4	1-Jul	0.005	0.005	0%
	12-Oct	0.005	0.005	0%
	18-Oct	0.005	0.005	0%
	25-Oct	0.005	0.005	0%
W5	1-Jul	0.050	0.050	0%
	20-Jul	0.040	0.040	0%
	13-Sep	0.010	0.010	0%
	27-Sep	0.019	0.021	7%
	12-Oct	0.005	0.005	0%
W6	25-Jun	0.030	0.040	20%
	1-Jul	0.040	0.040	0%
	15-Sep	0.010	0.010	0%
	21-Sep	0.010	0.010	0%
	27-Sep	0.005	0.005	0%
	8-Oct	0.017	0.016	4%
W7	1-Jul	0.005	0.005	0%
	23-Aug	0.040	0.050	16%
	13-Sep	0.010	0.005	47%
	27-Sep	0.013	0.011	12%
	12-Oct	0.005	0.005	0%
W8	25-Jun	0.005	0.005	0%
	1-Jul	0.005	0.005	0%
	13-Sep	0.005	0.005	0%
	27-Sep	0.014	0.015	5%
Average				3%

* 0.005 represents values <MDL

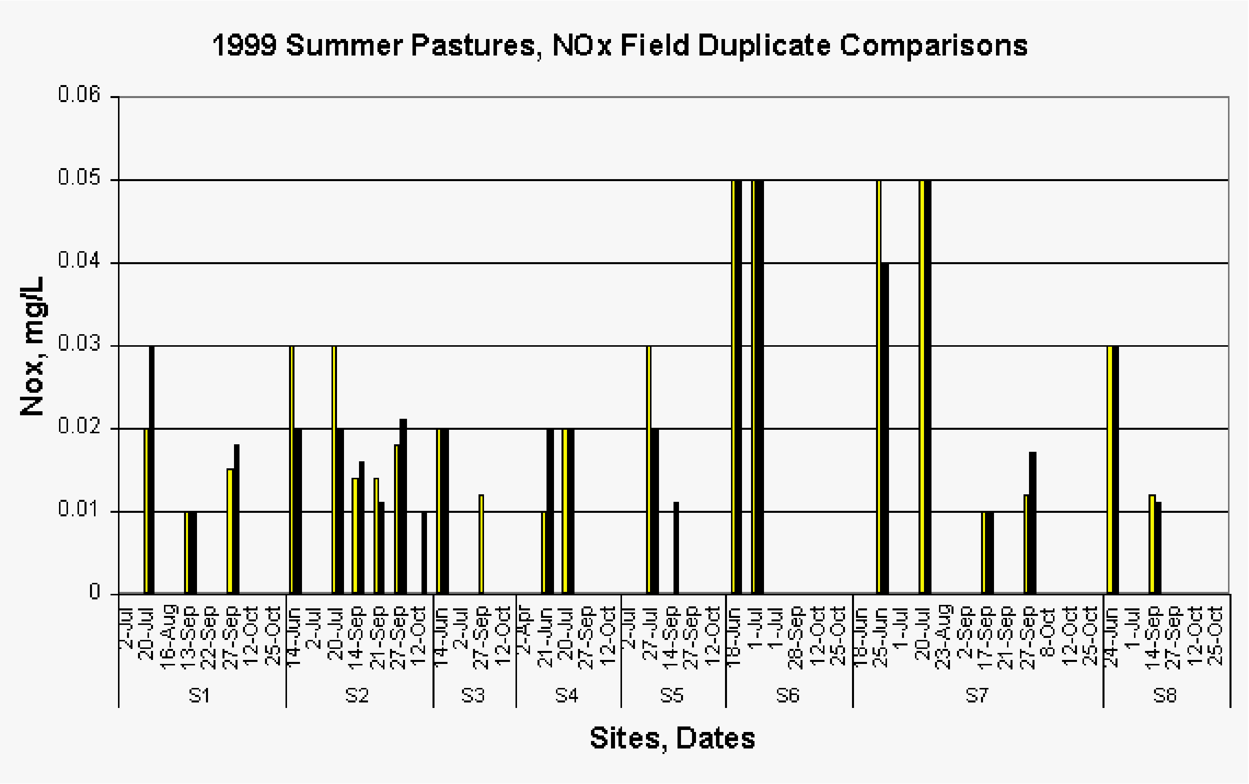


Figure 4.3.11. Visual composition of field duplicate for autosample concentration of N0x for summer pasture plots in 1999.

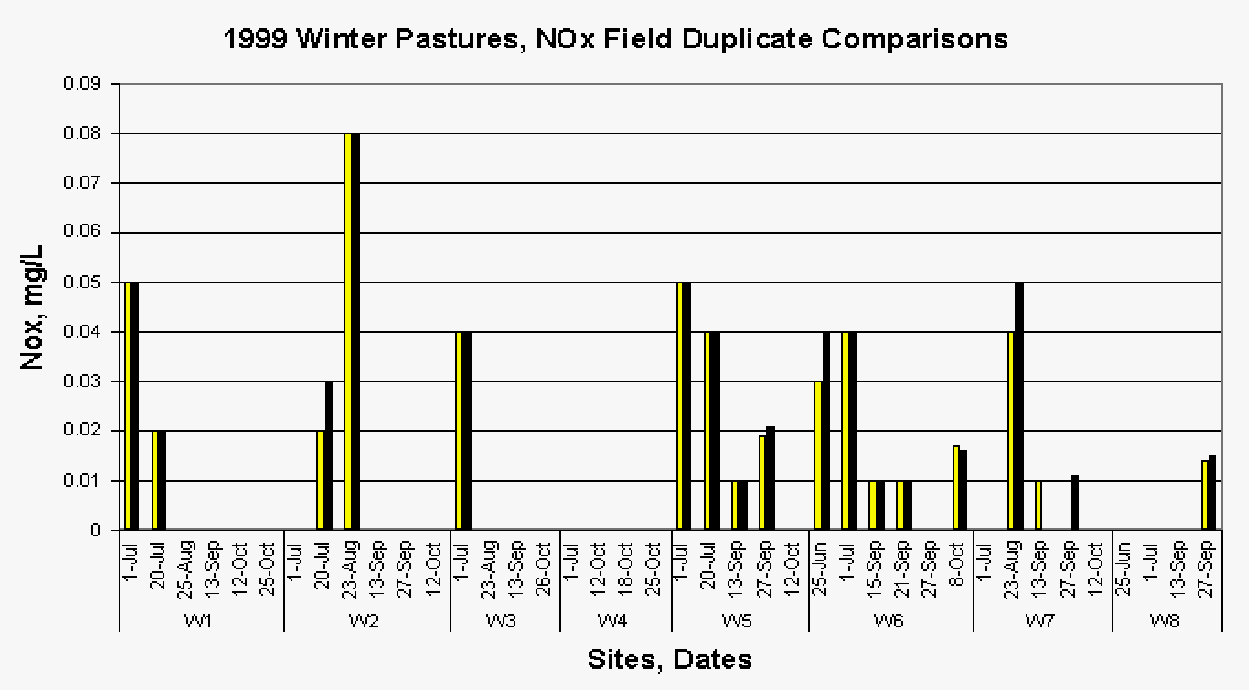


Figure 4.3.12. Visual composition of field duplicate for autosample concentration of N0x for winter pasture plots in 1999.

Table 4.3.5. Coefficient of variation of TKN-N concentrations for autosample duplicates (control plots highlighted).

1999 Site	Sampling Date	TKN		CV
		FD1	FD2	
S1	2-Jul	4.50	4.2	5%
	20-Jul	1.40	1.9	21%
	16-Aug	2.70	2.9	5%
	13-Sep	4.60	3.7	15%
	22-Sep	6.10	5.6	6%
	27-Sep	4.80	4.6	3%
	12-Oct	4.90	5.3	6%
	25-Oct	7.70	6.9	8%
S2	14-Jun	4.20	4.1	2%
	2-Jul	5.10	5.4	4%
	20-Jul	8.80	6.4	22%
	14-Sep	4.10	3.8	5%
	21-Sep	3.90	5.7	27%
	27-Sep	5.20	5.8	8%
	12-Oct	5.00	5.9	12%
S3	14-Jun	4.20	4.4	3%
	2-Jul	5.10	5.6	7%
	27-Sep	4.60	4.7	2%
	12-Oct	6.40	4.9	19%
S4	2-Apr	2.50	2.4	3%
	21-Jun	0.55	2.0	80%
	20-Jul	5.10	5.5	5%
	27-Sep	4.70	3.0	31%
	12-Oct	5.50	5.8	4%
S5	2-Jul	5.70	6.5	9%
	27-Jul	6.50	3.4	44%
	14-Sep	5.40	5.7	4%
	27-Sep	2.50	0.1	135%
	12-Oct	5.80	5.6	2%
S6	18-Jun	6.60	7.0	4%
	1-Jul	2.40	2.5	3%
	1-Jul	6.00	5.6	5%
	28-Sep	4.90	7.2	27%
	12-Oct	6.10	3.5	38%
	25-Oct	5.20	5.6	5%
S7	18-Jun	1.70	1.8	4%
	25-Jun	5.90	5.6	4%
	1-Jul	3.60	7.2	47%
	20-Jul	0.44	7.0	125%
	23-Aug	1.20	1.7	24%
	2-Sep	5.80	3.9	28%
	17-Sep	0.01	5.5	141%
	21-Sep	2.40	4.4	42%
	27-Sep	5.20	6.9	20%
	8-Oct	5.70	5.0	9%
	12-Oct	6.10	5.7	5%
	25-Oct	6.60	6.2	4%
S8	24-Jun	3.80	3.2	12%
	1-Jul	7.70	6.8	9%
	14-Sep	4.40	4.4	0%
	27-Sep	4.40	4.3	2%
	12-Oct	4.60	4.4	3%
	25-Oct	4.60	4.1	8%
Average				20%

Table 4.3.6. Coefficient of variation of TKN-N concentrations for autosample duplicates (control plots highlighted). Laboratory results less than the MDL are reported as 50% of MDL level (0.01 in this case).

1999	Sampling	TKN *		
Station	Date	FD1	FD2	CV
W1	1-Jul	3.80	3.60	4%
	20-Jul	5.00	5.30	4%
	25-Aug	1.80	2.00	7%
	13-Sep	2.80	2.00	24%
	12-Oct	4.50	4.00	8%
	25-Oct	2.00	2.40	13%
W2	1-Jul	3.80	4.00	4%
	20-Jul	5.70	4.70	14%
	23-Aug	2.20	2.00	7%
	13-Sep	3.40	3.00	9%
	27-Sep	3.20	3.00	5%
	12-Oct	0.06	4.10	137%
W3	1-Jul	4.50	3.60	16%
	23-Aug	1.10	0.92	13%
	13-Sep	4.40	4.50	2%
	26-Oct	2.80	3.10	7%
W4	1-Jul	5.60	5.50	1%
	12-Oct	5.00	4.80	3%
	18-Oct	5.00	4.80	3%
	25-Oct	1.20	1.50	16%
W5	1-Jul	4.90	4.20	11%
	20-Jul	5.70	6.10	5%
	13-Sep	3.90	4.10	4%
	27-Sep	3.50	4.40	16%
	12-Oct	4.30	4.20	2%
W6	25-Jun	4.80	4.70	1%
	1-Jul	5.90	5.10	10%
	15-Sep	3.90	3.40	10%
	21-Sep	3.60	3.90	6%
	27-Sep	4.10	3.60	9%
	8-Oct	7.60	4.80	32%
W7	1-Jul	3.20	3.10	2%
	23-Aug	2.10	2.20	3%
	13-Sep	0.01	1.90	140%
	27-Sep	4.20	3.90	5%
	12-Oct	4.80	5.10	4%
W8	25-Jun	3.30	3.90	12%
	1-Jul	3.10	3.10	0%
	13-Sep	2.90	2.80	2%
	27-Sep	2.00	3.90	46%
Average				15%

* 0.01 represents values <MDL

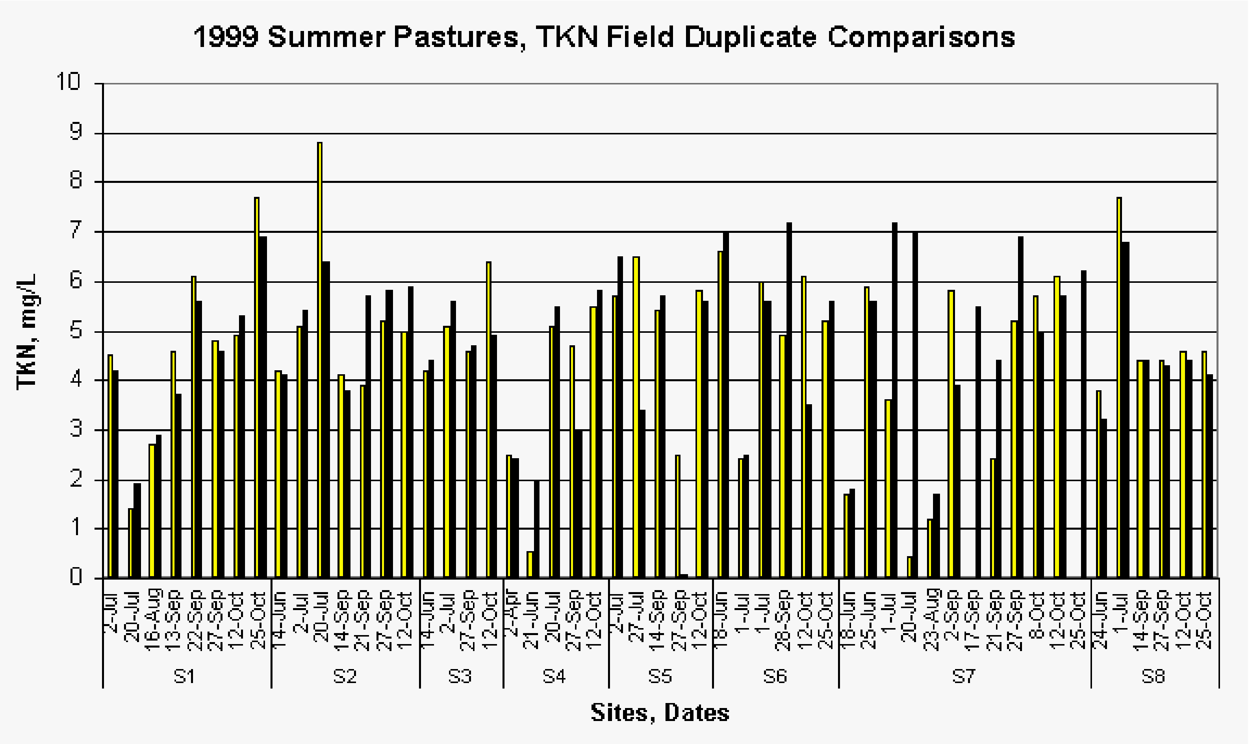


Figure 4.3.13. Visual composition of field duplicate for autosample concentration of TKN for summer pasture plots in 1999.

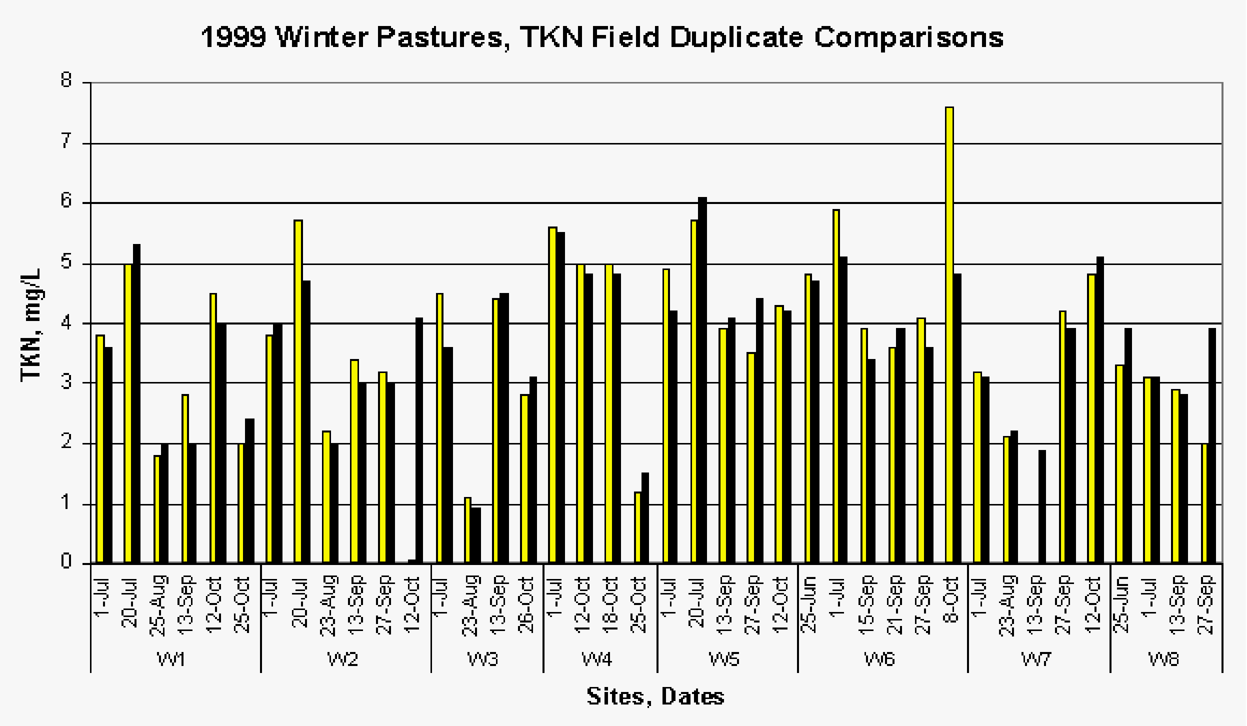


Figure 4.3.14. Visual composition of field duplicate for autosample concentration of TKN for winter pasture plots in 1999.

Table 4.3.7. Coefficient of variation of TP-P concentrations for autosample duplicates (control plots highlighted).

1999 Site	Sampling Date	TP FD1	 FD2	 CV
S1	2-Jul	0.78	0.70	8%
	20-Jul	0.09	0.12	20%
	16-Aug			
	13-Sep	0.29	0.42	26%
	22-Sep	0.87	0.87	0%
	27-Sep	0.33	0.29	9%
	12-Oct	0.48	0.48	0%
	25-Oct	0.21	0.27	18%
S2	14-Jun	0.88	0.84	3%
	2-Jul	0.86	0.91	4%
	20-Jul	0.43	0.43	0%
	14-Sep	0.86	0.41	50%
	21-Sep	0.50	0.65	18%
	27-Sep	0.26	0.55	51%
	12-Oct	0.47	0.45	3%
S3	14-Jun	0.66	0.64	2%
	2-Jul	0.67	0.70	3%
	27-Sep	0.26	0.50	45%
	12-Oct	0.36	0.43	13%
S4	2-Apr	0.51	0.46	7%
	21-Jun	0.16	0.54	77%
	20-Jul	0.45	0.44	2%
	27-Sep	0.06	0.04	28%
	12-Oct	0.31	0.35	9%
S5	2-Jul	1.20	1.40	11%
	27-Jul	1.00	0.71	24%
	14-Sep	1.00	1.00	0%
	27-Sep	0.08	0.06	20%
	12-Oct	0.54	0.49	7%
S6	18-Jun	0.90	0.92	2%
	1-Jul	0.57	0.58	1%
	1-Jul	0.98	1.10	8%
	28-Sep	0.43	0.28	30%
	12-Oct	0.42	0.25	36%
	25-Oct	0.30	0.25	13%
S7	18-Jun	0.05	0.05	0%
	25-Jun	1.20	1.10	6%
	1-Jul	0.69	1.30	43%
	20-Jul	0.14	0.83	101%
	23-Aug	0.25	0.20	16%
	2-Sep	0.20	0.24	13%
	17-Sep	0.01	0.47	138%
	21-Sep	0.24	0.61	62%
	27-Sep	0.52	0.62	12%
	8-Oct	0.65	0.07	114%
	12-Oct	0.74	0.68	6%
	25-Oct	0.40	0.35	9%
S8	24-Jun	0.97	0.76	17%
	1-Jul	1.30	1.20	6%
	14-Sep	0.78	0.72	6%
	27-Sep	0.00	0.05	153%
	12-Oct	0.75	0.68	7%
	25-Oct	0.43	0.35	15%
Average				24%

Table 4.3.8. Coefficient of variation of TP-P concentrations for autosample duplicates (control plots highlighted).

1999 Station	Sampling Date	TP		CV
		FD1	FD2	
W1	1-Jul	0.10	0.07	25%
	20-Jul	0.08	0.17	51%
	25-Aug	0.07	0.08	9%
	13-Sep	0.05	0.04	16%
	12-Oct	0.09	0.06	28%
	25-Oct	0.06	0.07	11%
W2	1-Jul	0.04	0.09	54%
	20-Jul	0.21	0.10	50%
	23-Aug	0.26	0.26	0%
	13-Sep	0.05	0.04	16%
	27-Sep	0.04	0.02	47%
	12-Oct	0.007	0.009	18%
W3	1-Jul	0.17	0.14	14%
	23-Aug	0.06	0.23	83%
	13-Sep	0.12	0.08	28%
	26-Oct	0.06	0.07	11%
W4	1-Jul	0.09	0.09	0%
	12-Oct	0.09	0.06	28%
	18-Oct	0.08	0.06	20%
	25-Oct	0.03	0.14	92%
W5	1-Jul	0.09	0.07	18%
	20-Jul	0.08	0.16	47%
	13-Sep	0.06	0.07	11%
	27-Sep	0.21	0.25	12%
	12-Oct	0.08	0.04	47%
W6	25-Jun	0.05	0.06	13%
	1-Jul	0.11	0.08	22%
	15-Sep	0.07	0.09	18%
	21-Sep	0.08	0.10	16%
	27-Sep	0.09	0.06	28%
	8-Oct	0.12	0.05	58%
W7	1-Jul	0.06	0.08	20%
	23-Aug	0.25	0.19	19%
	13-Sep	0.005	0.04	110%
	27-Sep	0.06	0.04	28%
	12-Oct	0.06	0.09	28%
W8	25-Jun	0.04	0.03	20%
	1-Jul	0.06	0.07	11%
	13-Sep	0.10	0.11	7%
	27-Sep	0.59	0.05	119%
Average				31%

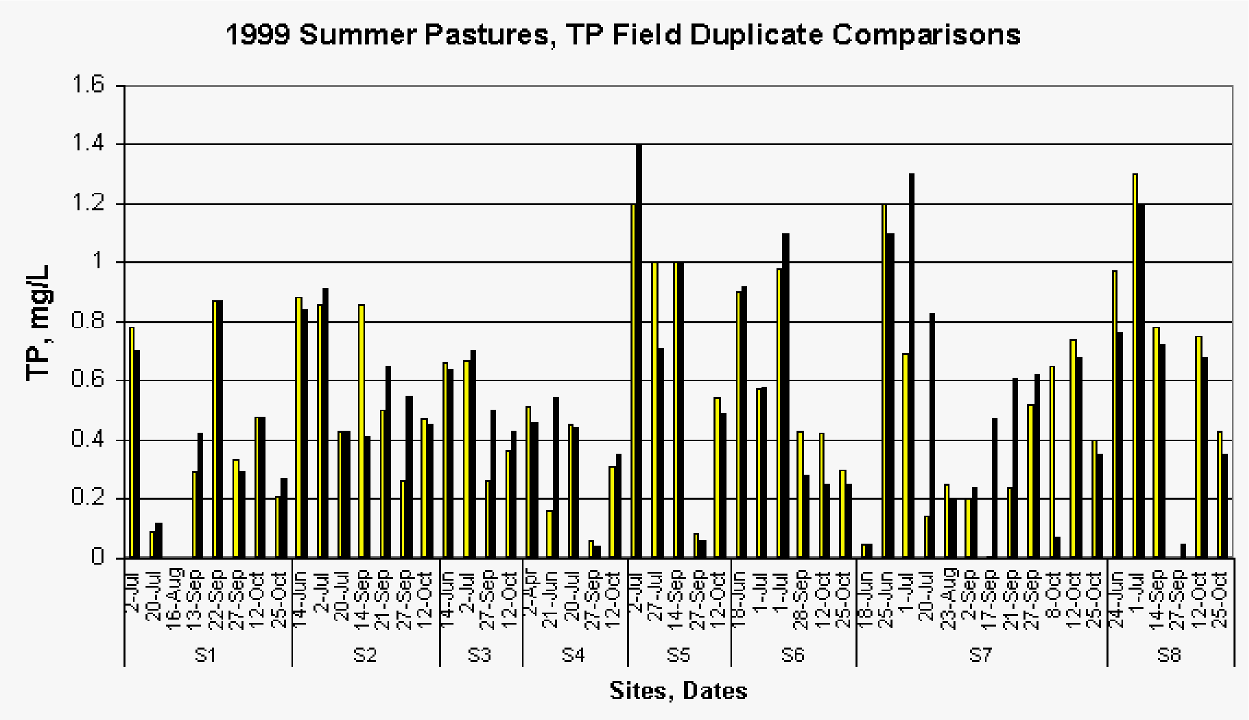


Figure 4.3.15. Visual composition of field duplicate for autosample concentration of TP for summer pasture plots in 1999.

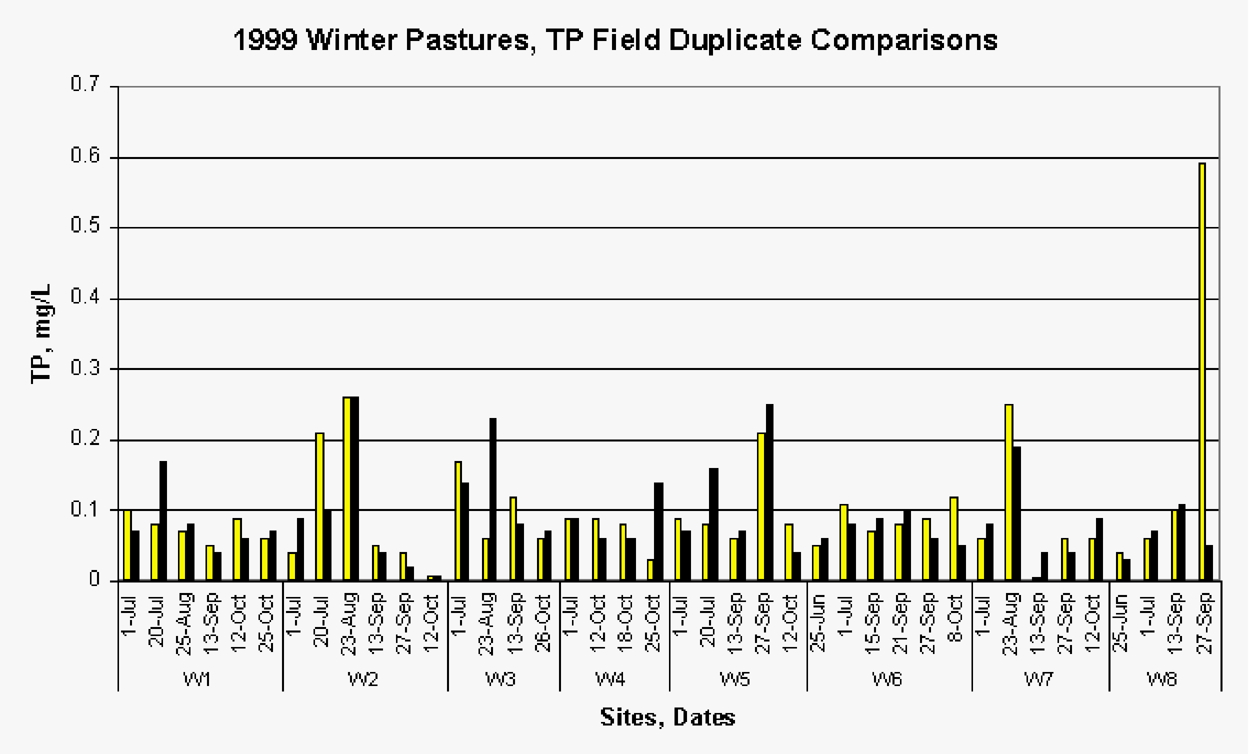


Figure 4.3.16. Visual composition of field duplicate for autosample concentration of TP for winter pasture plots in 1999.

Table 4.3.9. Differences in field duplicate measurements (error) for grab sample nutrients and mean values for field duplicate nutrient concentrations.

Nutrient	Winter		Summer	
	Mean mg/L	Error mg/L	Mean mg/L	Error mg/L
NH3	0.20	0.03	0.29	0.04
NOx	0.016	0.001	0.013	0.002
TKN	3.66	0.58	4.66	1.00
TP	0.10	0.05	0.54	0.13

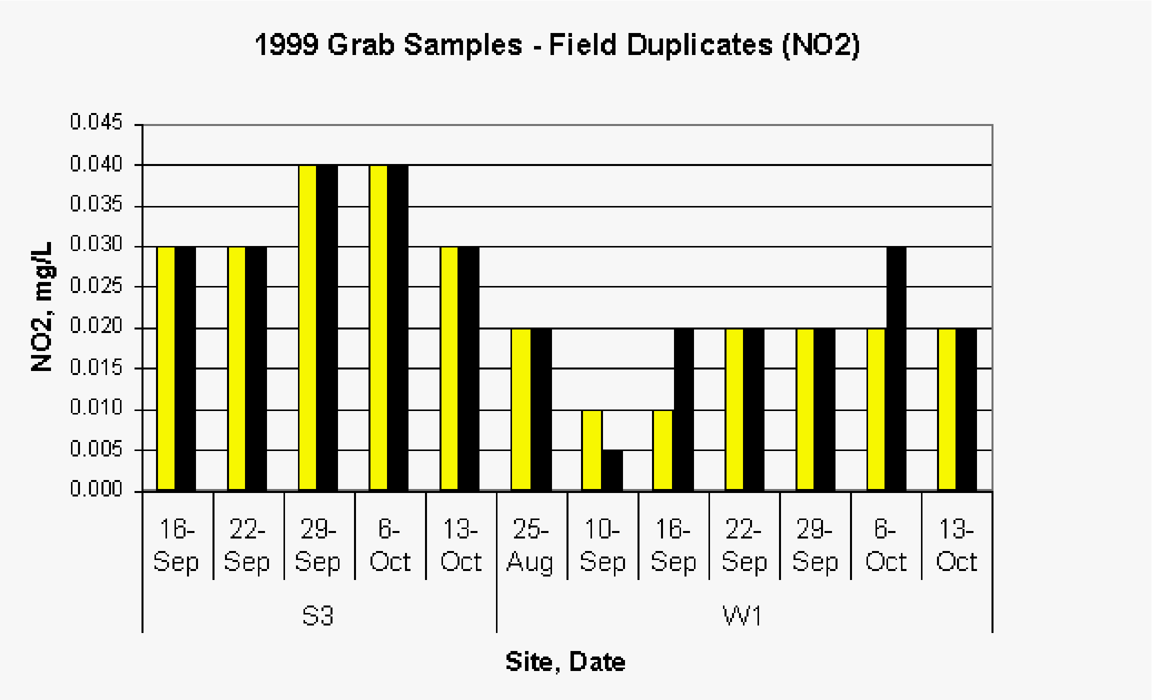


Figure 4.3.17. Visual comparisons of field duplicate pairs for grab sample N02-N concentration for pasture plots in 1999.

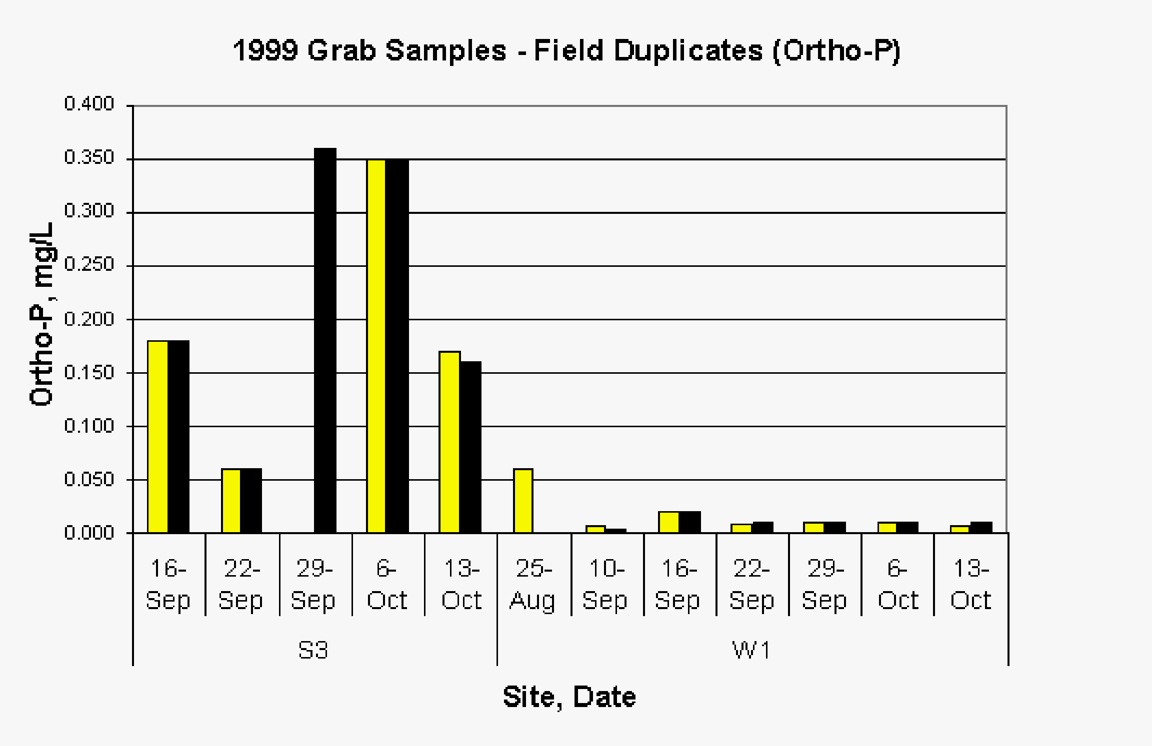


Figure 4.3.18. Visual comparisons of field duplicate pairs for grab sample Ortho-P concentration for pasture plots in 1999. Very low value not appearing on graph (S3 29 Sep value=0.001 and W1 25 Aug value=0.001).

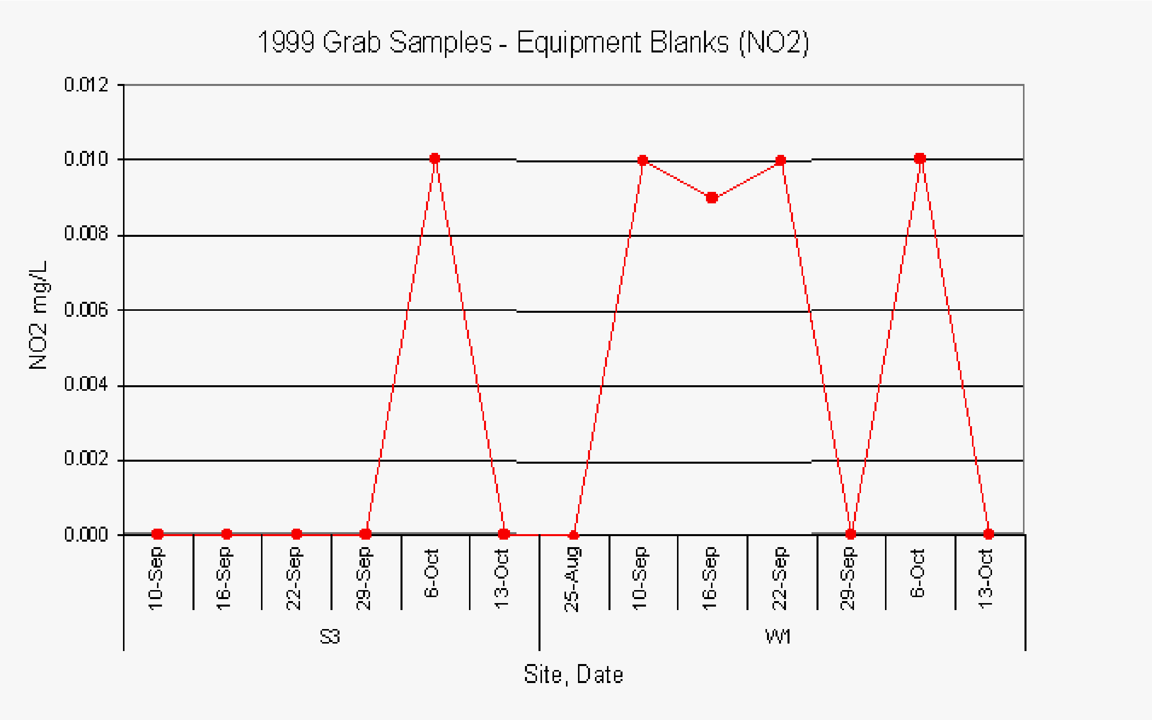


Figure 4.3.19. Concentration of NO2-N detected in grab sample equipment blanks for pasture plots in 1999.

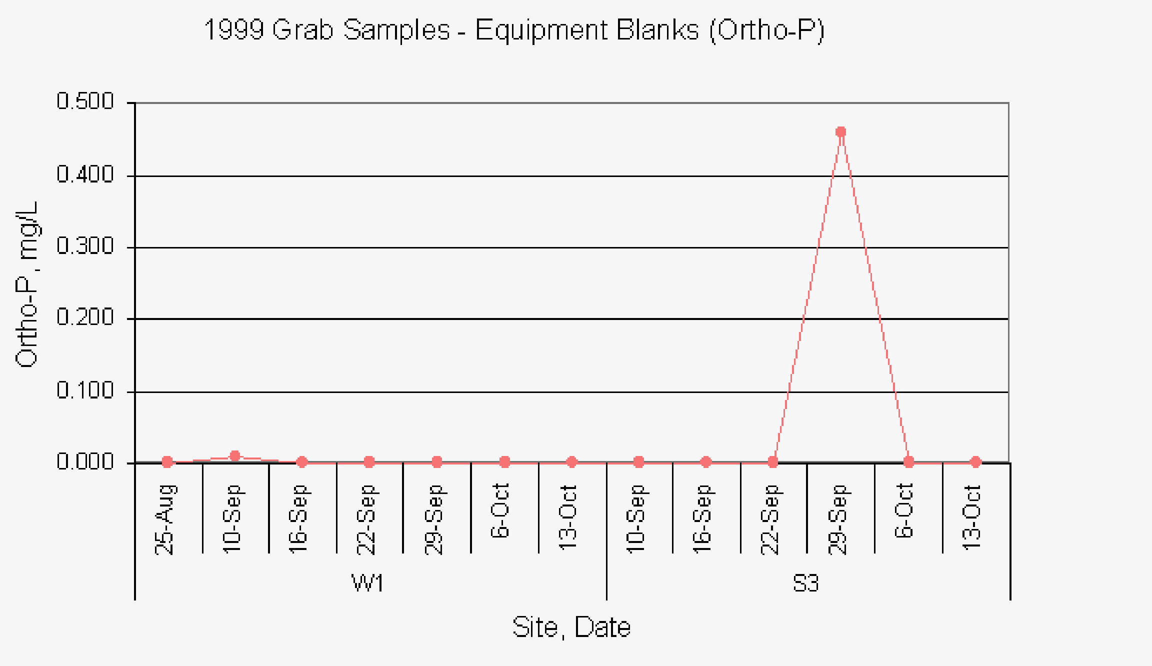


Figure 4.3.20. Concentration of Ortho-P detected in grab sample equipment blanks for pasture plots in 1999.

5. Nutrient Loads

Nutrient loads are calculated by multiplying incremental runoff volumes by the nutrient concentration measurement corresponding to the end of the runoff increment. Thus, load values embody errors from both the concentration measurements and the runoff measurements. Calculating runoff rates proved to be difficult because of several factors. Perhaps the most difficult problem was the high degree of submergence (lack of freeflow hydraulic conditions) encountered at these sites. Causes for the submergence included waterways blocked by aquatic vegetation and high downstream water levels from Harney Pond Canal.

Figures 5.1.1 to 5.1.6 present the data records, and breaks in those records, caused by instrument failures and maintenance problems. In those cases where adjacent plots could be used as good models for water levels, efforts were made to fill some of the missing data gaps with reasonable estimates.

Table 5.1.1 provides a summary of all calculated loads along with the measured runoff depth for each pasture plot. Measured annual runoff varied by more than 100% in some cases. The variability cannot be explained by rainfall differences in all cases since adjacent plots show higher than expected runoff volumes. Some of this variability may be due to plot topography and ditching differences. Instruments and flow measurement problems probably account for some of the differences in observed runoff volume. Rainfall totals are not reported due to instrument maintenance problems.

Calculated total phosphorus loads from the winter plots were approximately 0.15 kg/ha while the summer plots were much higher at 0.75 kg/ha, a difference factor of 5. Tables 5.1.2 to 5.1.9 and Figures 5.1.7 to 5.1.14 compare loads calculated using the frequent autosamples versus the infrequent grab samples. Results indicate that, in some cases, load estimates based on grab samples can be very different from the autosample load estimates.

The tabbed sections 11-18 and 21-28 present flow and load results for W1-W8 and S1-S8, respectively. Within each section are two sets of graphs, one for 1998 and another for 1999. Each set includes (1) a figure showing the headwater, tailwater, and offset data plus the resulting flow calculations, (2) a graphical depiction of the nutrient concentration variability over the period of the flow record plus markers indicating the time of autosample collection, (3) a cleaner graphic showing net flow rate and autosample collection occurrences, and (4) the accumulated runoff load for each nutrient of concern.

The detailed flow graphs show the final calculated flow rate as well as the flume upstream and downstream water depths and the offset values for the upstream and downstream water level encoders. The offset values were subject to change as the result of repositioning of the encoder tape attached to the float and counter weights.

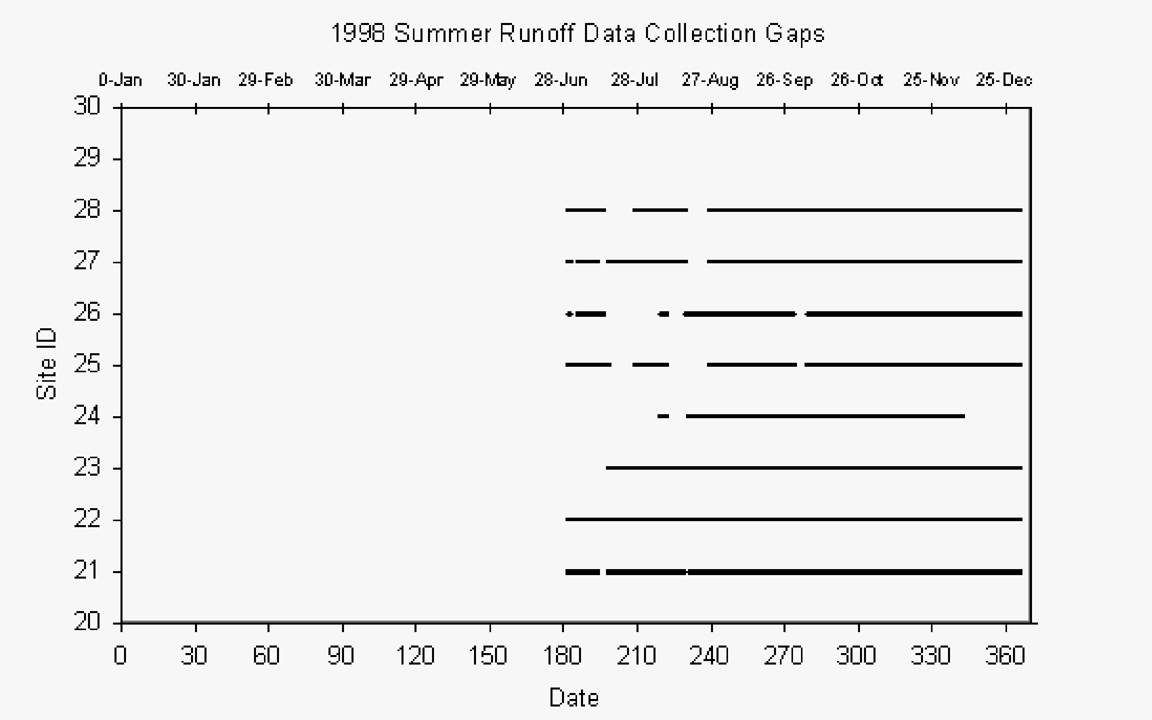


Figure 5.1.1. Data file gaps at summer flume datalogger stations in 1998.

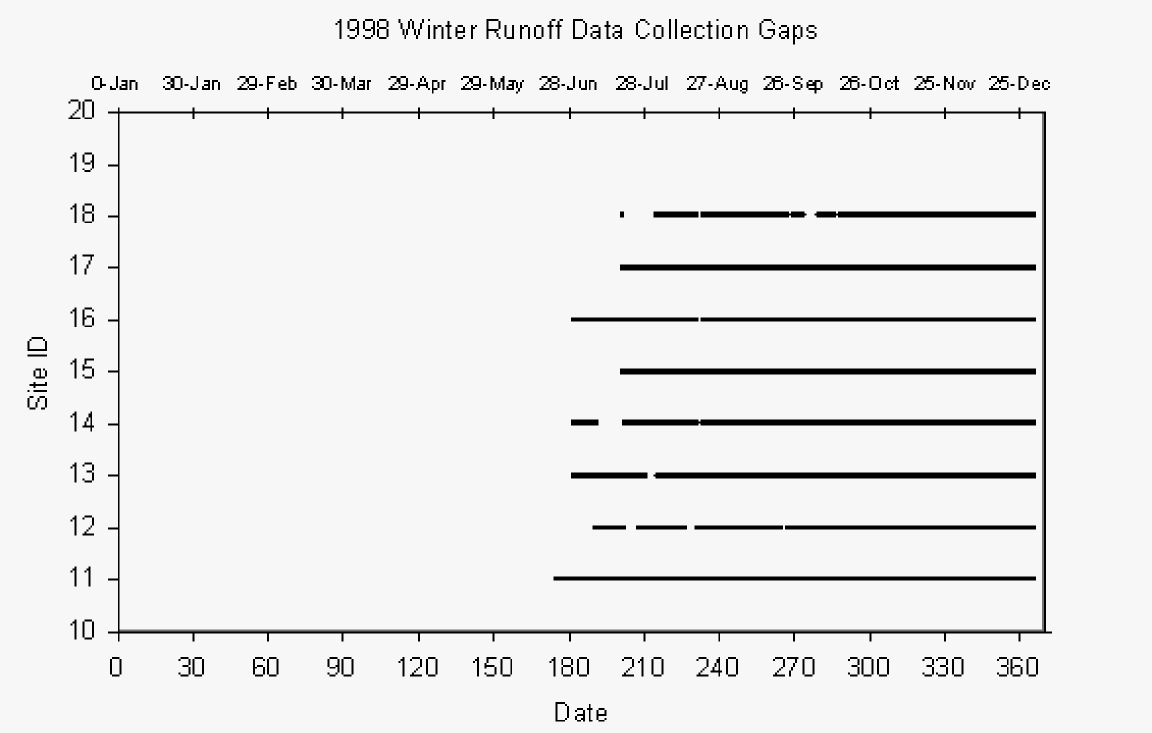


Figure 5.1.2. Data file gaps at winter flume datalogger stations in 1998.

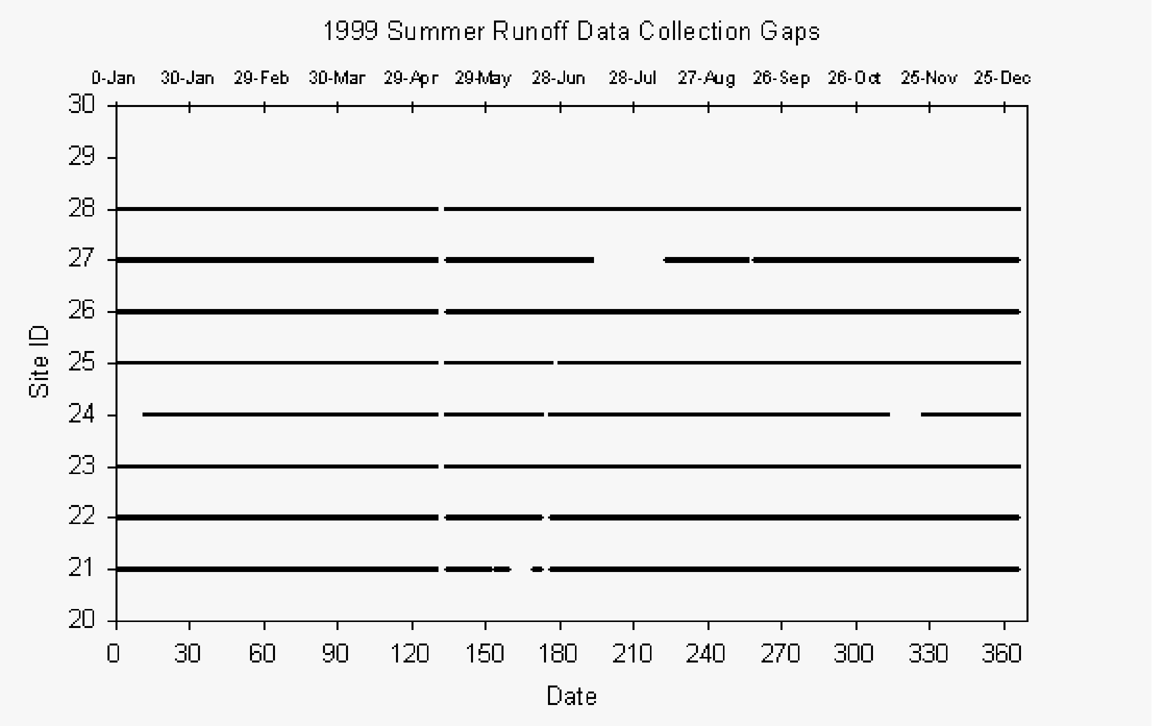


Figure 5.1.3. Original data file gaps at summer flume datalogger stations in 1999.

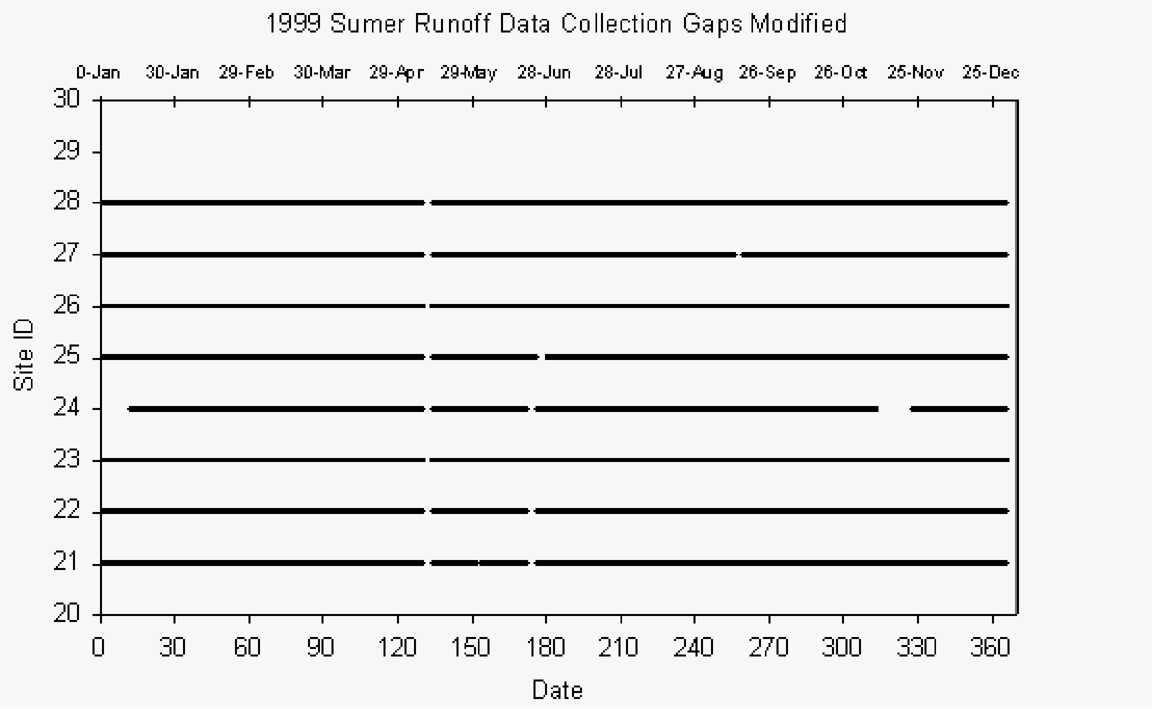


Figure 5.1.4. Adjusted data file gaps at summer flume datalogger stations in 1999.

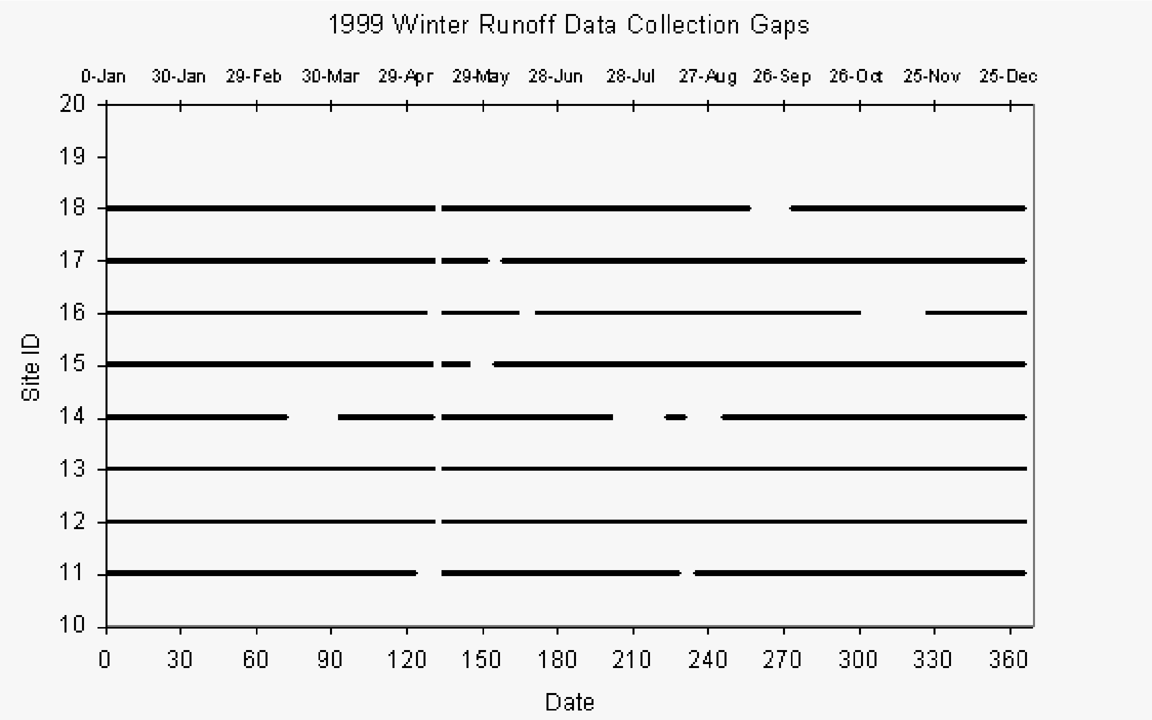


Figure 5.1.5. Original data file gaps at winter flume datalogger stations in 1999.

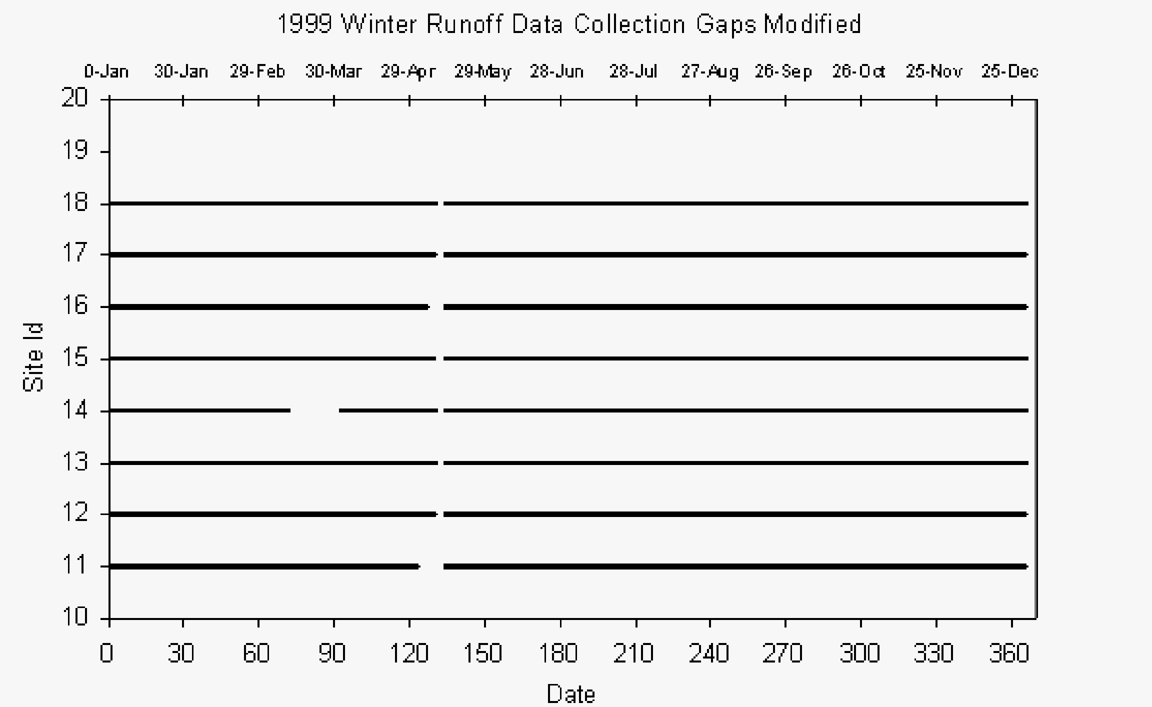


Figure 5.1.6. Adjusted data file gaps at winter flume datalogger stations in 1998.

Table 5.1.1. Runoff nutrient loads as elemental N and P (control plots highlighted).

Year	Site	Treatment	Rep	Runoff Volume (cm)	Loads, kg/ha			
					NH3	NOx	TKN	TP
1998	w1	15	1	10.5	0.12	0.02	3.9	0.07
	w2	20	1	15.7	0.25	0.03	5.6	0.07
	w3	35	1	12.0	0.14	0.02	4.1	0.10
	w4	C	1	21.5	0.30	0.04	7.0	0.12
	w5	35	2	24.7	0.29	0.04	8.9	0.14
	w6	15	2	20.9	0.31	0.03	6.7	0.14
	w7	C	2	24.4	0.41	0.07	8.4	0.13
	w8	20	2	20.9	0.43	0.06	6.9	0.10
	Average			18.8	0.28	0.04	6.4	0.11
	s1	C	1	8.7	0.12	0.02	4.1	0.58
	s2	20	1	13.5	0.17	0.02	7.0	0.51
	s3	35	1	14.5	0.10	0.03	6.9	0.60
	s4	15	1	6.6	0.13	0.01	2.3	0.66
	s5	35	2	14.7	0.35	0.04	6.6	1.17
	s6	15	2	15.3	0.26	0.01	7.3	0.46
	s7	20	2	16.0	0.29	0.01	8.2	0.64
	s8	C	2	14.2	0.26	0.02	5.3	1.25
	Average			12.9	0.21	0.02	6.0	0.73
1999	w1	15	1	6.7	0.15	0.03	2.6	0.16
	w2	20	1	6.9	0.13	0.02	2.1	0.24
	w3	35	1	14.8	0.32	0.01	4.8	0.18
	w4	C	1	10.8	0.24	0.02	4.9	0.08
	w5	35	2	13.4	0.32	0.04	4.5	0.12
	w6	15	2	15.7	0.29	0.02	6.2	0.12
	w7	C	2	15.0	0.32	0.01	3.7	0.18
	w8	20	2	12.9	0.30	0.02	4.0	0.10
	Average			12.0	0.26	0.02	4.1	0.15
	s1	C	1	10.2	0.34	0.01	4.6	0.55
	s2	20	1	13.0	0.49	0.02	6.9	0.89
	s3	35	1	9.5	0.46	0.00	4.2	0.47
	s4	15	1	15.1	0.39	0.01	5.8	0.89
	s5	35	2	14.9	0.39	0.01	6.9	1.12
	s6	15	2	14.2	0.34	0.01	7.2	0.64
	s7	20	2	20.2	0.61	0.03	10.5	1.37
	s8	C	2	7.6	0.27	0.01	4.0	0.58
	Average			13.1	0.41	0.01	6.3	0.82

Table 5.1.2. Comparison of nutrient loads calculated using autosamples and grab samples in 1998 (control plots highlighted).

1998	NH3-N Load, kg/ha			%
Site	Auto	Grab	Difference	Grab/Auto
w1	0.12	0.038	0.081	32%
w2	0.25	0.086	0.165	34%
w3	0.14	0.048	0.087	35%
w4	0.30	0.105	0.191	35%
w5	0.29	0.171	0.122	58%
w6	0.31	0.151	0.156	49%
w7	0.41	0.230	0.178	56%
w8	0.43	0.176	0.259	40%
Average	0.28	0.13	0.16	43%
s1	0.12	0.067	0.053	56%
s2	0.17	0.104	0.070	60%
s3	0.10	0.094	0.003	97%
s4	0.13	0.037	0.090	29%
s5	0.35	0.132	0.218	38%
s6	0.26	0.111	0.145	43%
s7	0.29	0.149	0.137	52%
s8	0.26	0.097	0.164	37%
Average	0.21	0.10	0.11	51%

Table 5.1.3. Comparison of nutrient loads calculated using autosamples and grab samples in 1999 (control plots highlighted).

1999	NH3-N Load, kg/ha			%
Site	Auto	Grab	Difference	Grab/Auto
w1	0.15	0.02	0.13	11%
w2	0.13	0.06	0.08	42%
w3	0.32	0.31	0.01	98%
w4	0.24	0.08	0.16	35%
w5	0.32	0.15	0.17	47%
w6	0.29	0.29	0.00	101%
w7	0.32	0.30	0.02	94%
w8	0.30	0.28	0.01	96%
Average	0.26	0.19	0.07	65%
s1	0.34	0.21	0.13	62%
s2	0.49	0.40	0.10	80%
s3	0.46	0.15	0.31	32%
s4	0.39	0.18	0.21	45%
s5	0.39	0.16	0.22	42%
s6	0.34	0.25	0.09	73%
s7	0.51	0.29	0.22	57%
s8	0.27	0.24	0.04	86%
Average	0.40	0.23	0.17	60%

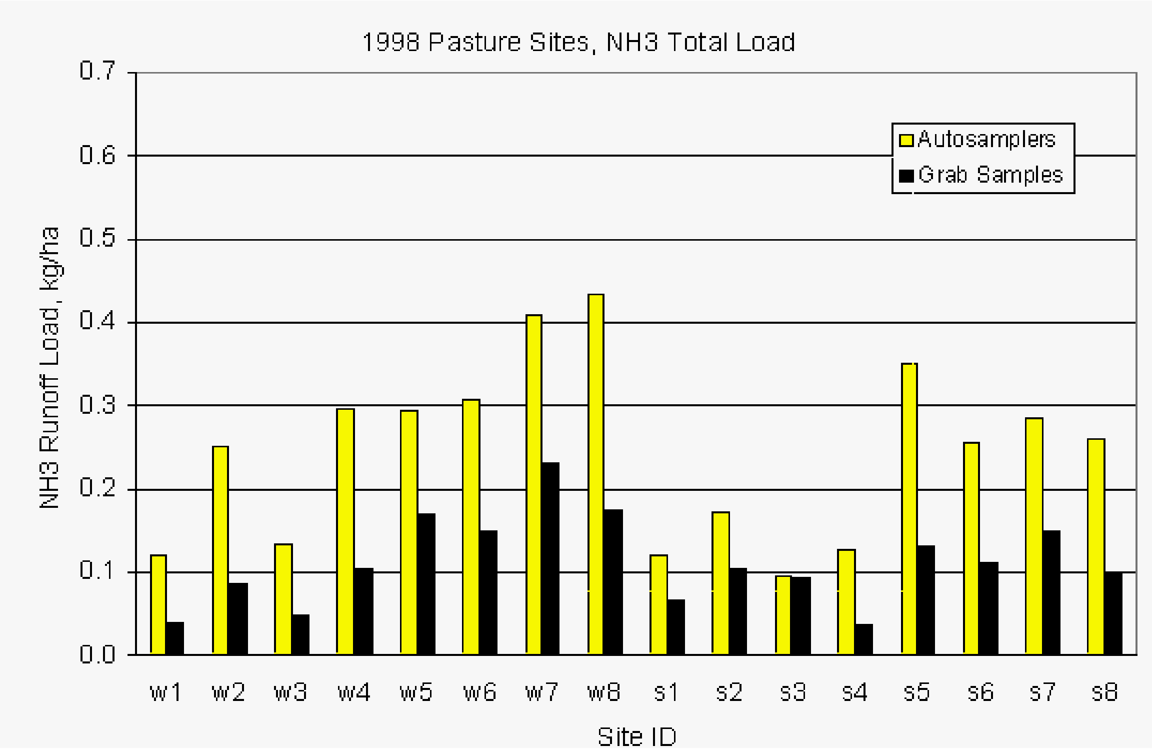


Figure 5.1.7. Comparison of NH3-N runoff nutrient loads for 1998 as calculated using autosamples and grab samples.

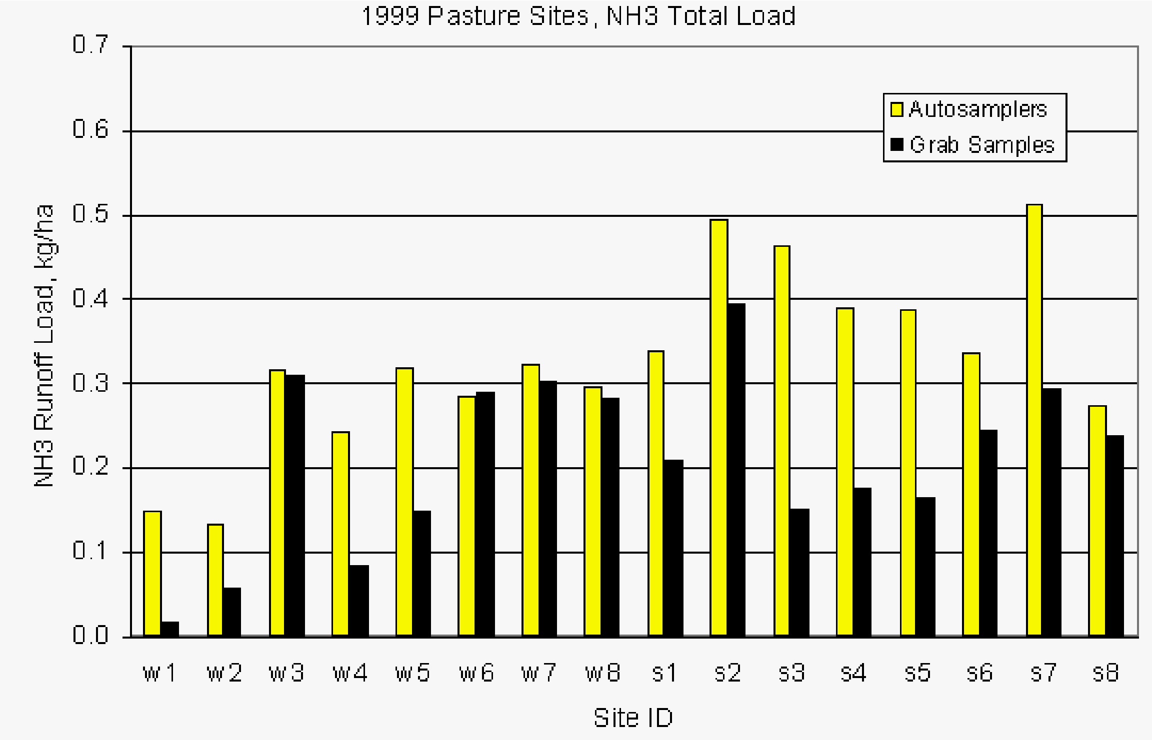


Figure 5.1.8. Comparison of NH3-N runoff nutrient loads for 1999 as calculated using autosamples and grab samples.

Table 5.1.4. Comparison of nutrient loads calculated using autosamples and grab samples in 1998 (control plots highlighted).

1998	NOx-N Load, kg/ha			%
Site	Auto	Grab	Difference	Grab/Auto
w1	0.023	0.01	0.02	29%
w2	0.030	0.01	0.02	33%
w3	0.023	0.02	0.01	74%
w4	0.042	0.03	0.01	69%
w5	0.043	0.03	0.01	72%
w6	0.029	0.03	0.00	92%
w7	0.071	0.04	0.03	58%
w8	0.056	0.04	0.02	72%
Average	0.04	0.03	0.01	62%
s1	0.02	0.024	0.00	100%
s2	0.02	0.019	0.00	100%
s3	0.03	0.028	0.00	100%
s4	0.01	0.009	0.00	100%
s5	0.04	0.038	0.00	100%
s6	0.01	0.012	0.00	100%
s7	0.01	0.012	0.00	100%
s8	0.02	0.015	0.00	100%
Average	0.02	0.02	0.00	100%

Table 5.1.5. Comparison of nutrient loads calculated using autosamples and grab samples in 1999 (control plots highlighted).

1999	NOx-N Load, kg/ha			%
Site	Auto	Grab	Difference	Grab/Auto
w1	0.032	0.000	0.032	0%
w2	0.017	0.000	0.017	0%
w3	0.011	0.009	0.002	82%
w4	0.020	0.000	0.020	0%
w5	0.044	0.003	0.041	7%
w6	0.018	0.004	0.014	21%
w7	0.013	0.000	0.013	0%
w8	0.019	0.009	0.010	48%
Average	0.02	0.00	0.02	20%
s1	0.014	0.001	0.013	10%
s2	0.017	0.061	0.044	367%
s3	0.000	0.000	0.000	0%
s4	0.009	0.004	0.006	37%
s5	0.005	0.002	0.003	48%
s6	0.008	0.000	0.008	0%
s7	0.030	0.003	0.026	12%
s8	0.008	0.002	0.006	23%
Average	0.01	0.01	0.01	62%

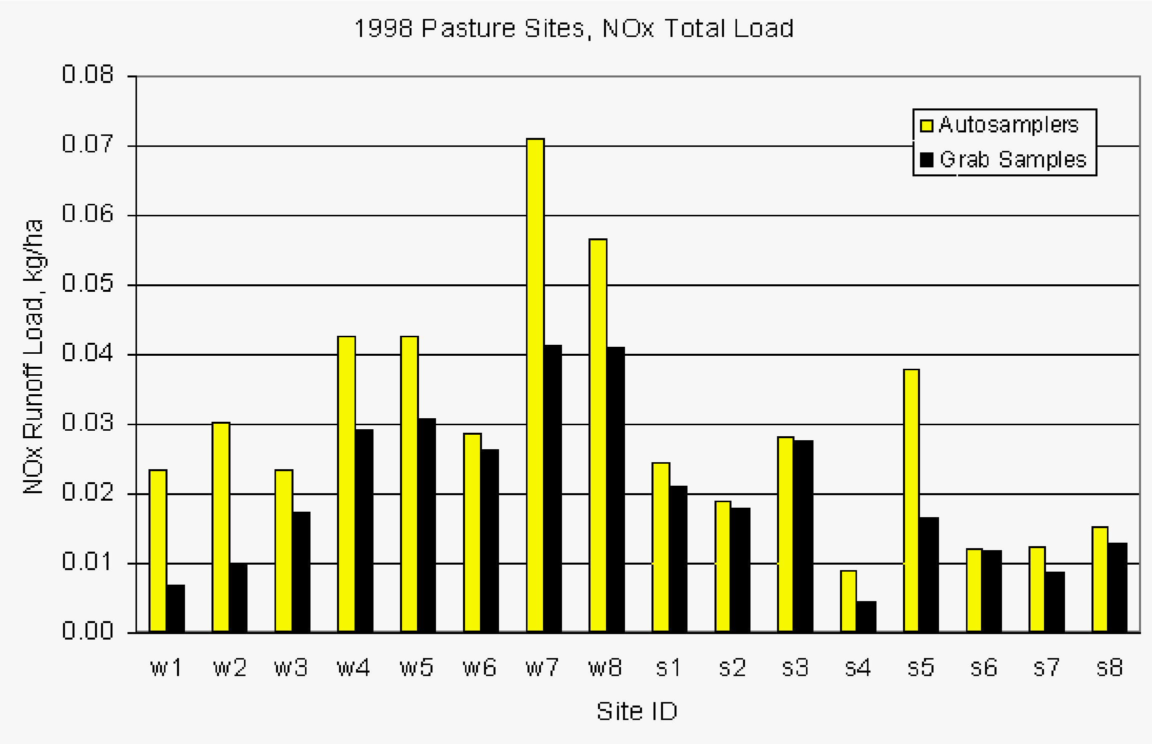


Figure 5.1.9. Comparison of NOx-N runoff nutrient loads for 1998 as calculated using autosamples and grab samples.

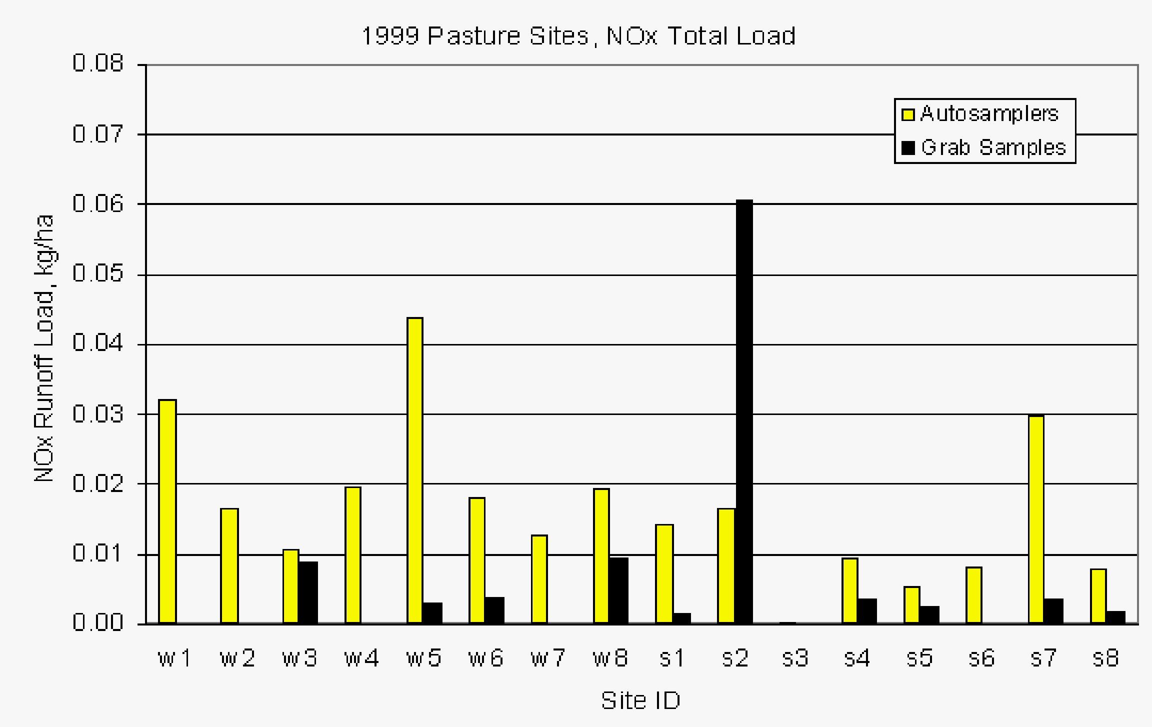


Figure 5.1.10. Comparison of NOx-N runoff nutrient loads for 1999 as calculated using autosamples and grab samples.

Table 5.1.6. Comparison of nutrient loads calculated using autosamples and grab samples in 1998 (control plots highlighted).

1998	TKN-N Load, kg/ha			%
Site	Auto	Grab	Difference	Grab/Auto
w1	3.87	3.55	0.32	92%
w2	5.62	5.30	0.32	94%
w3	4.11	3.80	0.30	93%
w4	6.95	7.78	0.83	112%
w5	8.88	8.92	0.04	100%
w6	6.70	7.86	1.16	117%
w7	8.36	9.91	1.56	119%
w8	6.92	6.92	0.01	100%
Average	6.43	6.76	0.57	103%
s1	4.08	3.96	0.12	97%
s2	6.98	6.88	0.10	99%
s3	6.89	6.87	0.01	100%
s4	2.31	2.25	0.05	98%
s5	6.65	6.94	0.29	104%
s6	7.25	7.02	0.23	97%
s7	8.17	9.57	1.40	117%
s8	5.29	4.91	0.38	93%
Average	5.95	6.05	0.32	101%

Table 5.1.7. Comparison of nutrient loads calculated using autosamples and grab samples in 1999 (control plots highlighted).

1999	TKN-N Load, kg/ha			%
Site	Auto	Grab	Difference	Grab/Auto
w1	2.58	1.35	1.23	52%
w2	2.13	2.55	0.42	120%
w3	4.80	4.98	0.18	104%
w4	4.91	3.33	1.59	68%
w5	4.51	4.58	0.07	102%
w6	6.19	5.17	1.01	84%
w7	3.67	6.23	2.56	170%
w8	3.98	4.64	0.66	117%
Average	4.10	4.10	0.97	102%
s1	4.60	3.92	0.68	85%
s2	6.86	5.93	0.93	86%
s3	4.25	4.36	0.11	103%
s4	5.83	6.51	0.67	112%
s5	6.93	6.15	0.78	89%
s6	7.17	6.90	0.27	96%
s7	10.48	9.60	0.87	92%
s8	4.02	4.98	0.96	124%
Average	6.27	6.04	0.66	98%

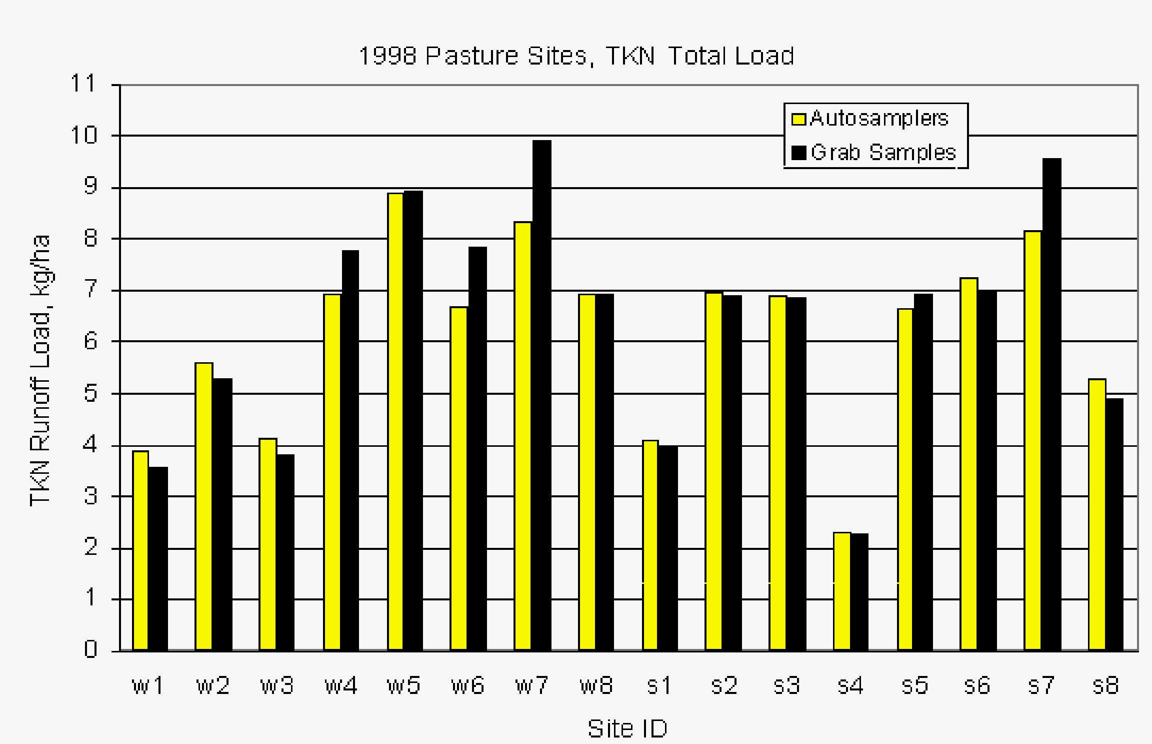


Figure 5.1.11. Comparison of TKN-N runoff nutrient loads for 1998 as calculated using autosamples and grab samples.

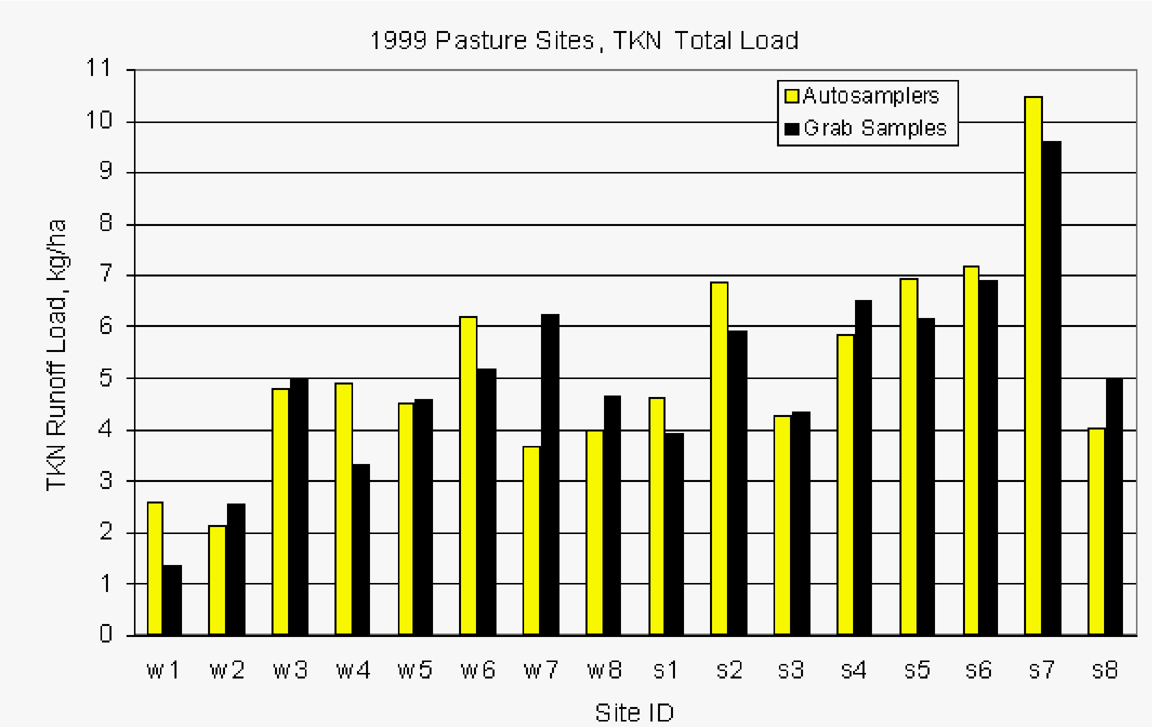


Figure 5.1.12. Comparison of TKN-N runoff nutrient loads for 1999 as calculated using autosamples and grab samples.

Table 5.1.8. Comparison of nutrient loads calculated using autosamples and grab samples in 1998 (control plots highlighted).

1998 Site	TP-P Load, kg/ha Auto	 Grab	Difference	% Grab/Auto
w1	0.07	0.044	0.03	60%
w2	0.07	0.073	0.00	104%
w3	0.10	0.081	0.02	83%
w4	0.12	0.086	0.03	73%
w5	0.14	0.107	0.04	75%
w6	0.14	0.122	0.02	87%
w7	0.13	0.148	0.02	116%
w8	0.10	0.102	0.00	97%
Average	0.11	0.10	0.02	87%
s1	0.58	0.53	0.05	91%
s2	0.51	0.48	0.03	94%
s3	0.60	0.60	0.01	101%
s4	0.66	0.61	0.05	93%
s5	1.17	1.18	0.01	101%
s6	0.46	0.63	0.17	137%
s7	0.64	0.77	0.13	121%
s8	1.25	1.00	0.25	80%
Average	0.73	0.73	0.09	102%

Table 5.1.9. Comparison of nutrient loads calculated using autosamples and grab samples in 1999 (control plots highlighted).

1999 Site	TP-P Load, kg/ha Auto	 Grab	Difference	% Grab/Auto
w1	0.16	0.04	0.12	27%
w2	0.24	0.04	0.19	18%
w3	0.18	0.09	0.09	49%
w4	0.08	0.08	0.00	95%
w5	0.12	0.05	0.06	46%
w6	0.12	0.11	0.01	91%
w7	0.18	0.11	0.07	61%
w8	0.10	0.08	0.02	82%
Average	0.15	0.08	0.07	59%
s1	0.55	0.43	0.12	77%
s2	0.89	0.55	0.34	62%
s3	0.47	0.34	0.13	73%
s4	0.89	1.12	0.23	126%
s5	1.12	0.91	0.21	81%
s6	0.64	0.81	0.17	126%
s7	1.37	1.15	0.22	84%
s8	0.58	0.65	0.07	112%
Average	0.82	0.75	0.19	93%

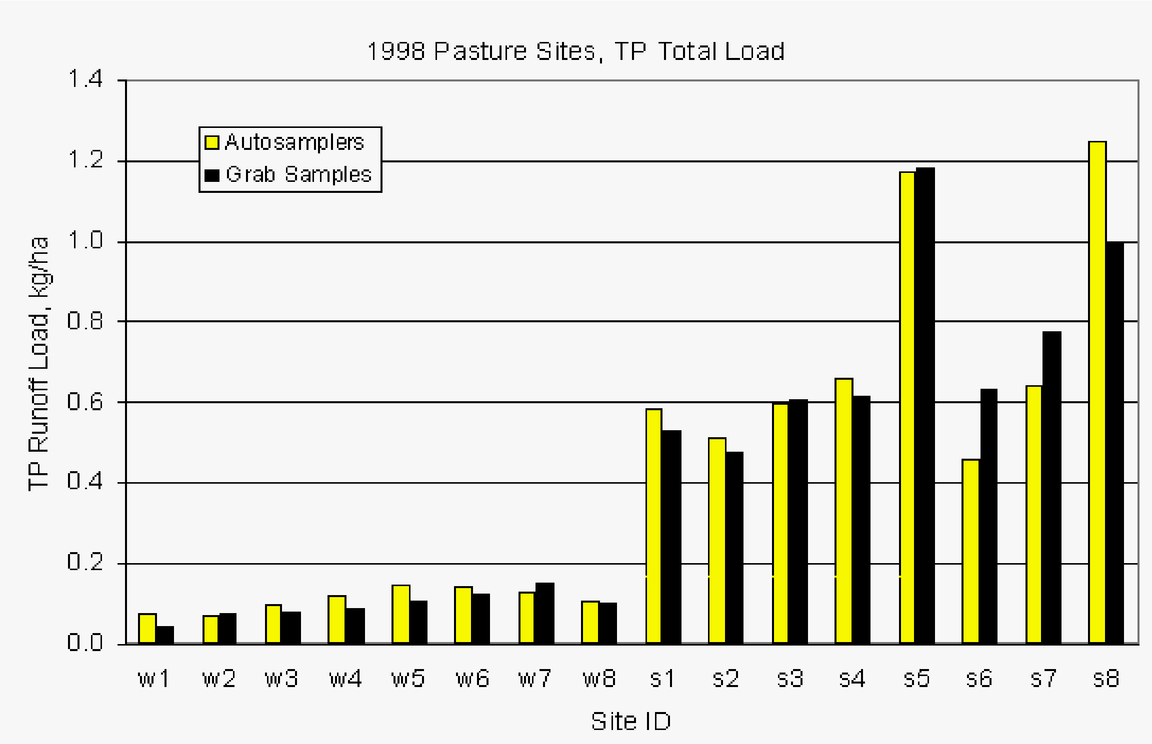


Figure 5.1.13. Comparison of TP-P runoff nutrient loads for 1998 as calculated using autosamples and grab samples.

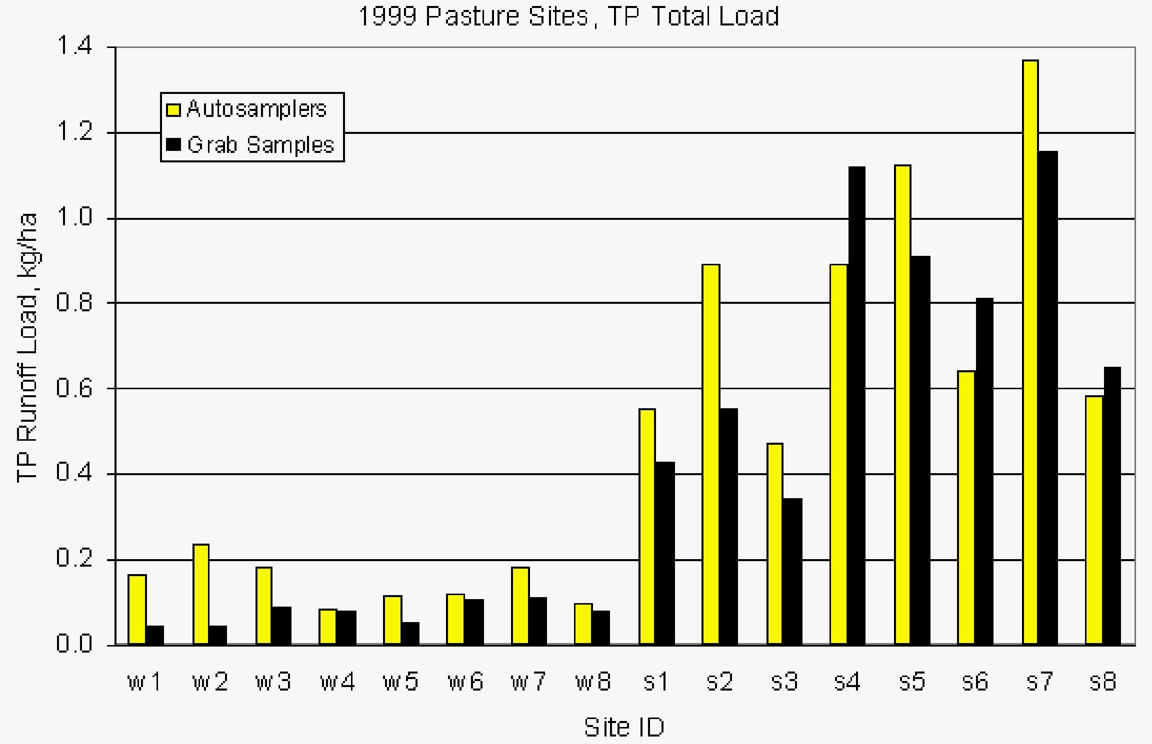


Figure 5.1.14. Comparison of TP-P runoff nutrient loads for 1999 as calculated using autosamples and grab samples.

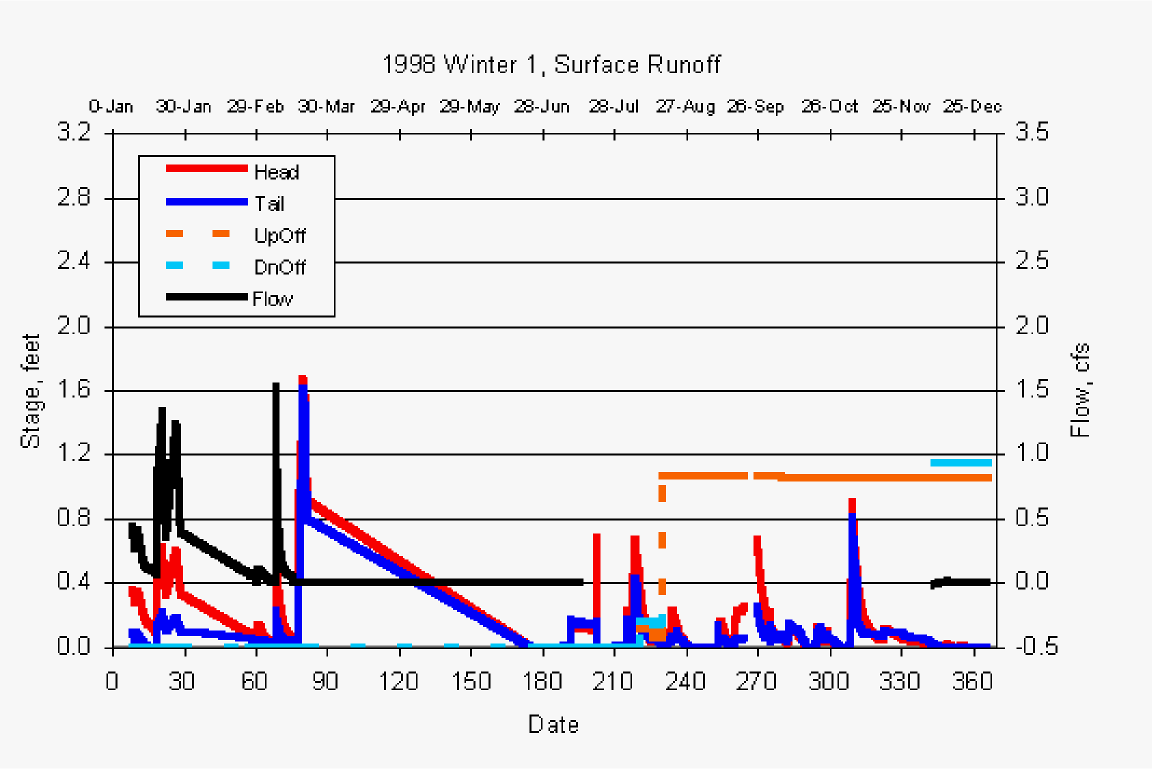


Figure 5.2.1.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 1 in 1998.

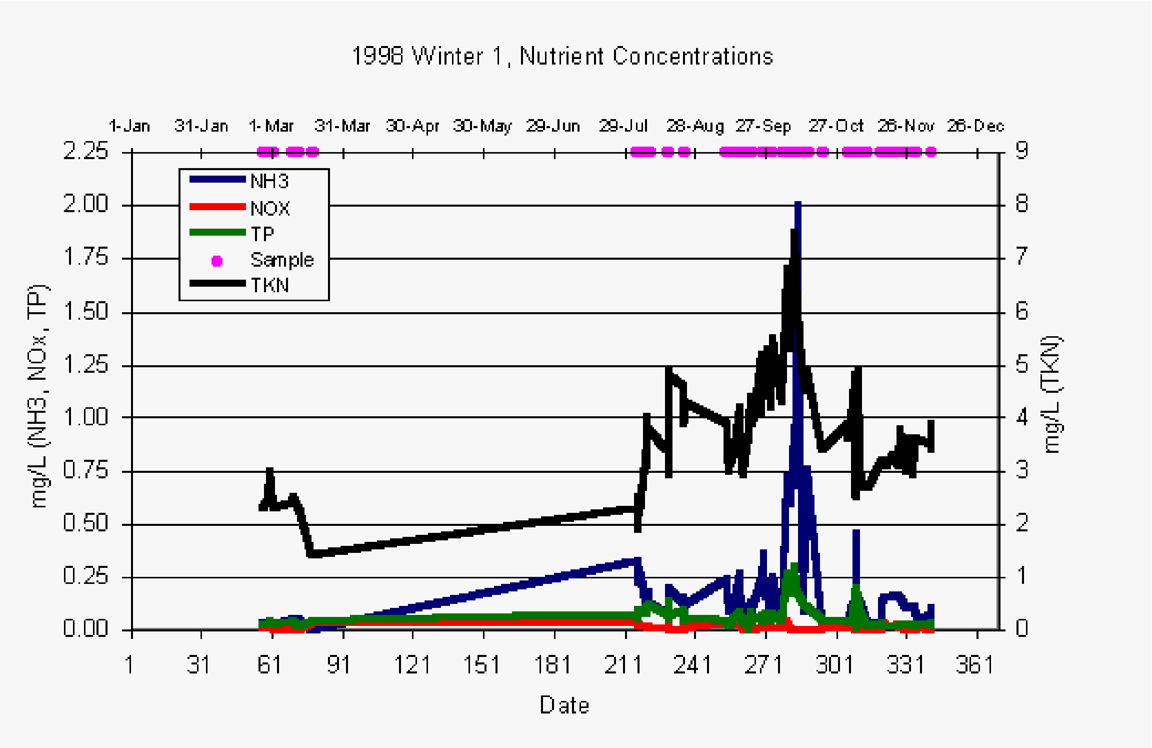


Figure 5.2.1.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 1 in 1998.

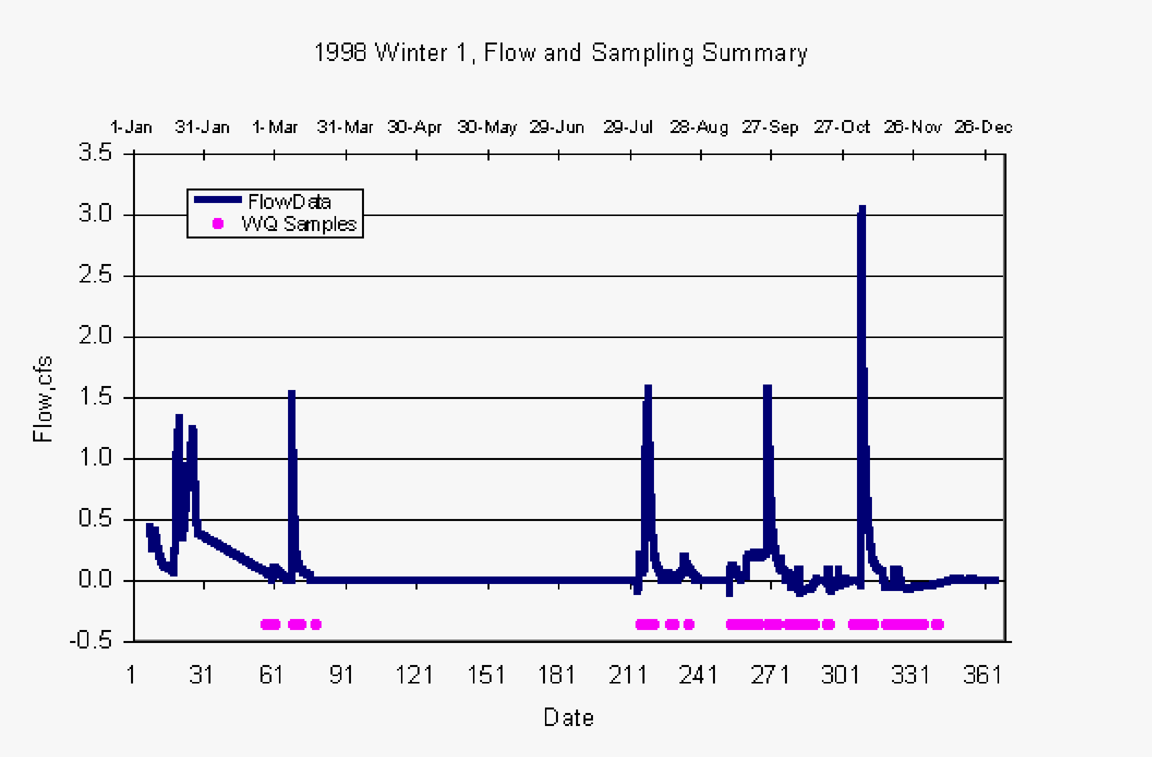


Figure 5.2.1.3. Collection dates and calculated runoff flow values for winter pasture 1 in 1998.

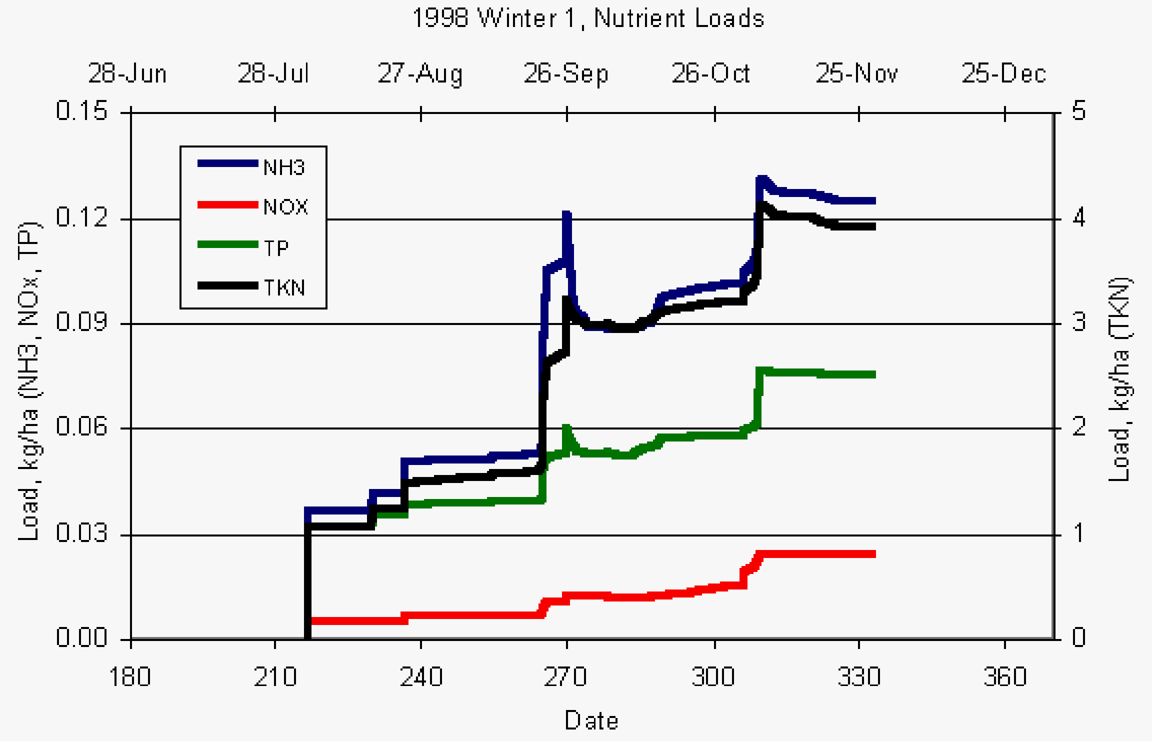


Figure 5.2.1.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 1 in 1998.

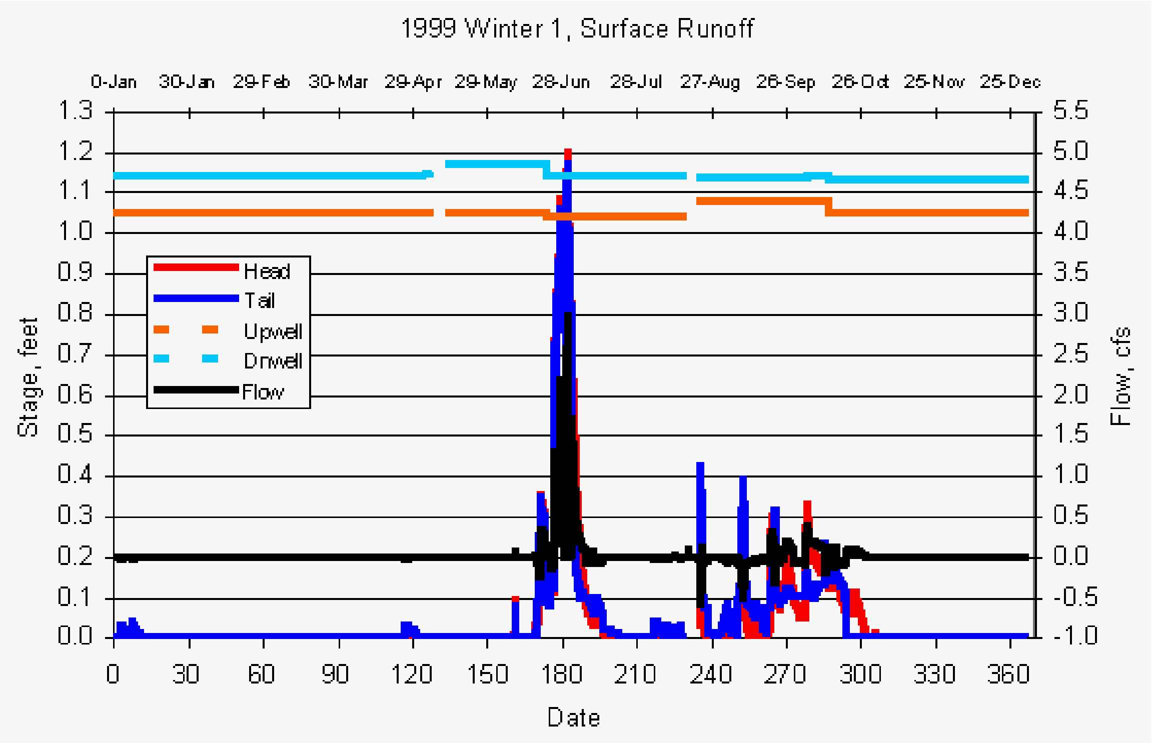


Figure 5.2.1.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 1 in 1999.

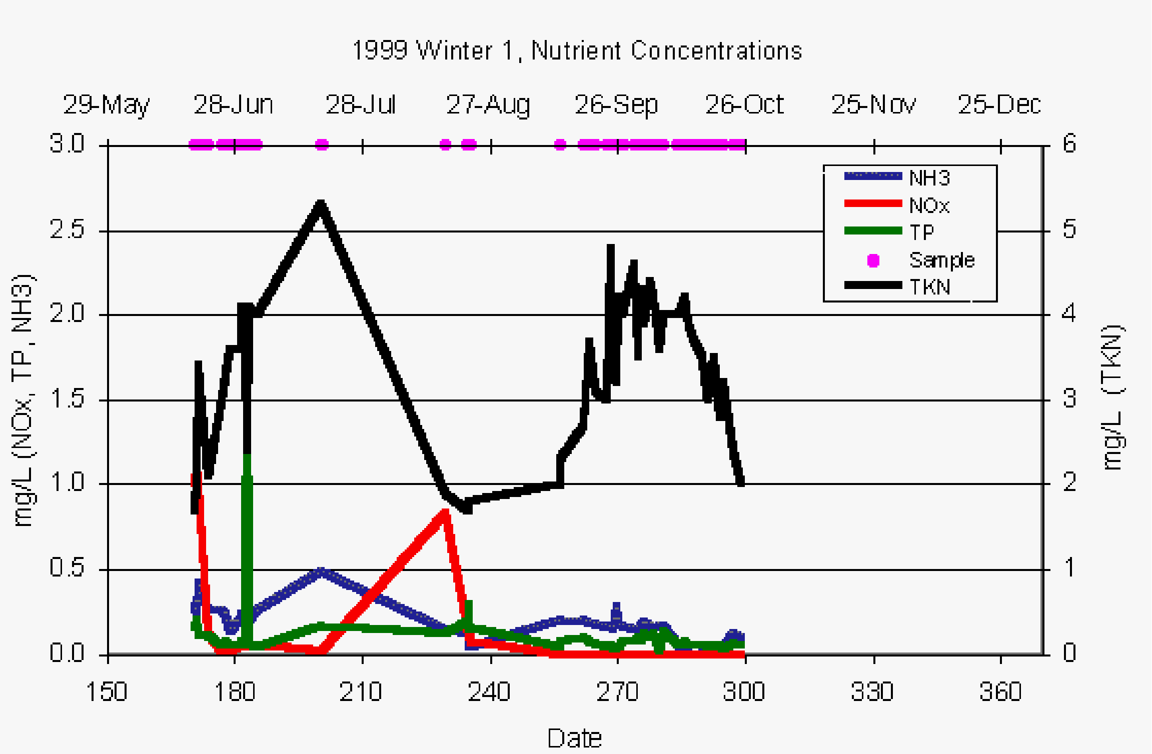


Figure 5.2.1.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 1 in 1999.

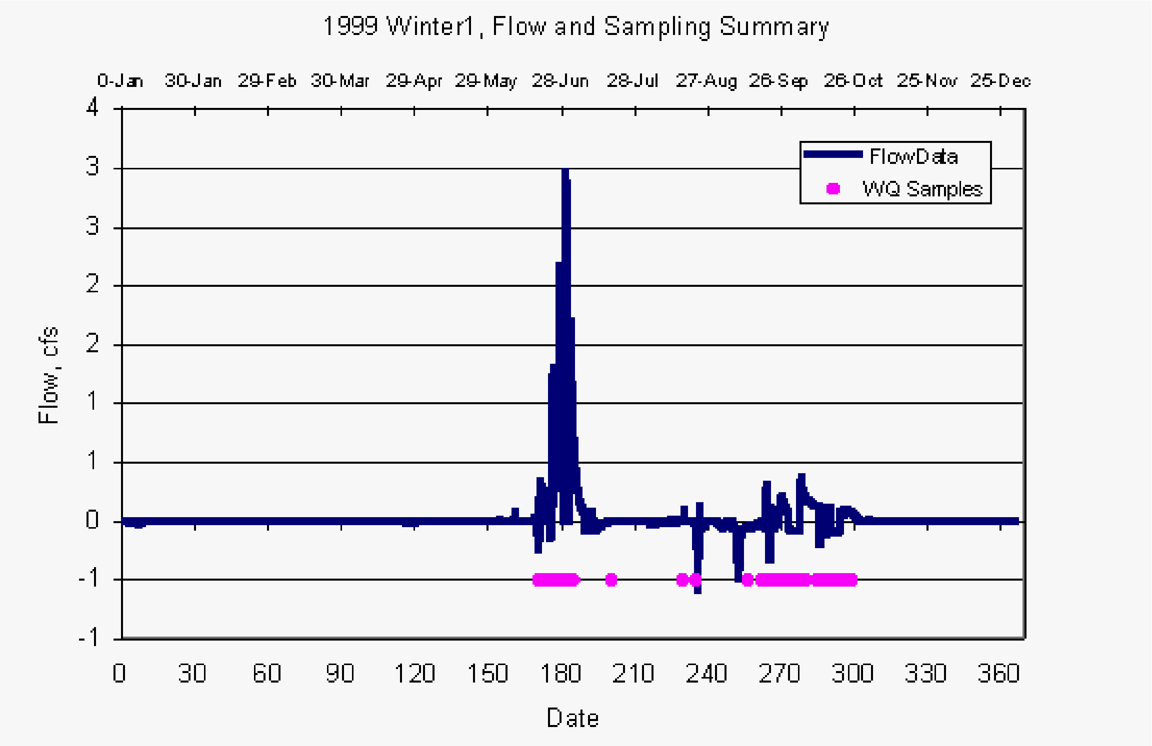


Figure 5.2.1.7. Collection dates and calculated runoff flow values for winter pasture 1 in 1999.

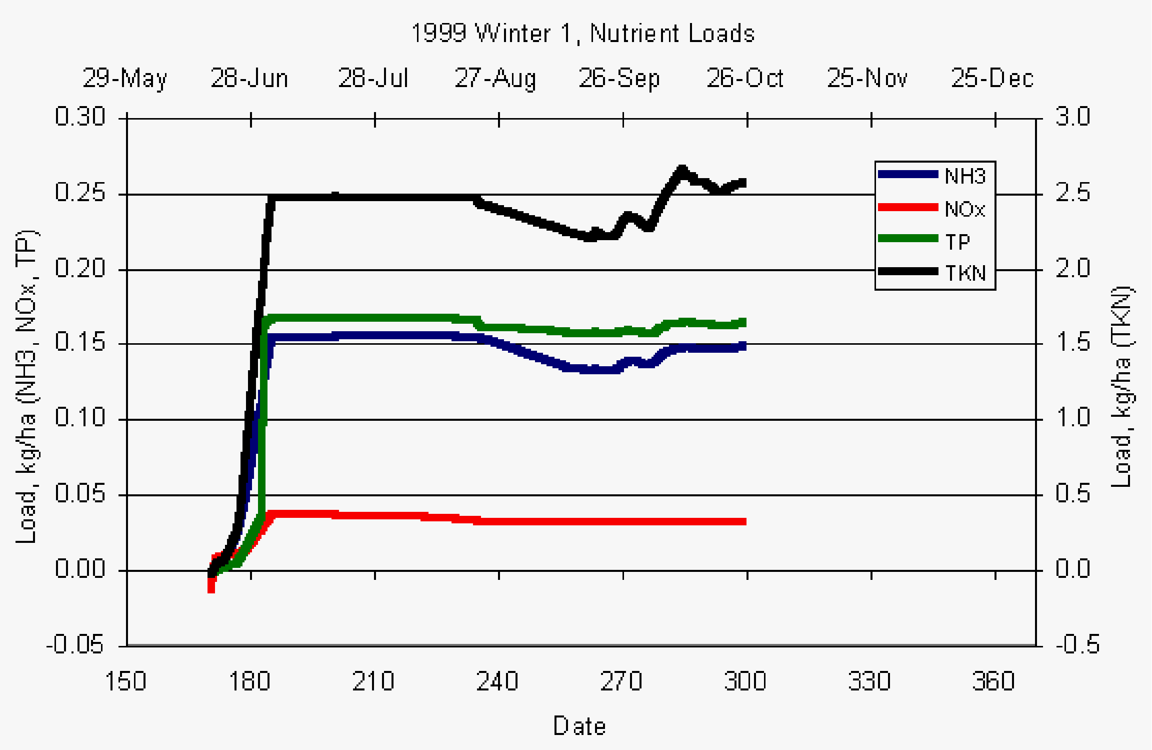


Figure 5.2.1.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 1 in 1999.

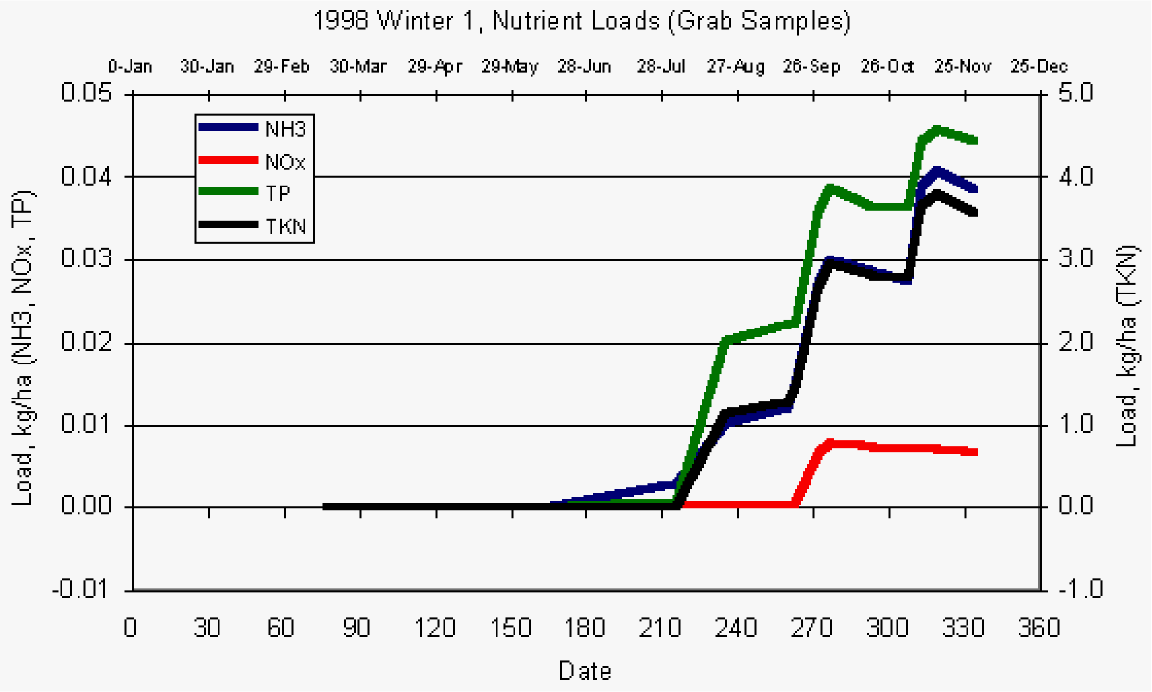


Figure 5.2.1.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 1 in 1998.

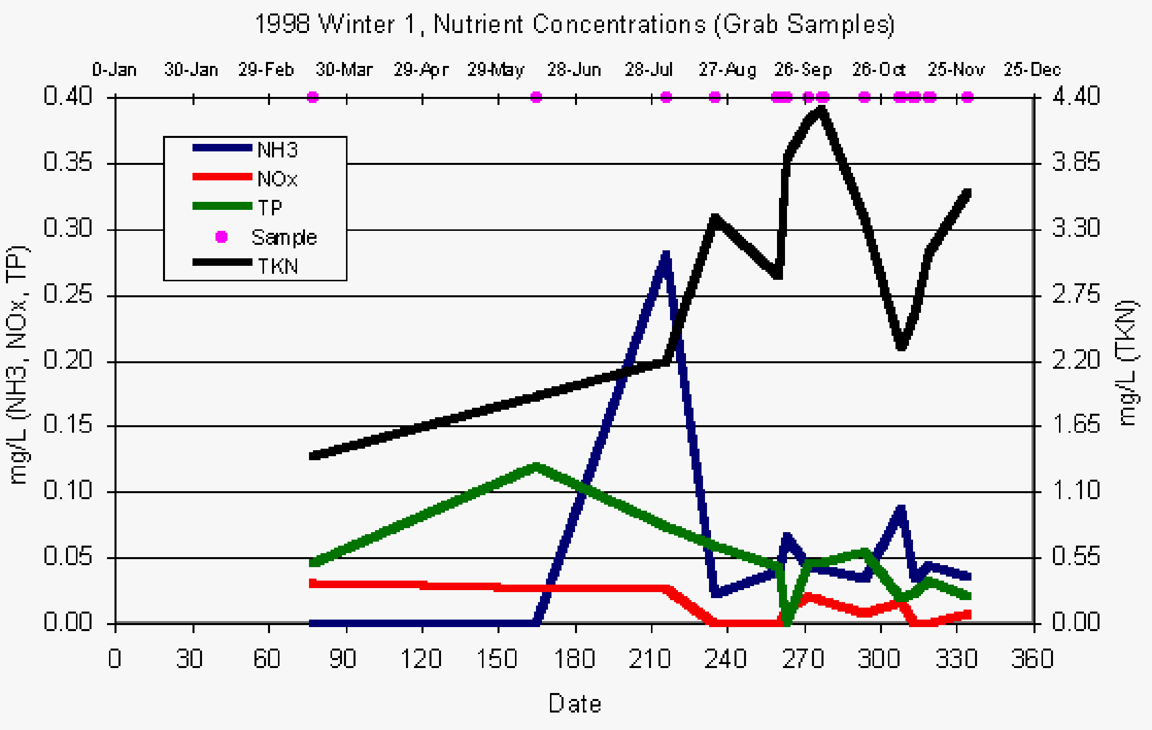


Figure 5.2.1.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 1 in 1998.

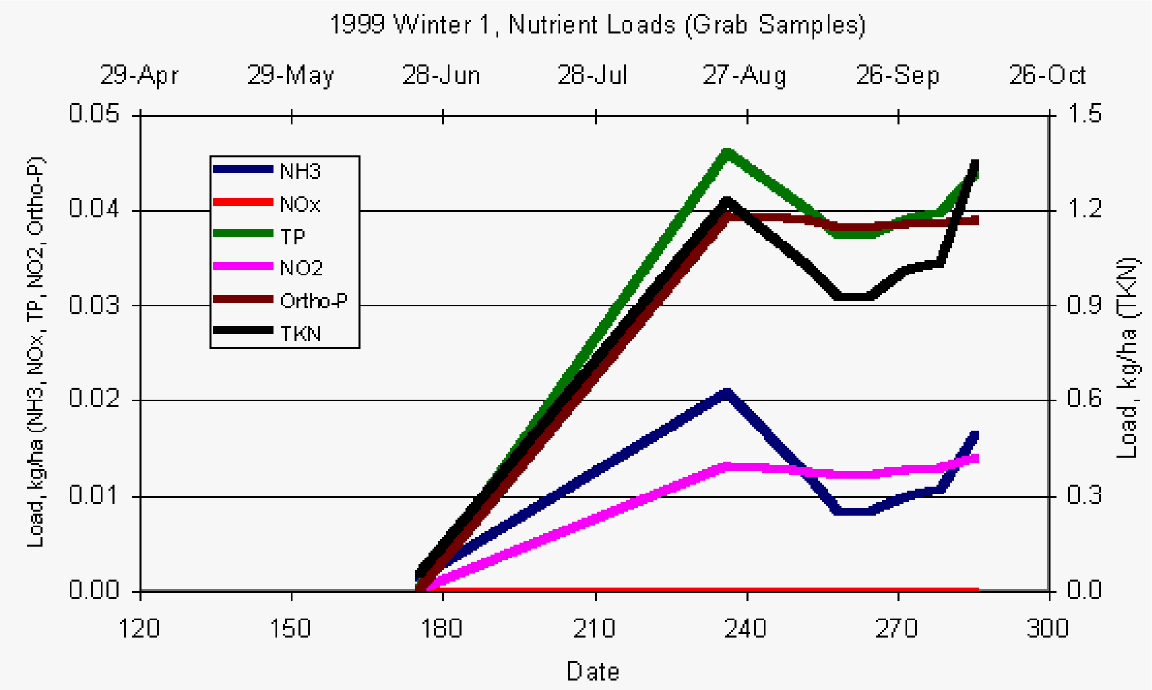


Figure 5.2.1.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 1 in 1999.

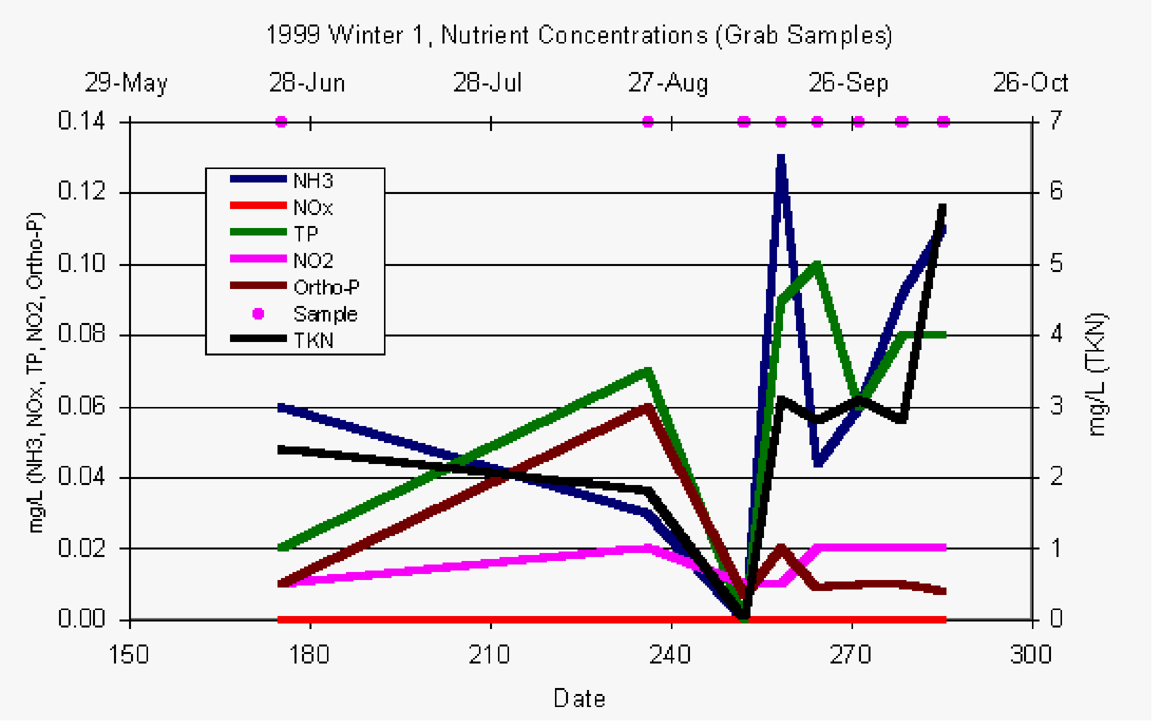


Figure 5.2.1.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 1 in 1999.

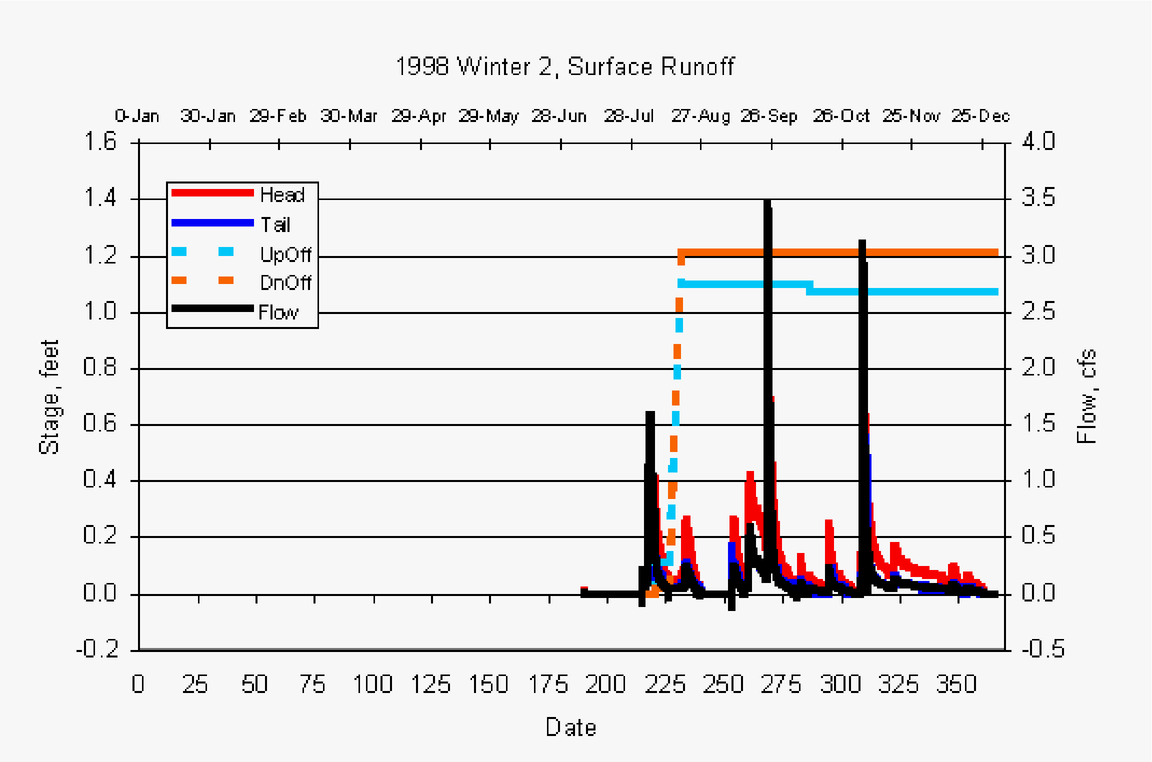


Figure 5.2.2.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 2 in 1998.

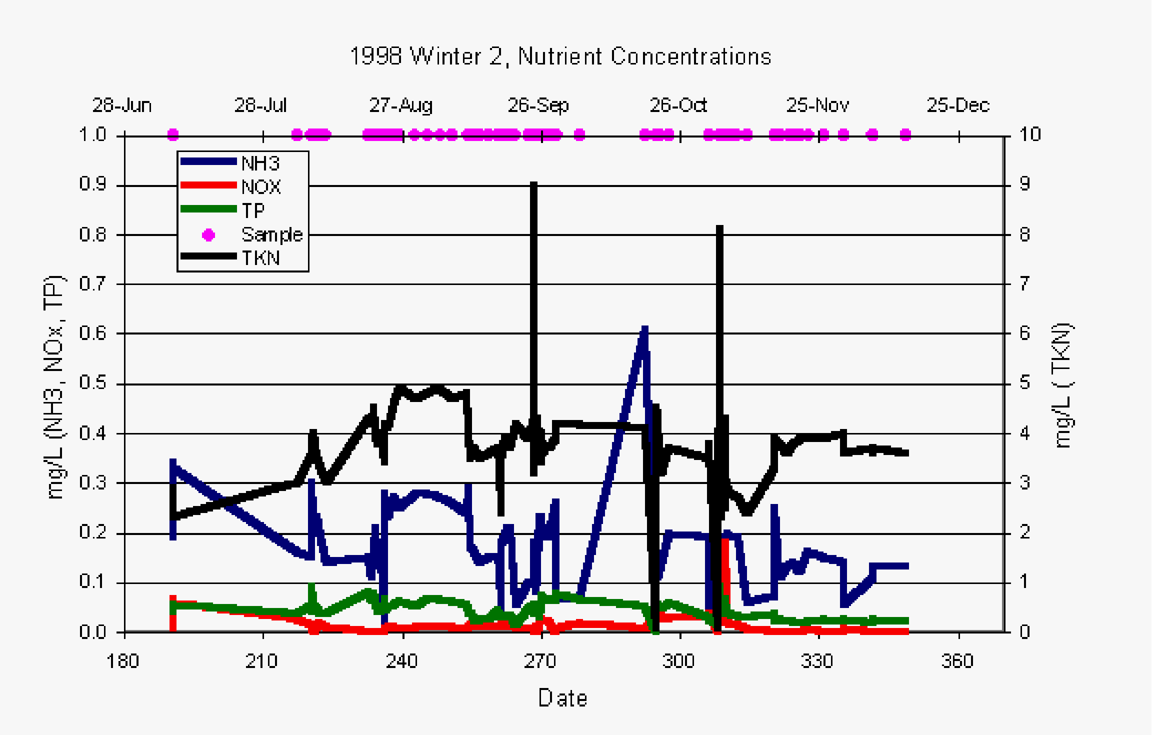


Figure 5.2.2.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 2 in 1998.

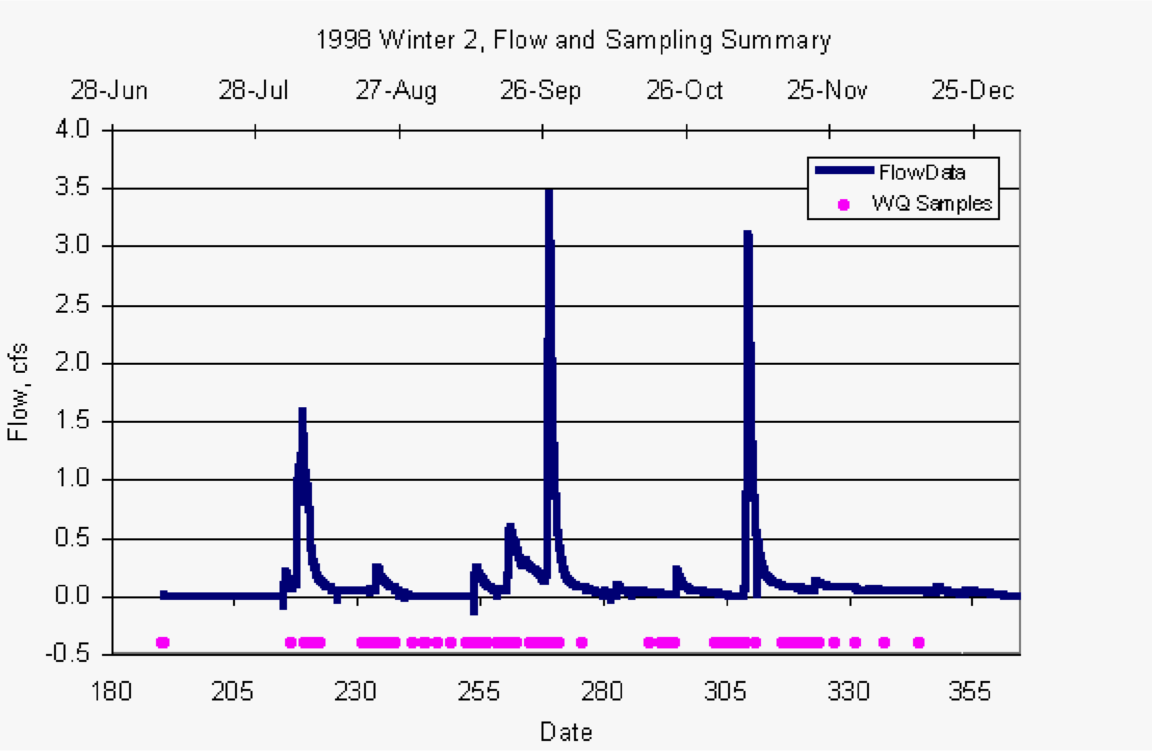


Figure 5.2.2.3. Collection dates and calculated runoff flow values for winter pasture 2 in 1998.

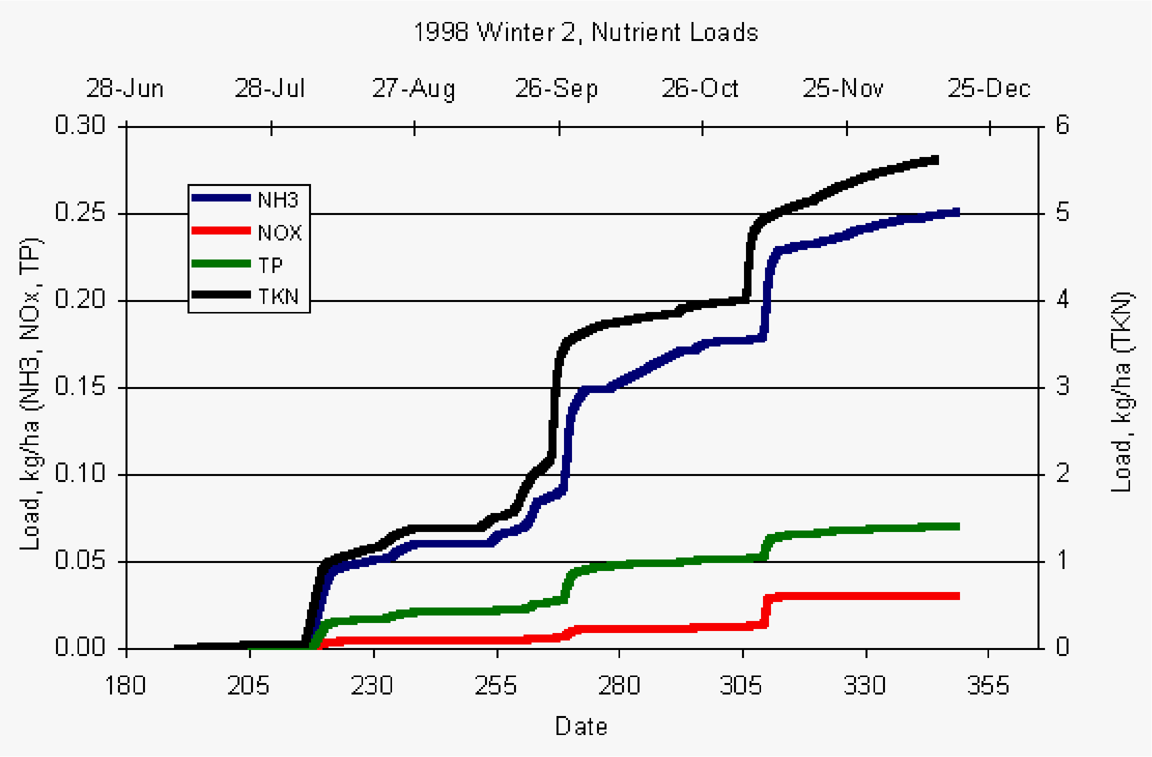


Figure 5.2.2.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 2 in 1998.

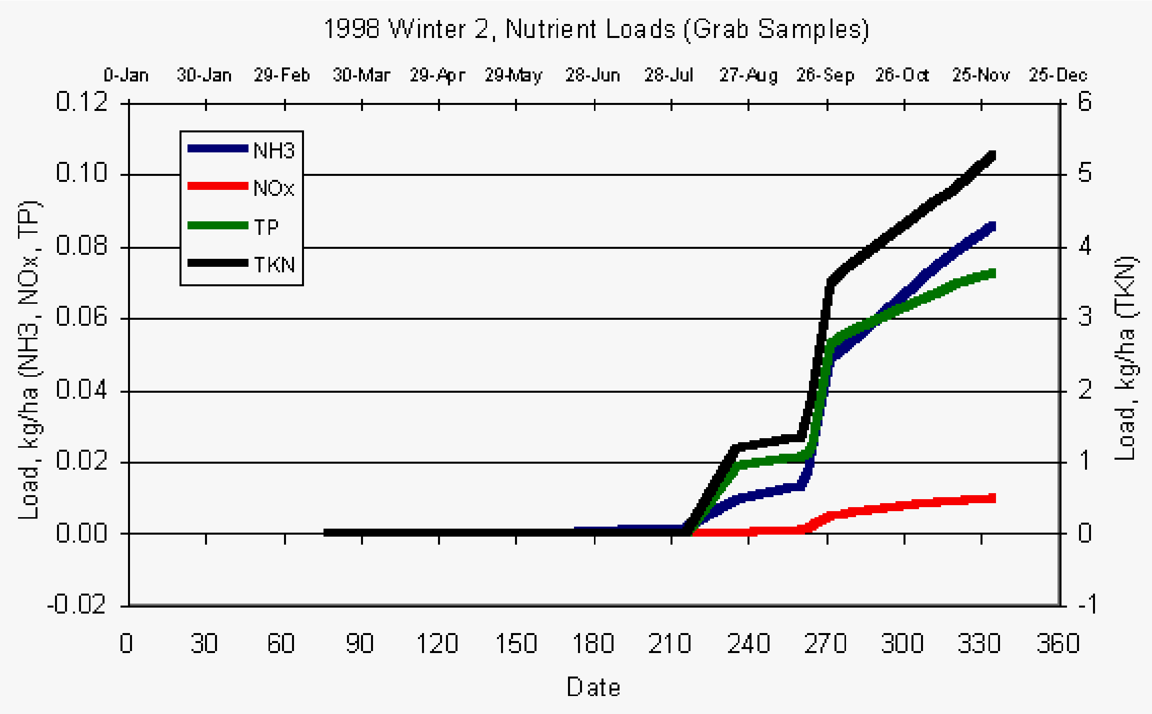


Figure 5.2.2.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 2 in 1998.

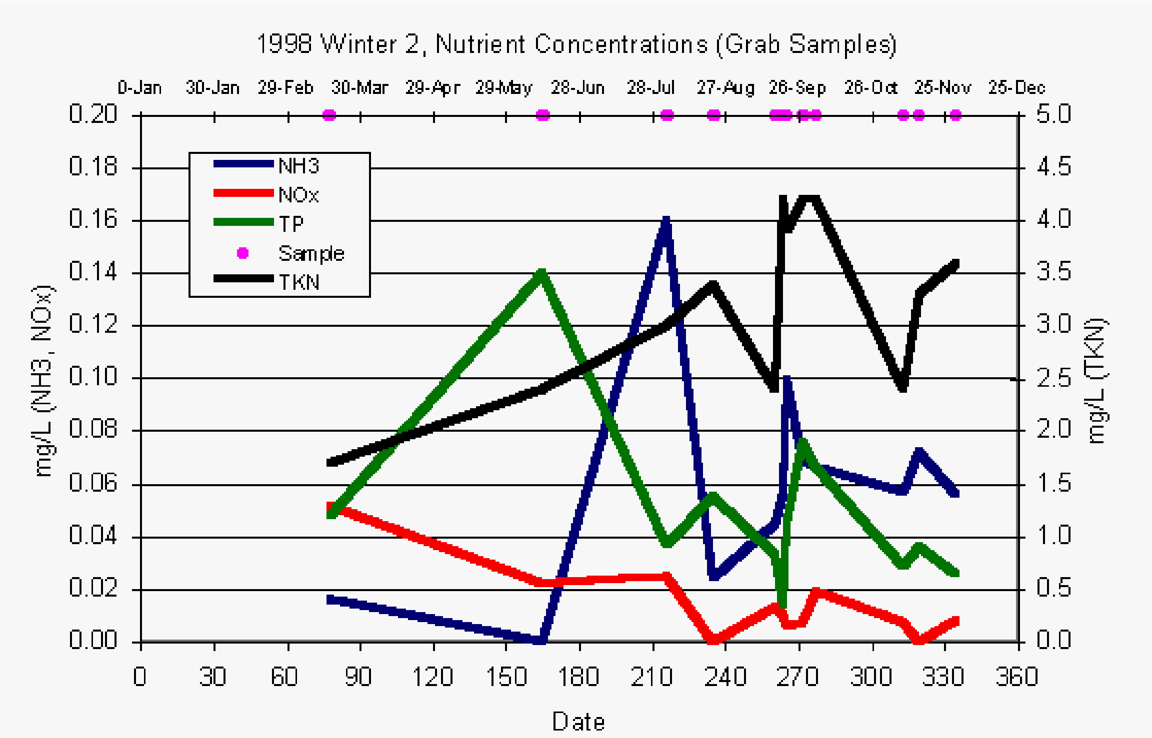


Figure 5.2.2.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 2 in 1998.

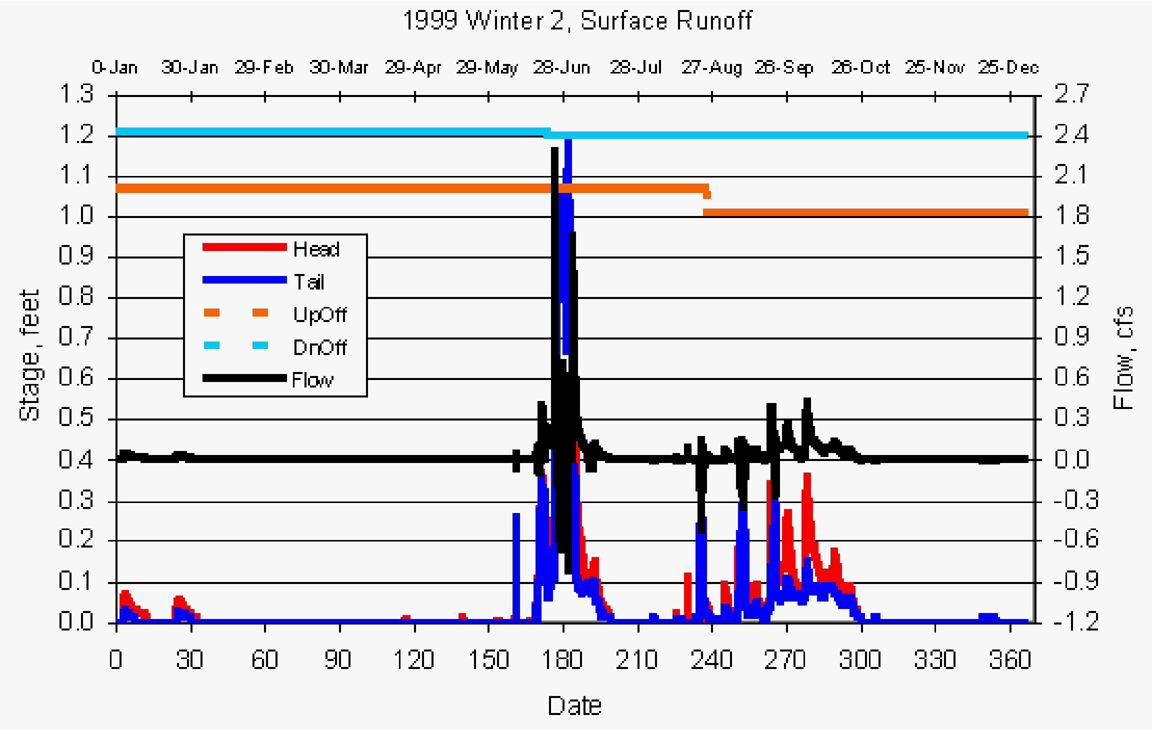


Figure 5.2.2.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 2 in 1999.

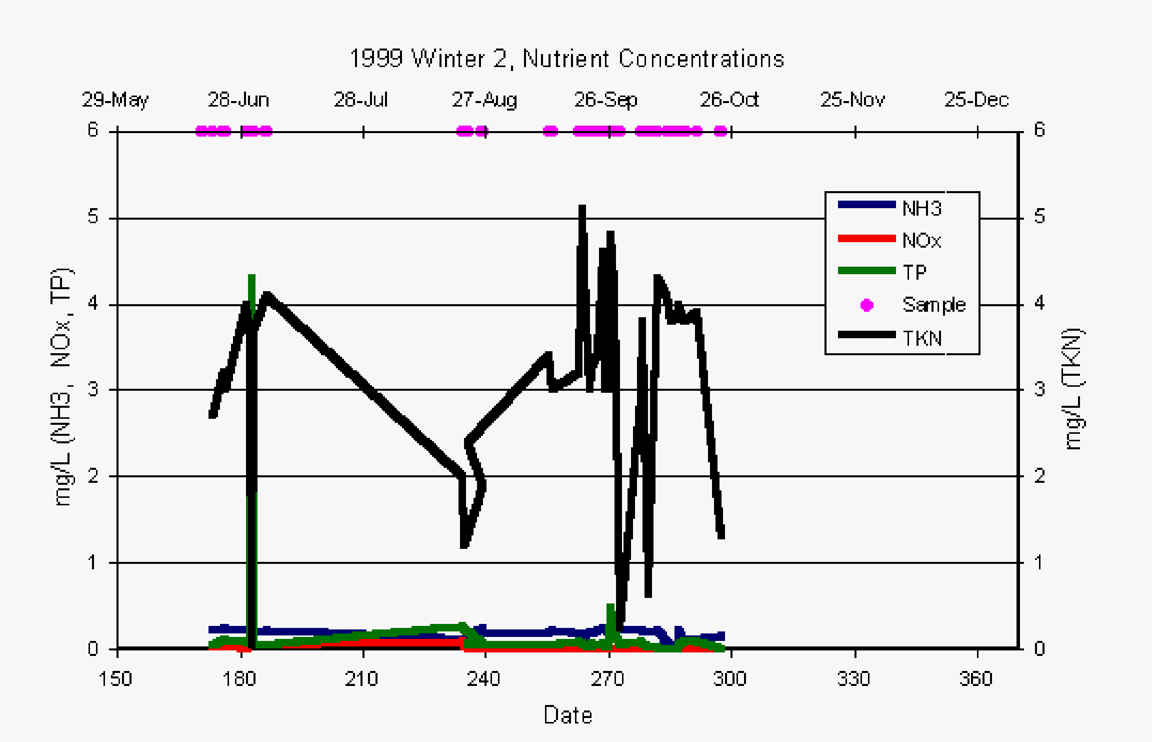


Figure 5.2.2.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 2 in 1999.

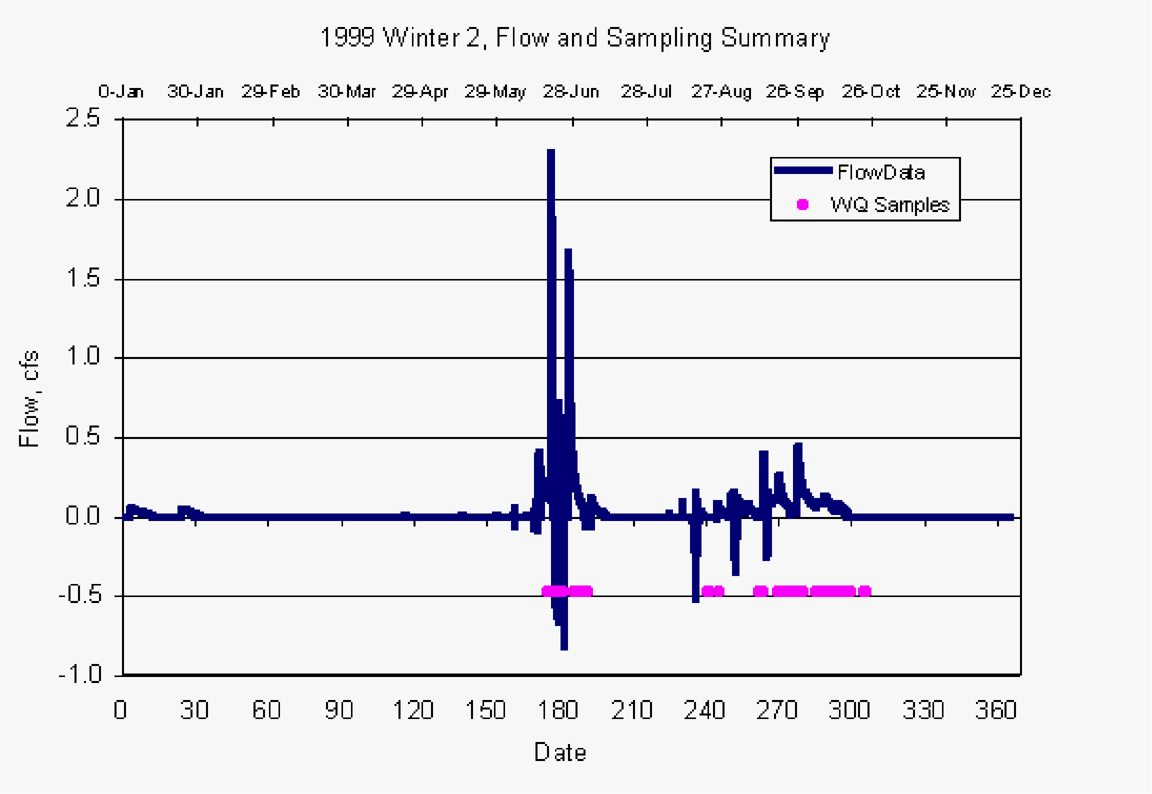


Figure 5.2.2.7. Collection dates and calculated runoff flow values for winter pasture 2 in 1999.

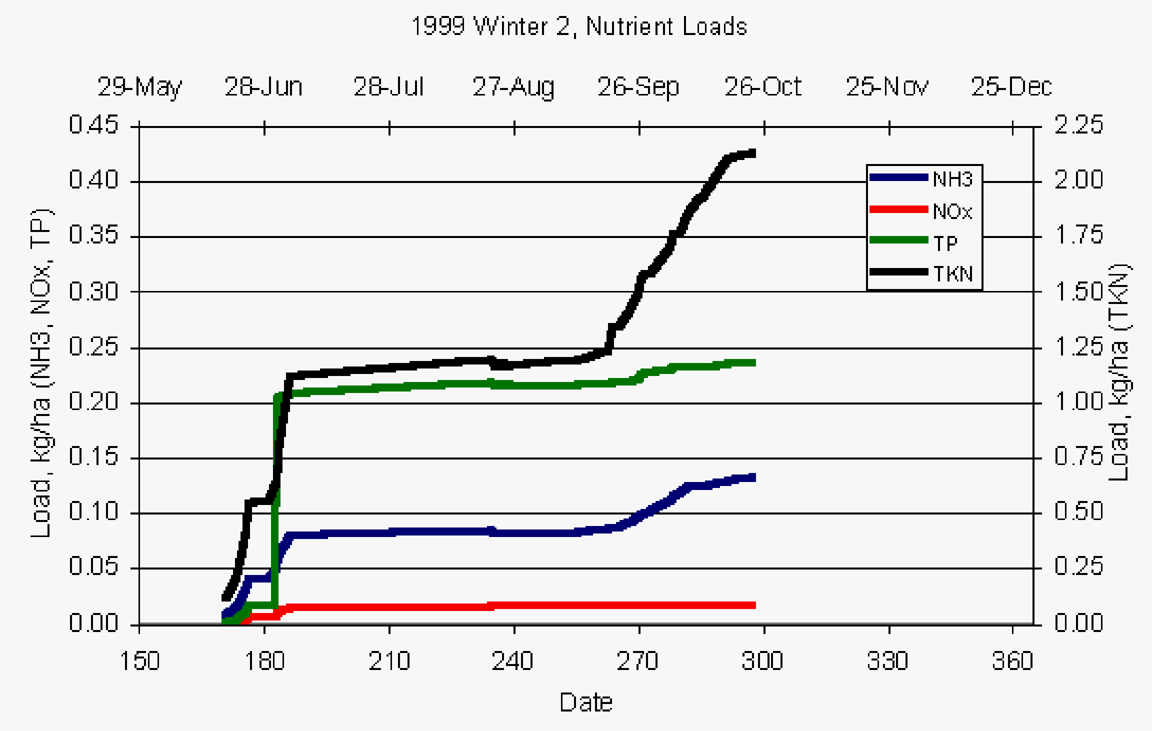


Figure 5.2.2.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 2 in 1999.

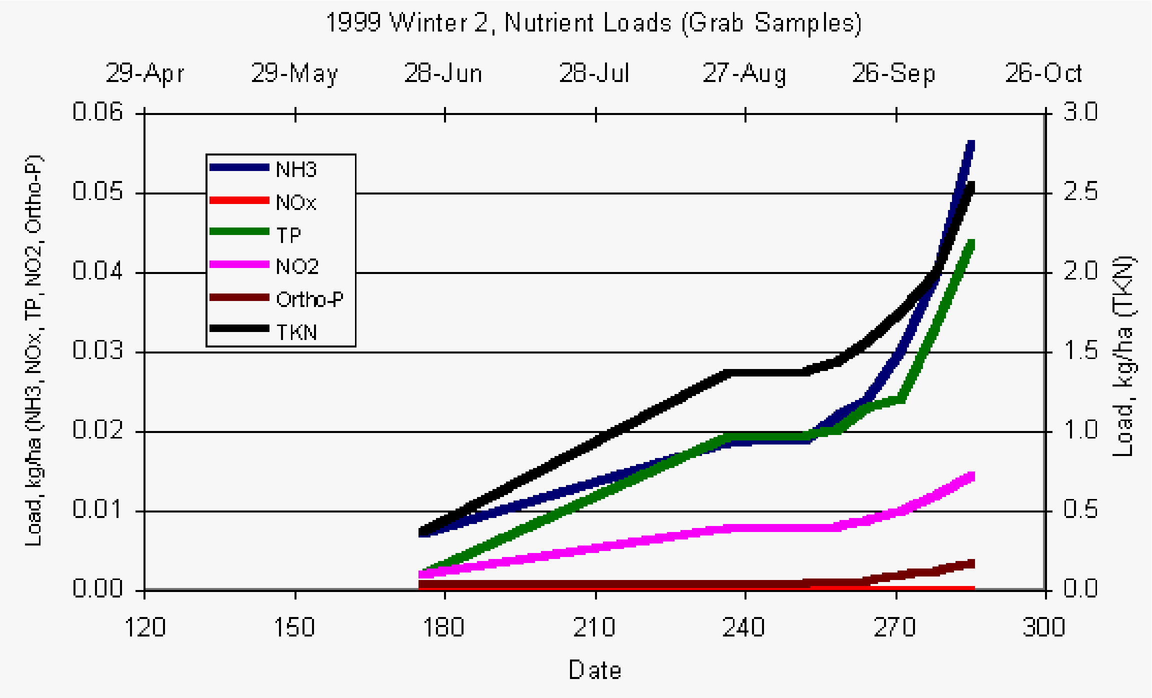


Figure 5.2.2.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 2 in 1999.

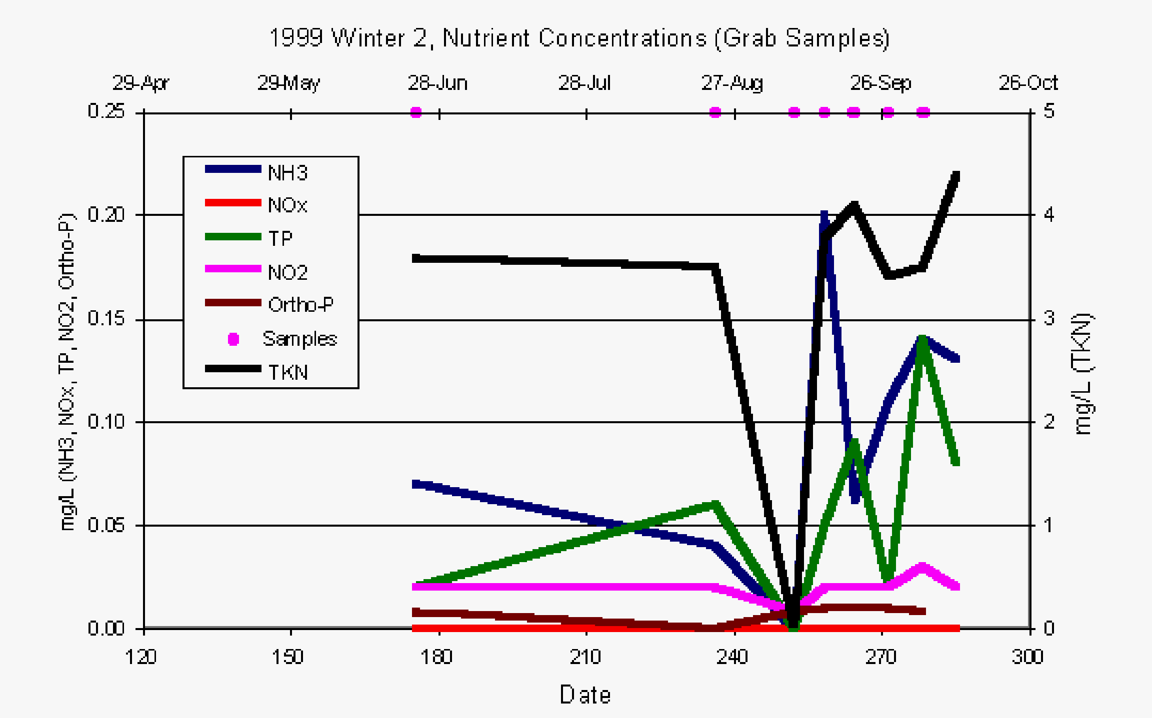


Figure 5.2.2.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 2 in 1999.

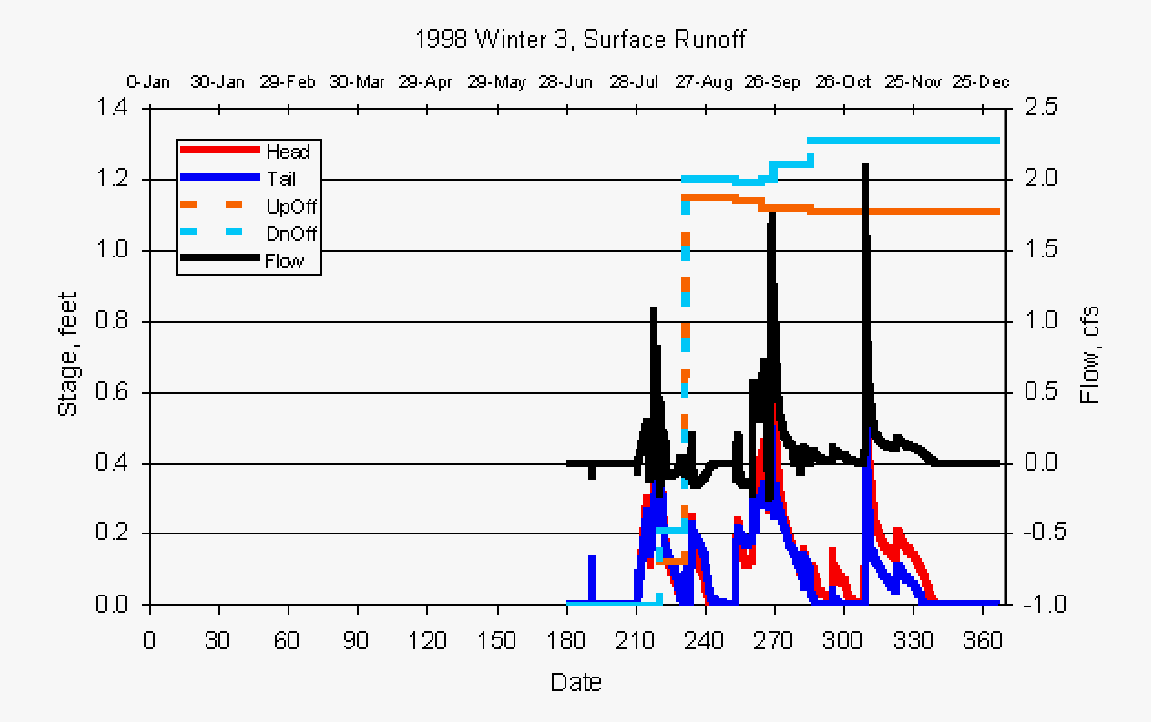


Figure 5.2.3.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 3 in 1998.

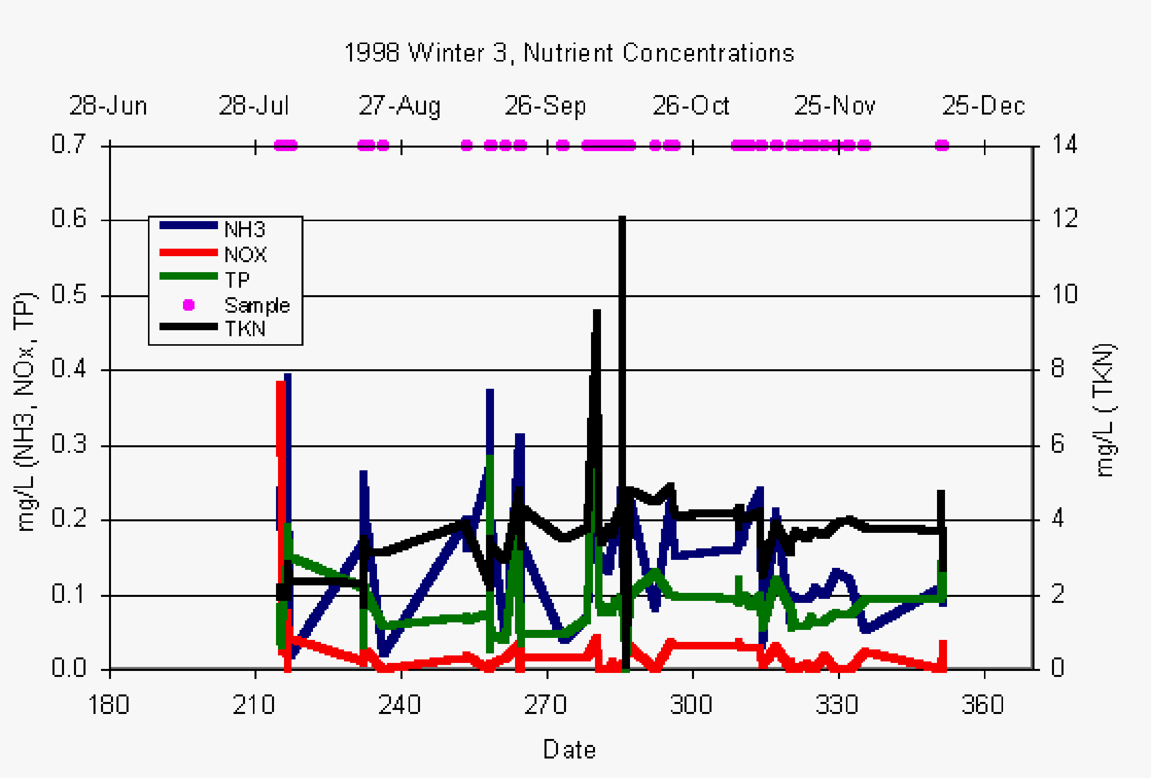


Figure 5.2.3.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 3 in 1998.

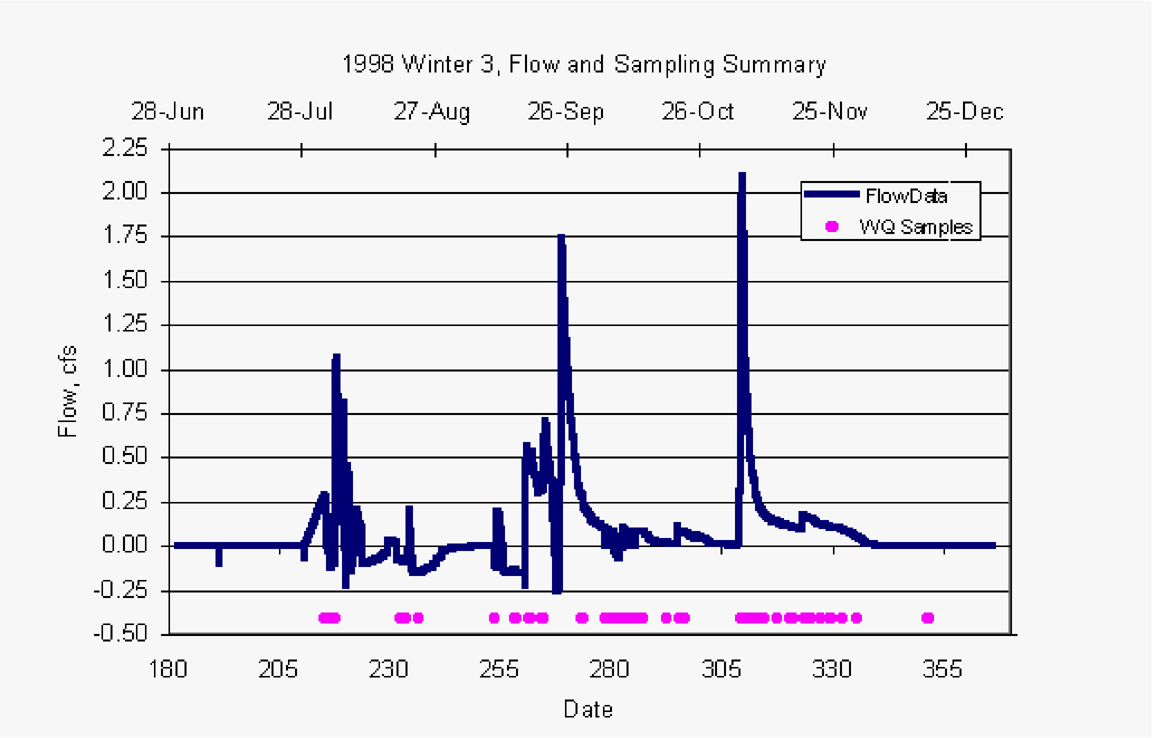


Figure 5.2.3.3. Collection dates and calculated runoff flow values for winter pasture 3 in 1998.

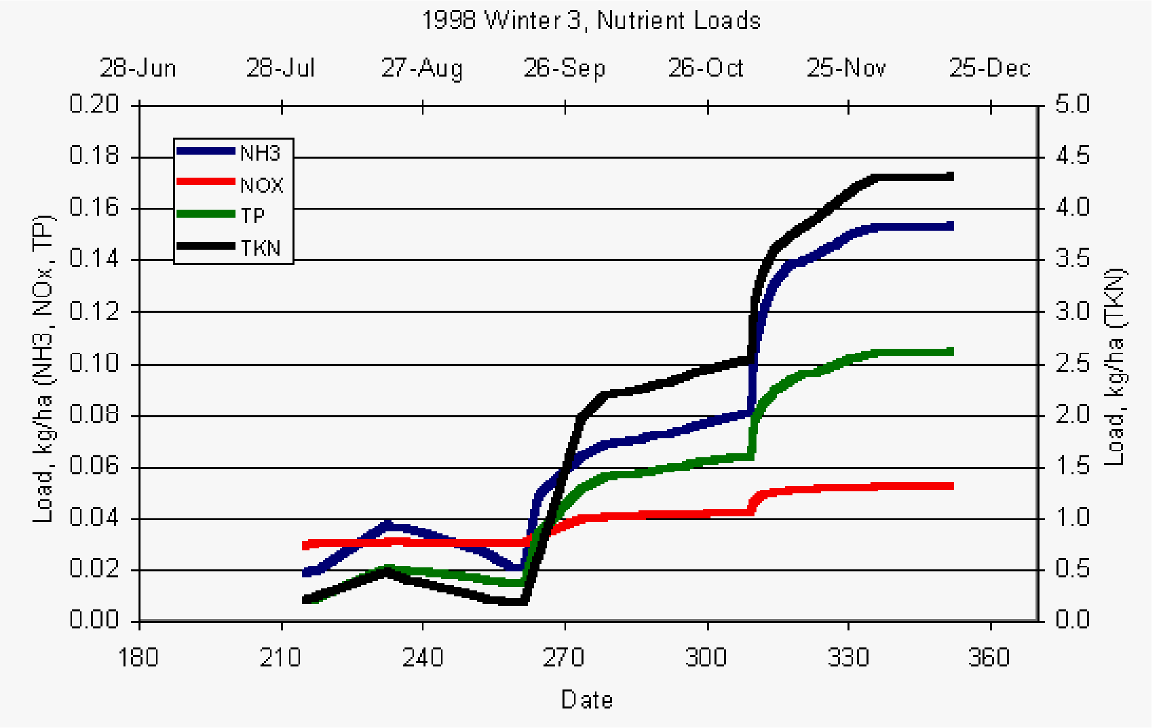


Figure 5.2.3.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 3 in 1998.

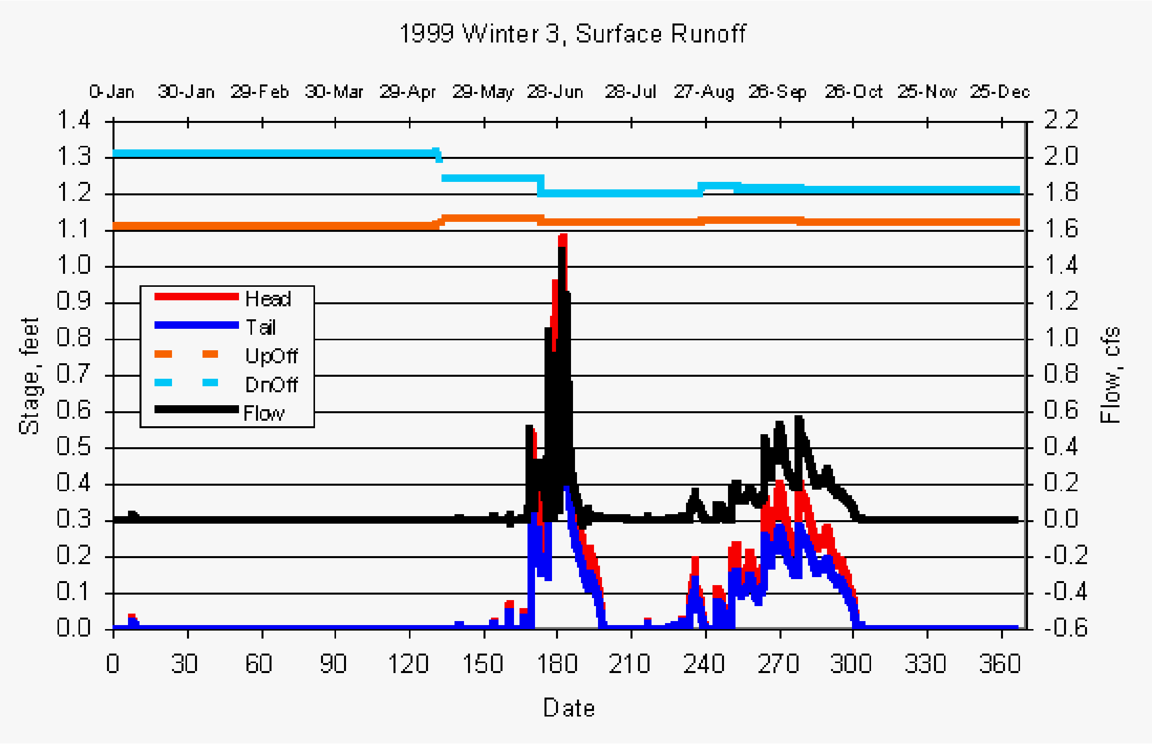


Figure 5.2.3.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 3 in 1999.

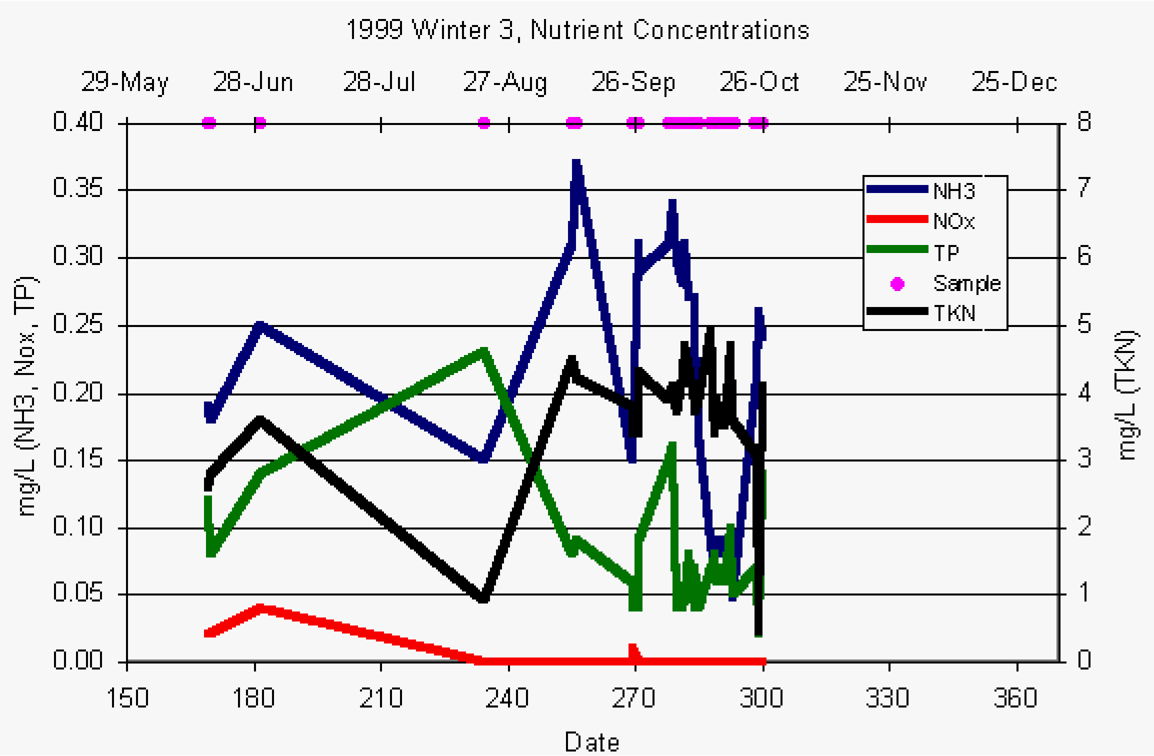


Figure 5.2.3.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 3 in 1999.

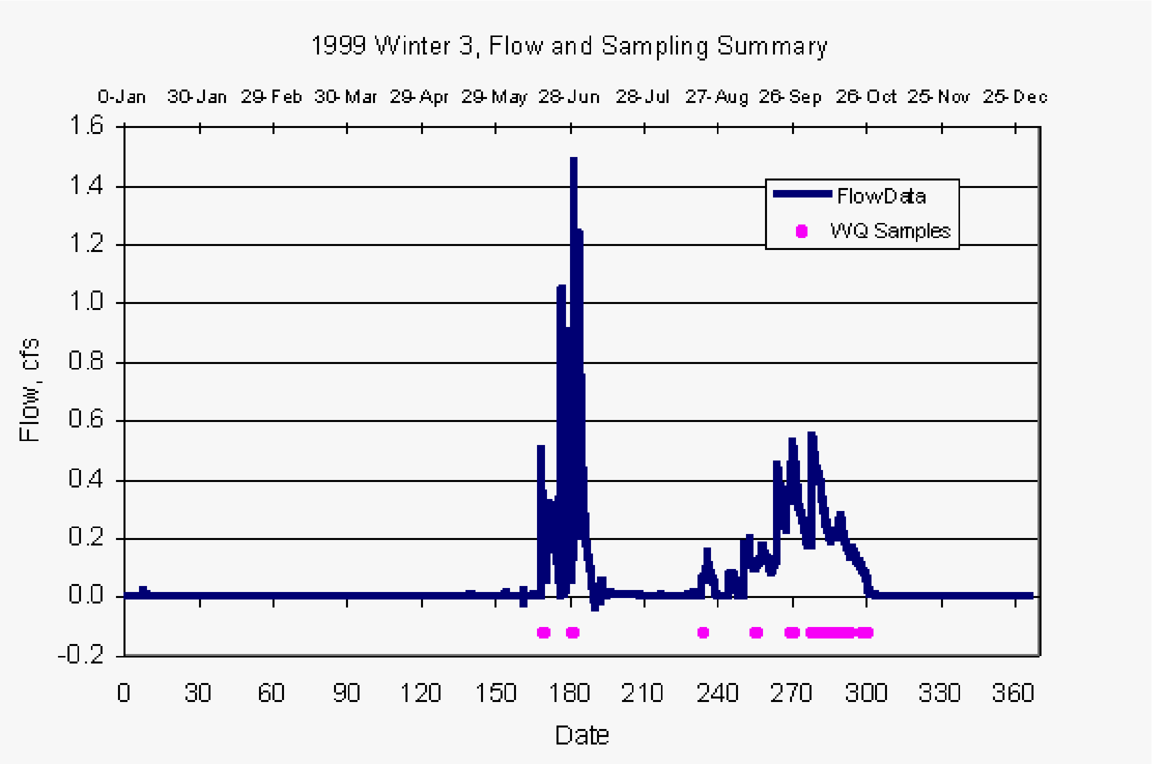


Figure 5.2.3.7. Collection dates and calculated runoff flow values for winter pasture 3 in 1999.

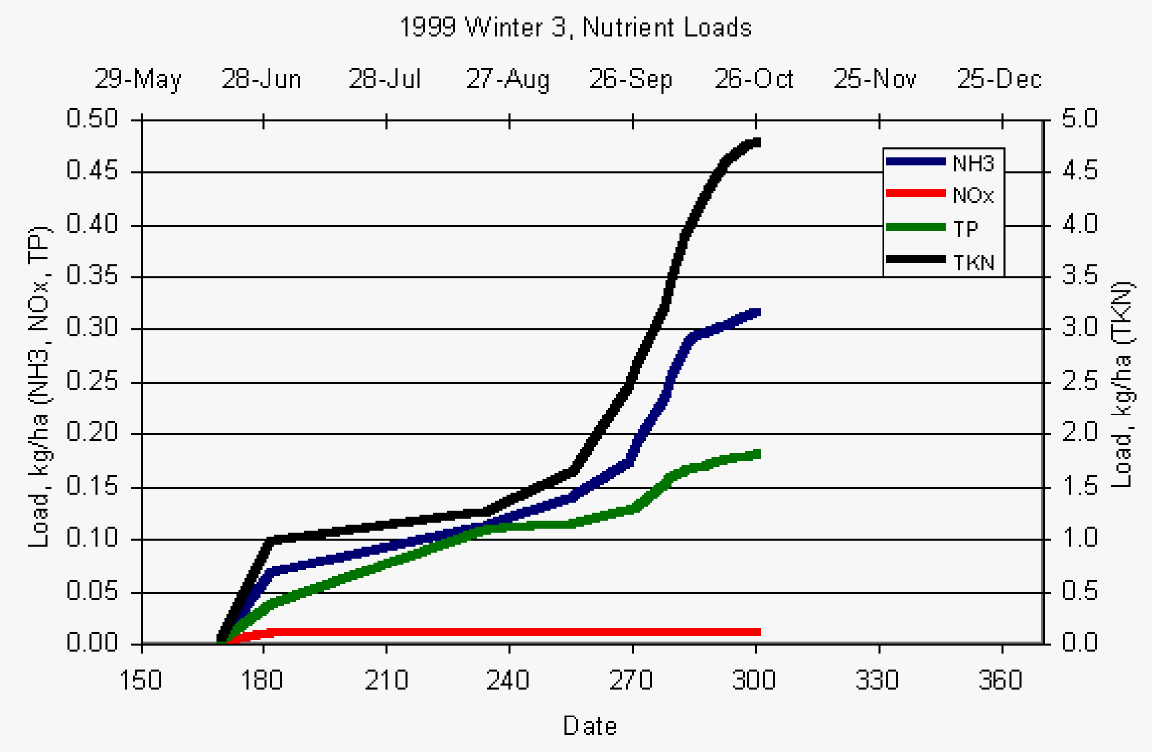


Figure 5.2.3.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 3 in 1999.

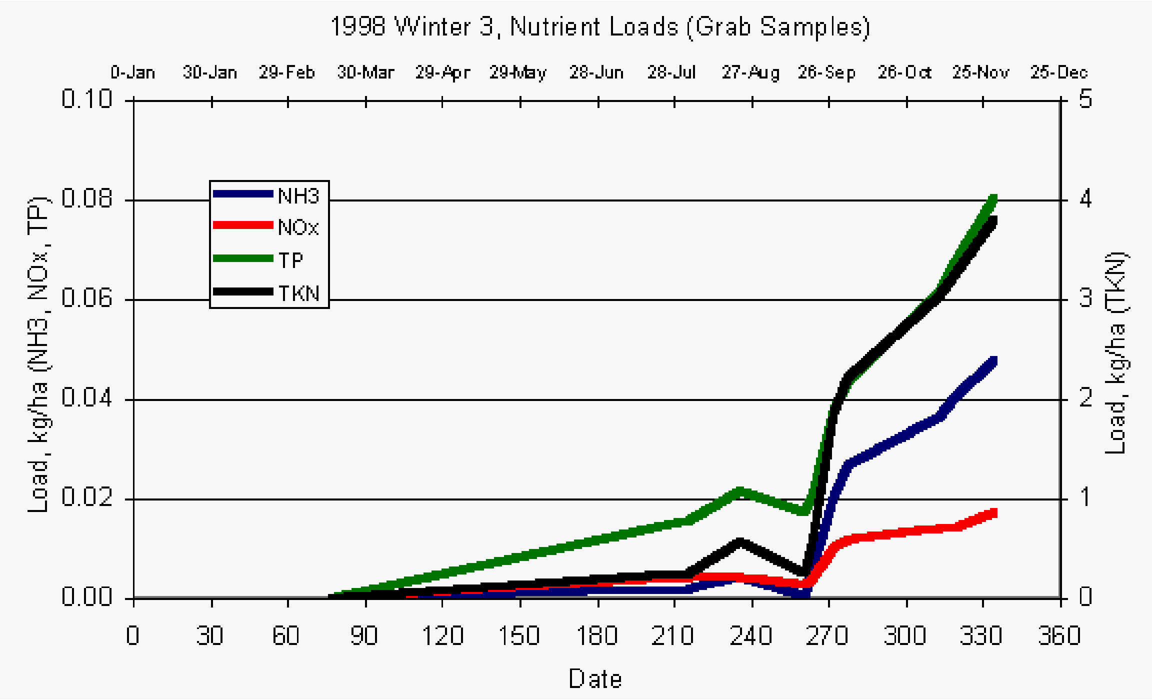


Figure 5.2.3.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 3 in 1998.

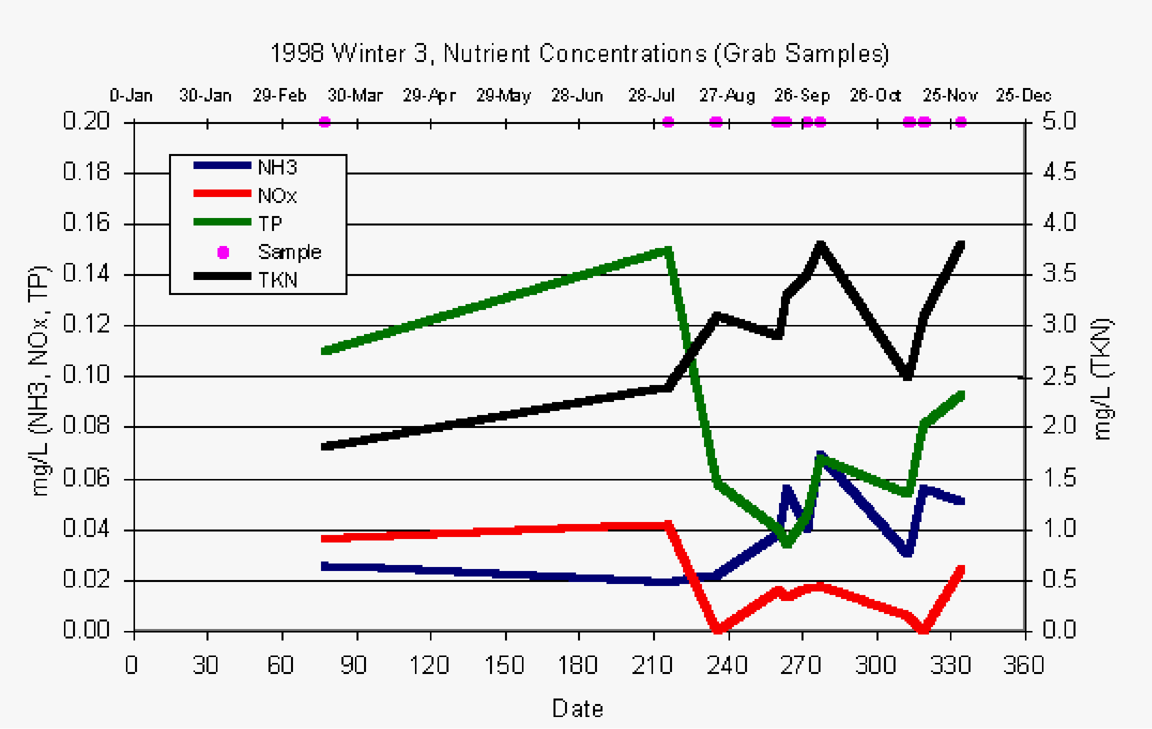


Figure 5.2.3.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 3 in 1998.

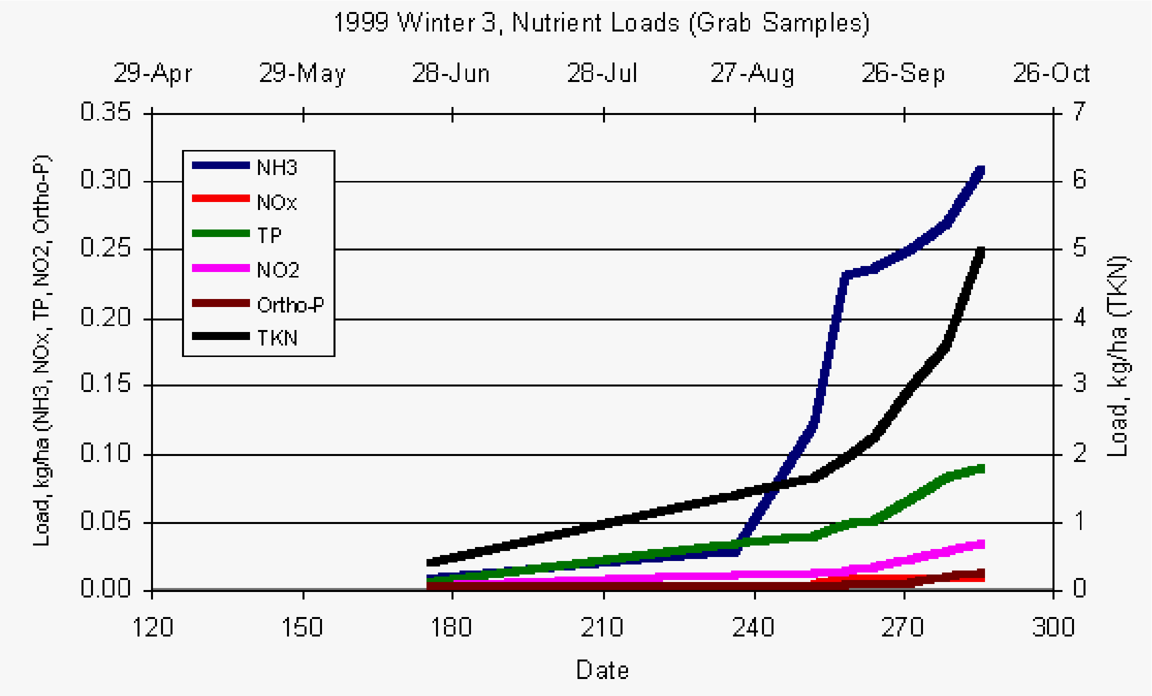


Figure 5.2.3.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 3 in 1999.

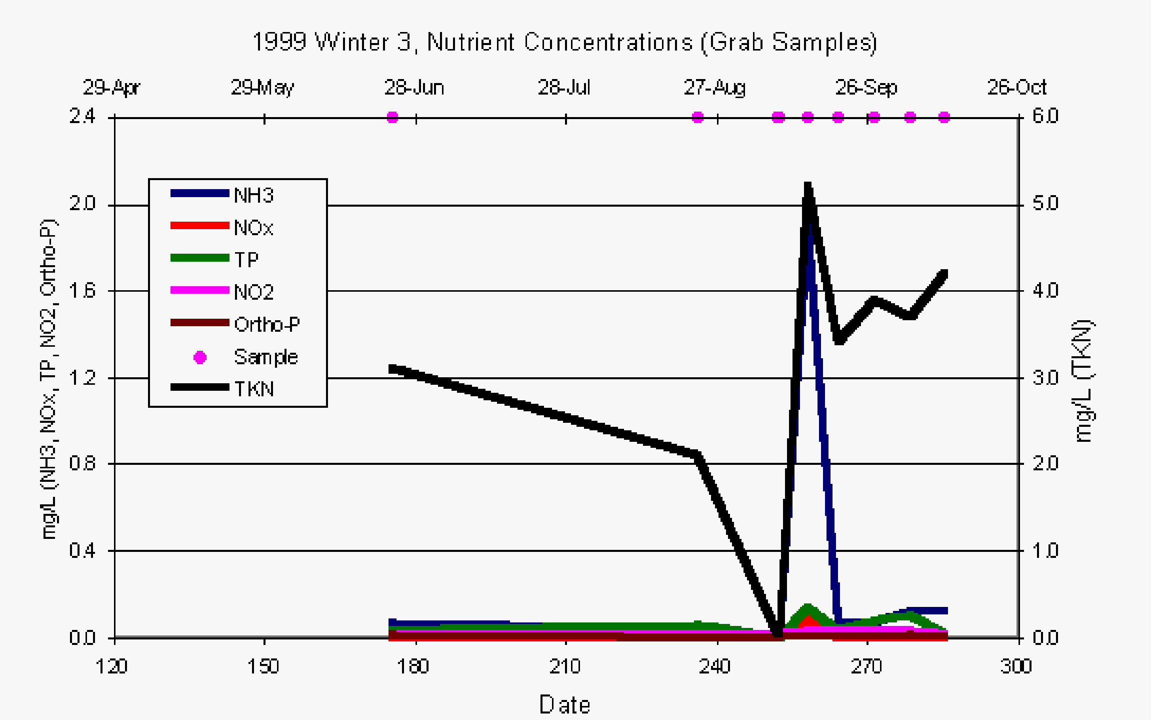


Figure 5.2.3.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 3 in 1999.

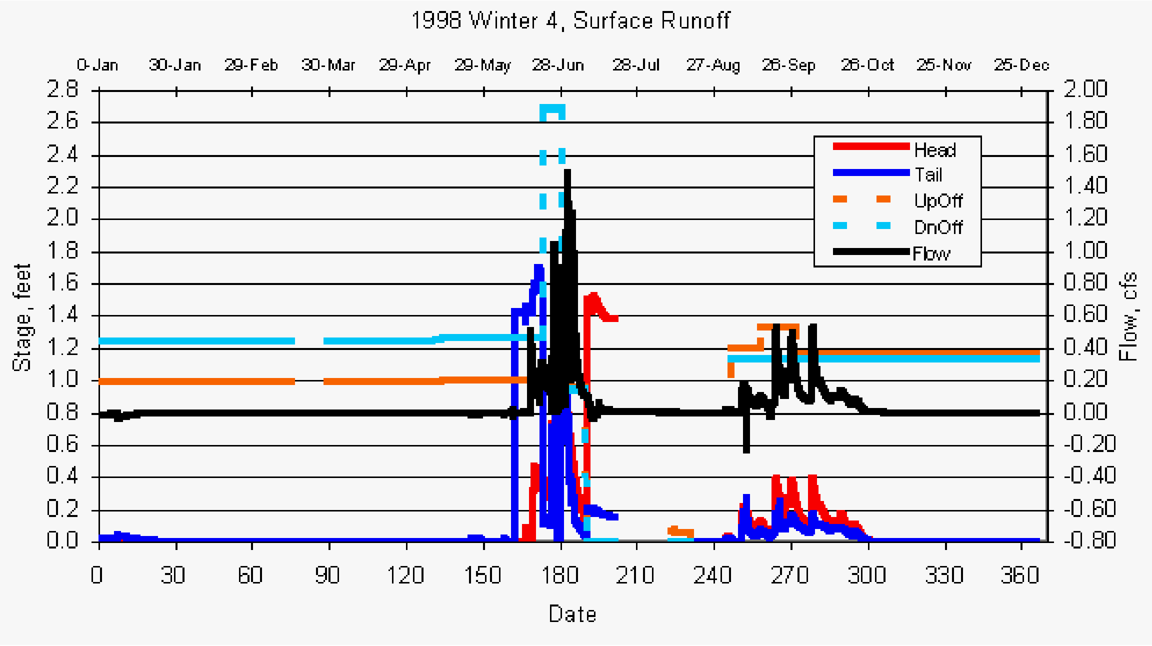


Figure 5.2.4.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 4 in 1998.

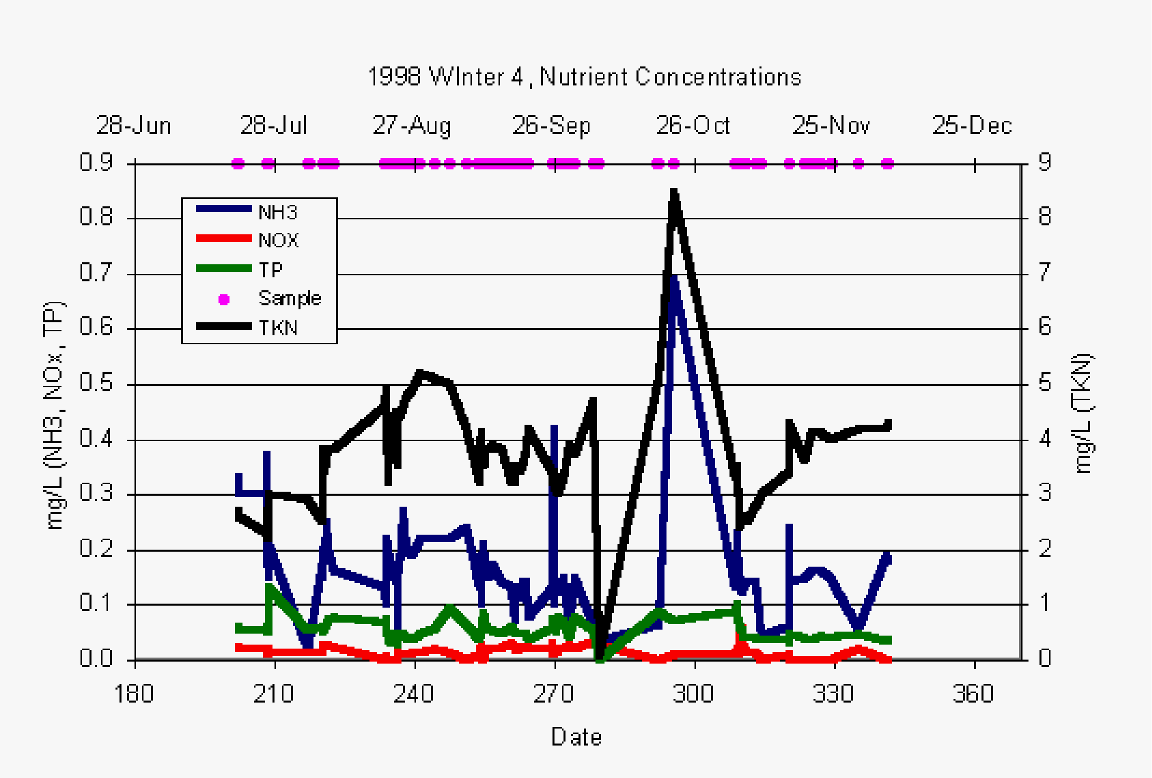


Figure 5.2.4.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 4 in 1998.

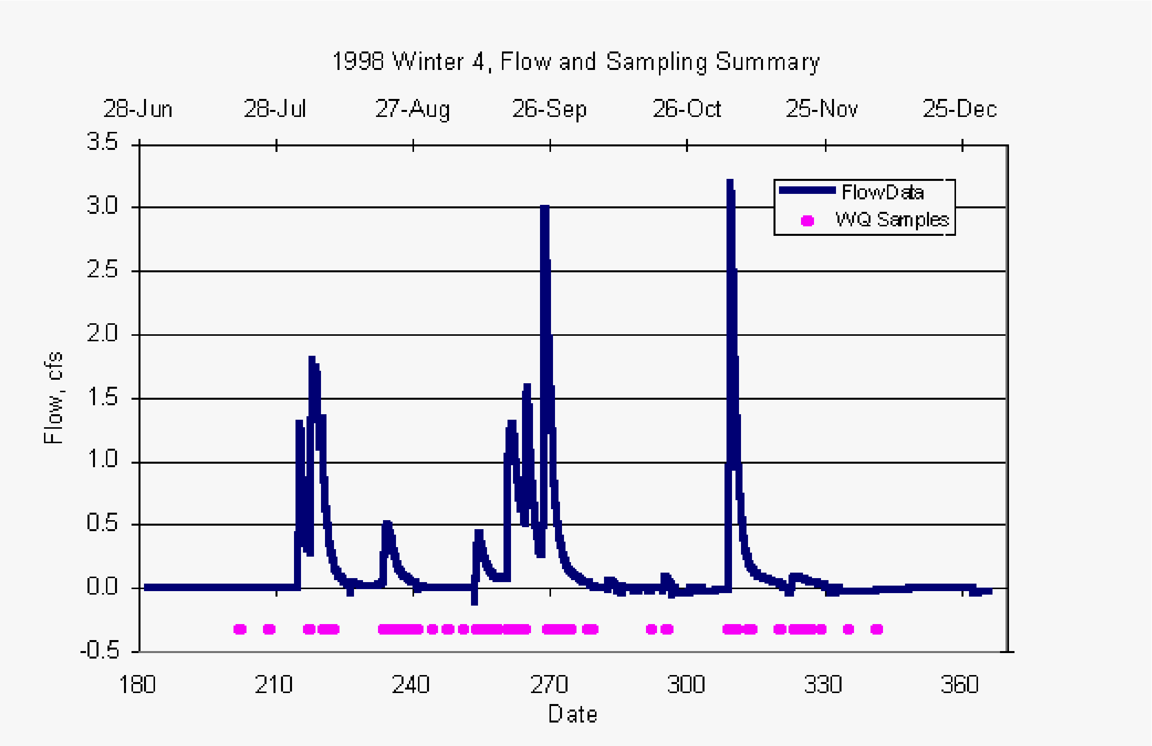


Figure 5.2.4.3. Collection dates and calculated runoff flow values for winter pasture 4 in 1998.

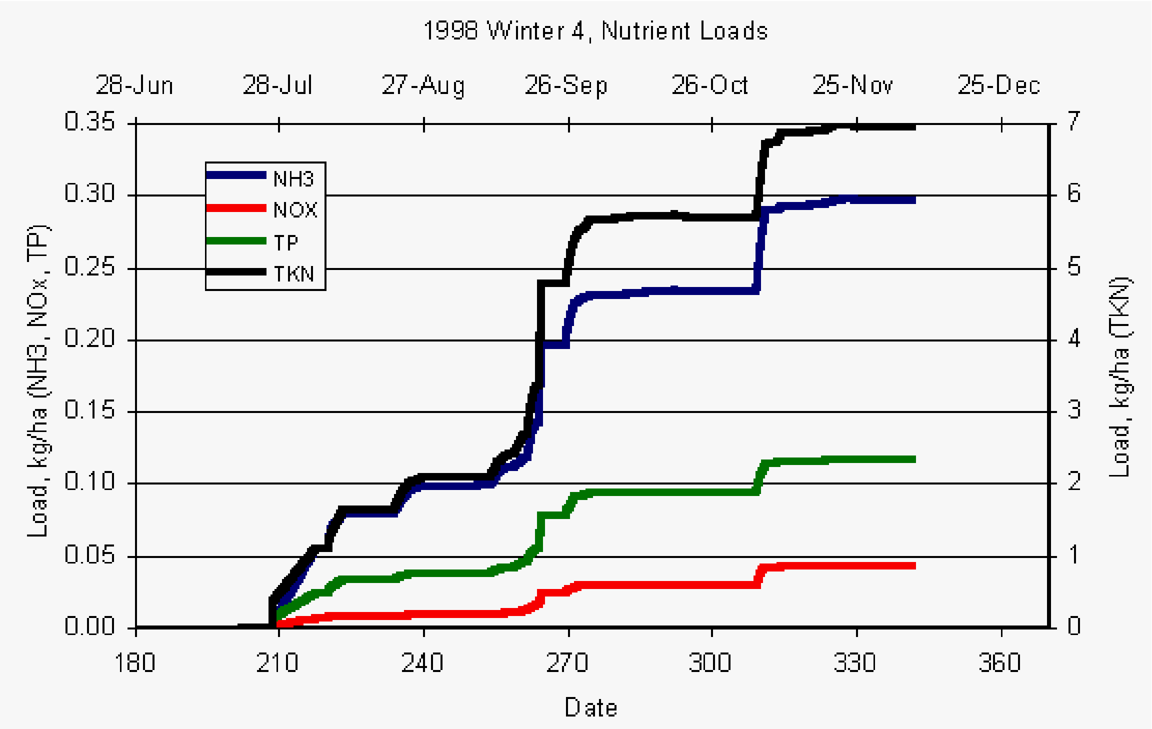


Figure 5.2.4.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 4 in 1998.

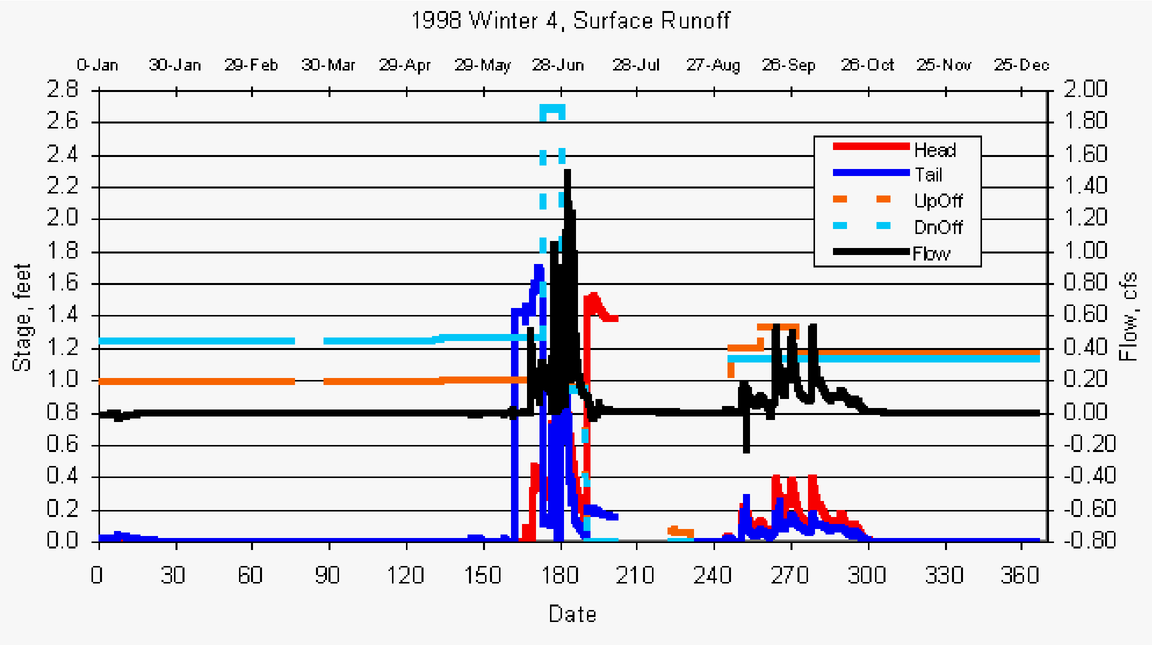


Figure 5.2.4.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 4 in 1999.

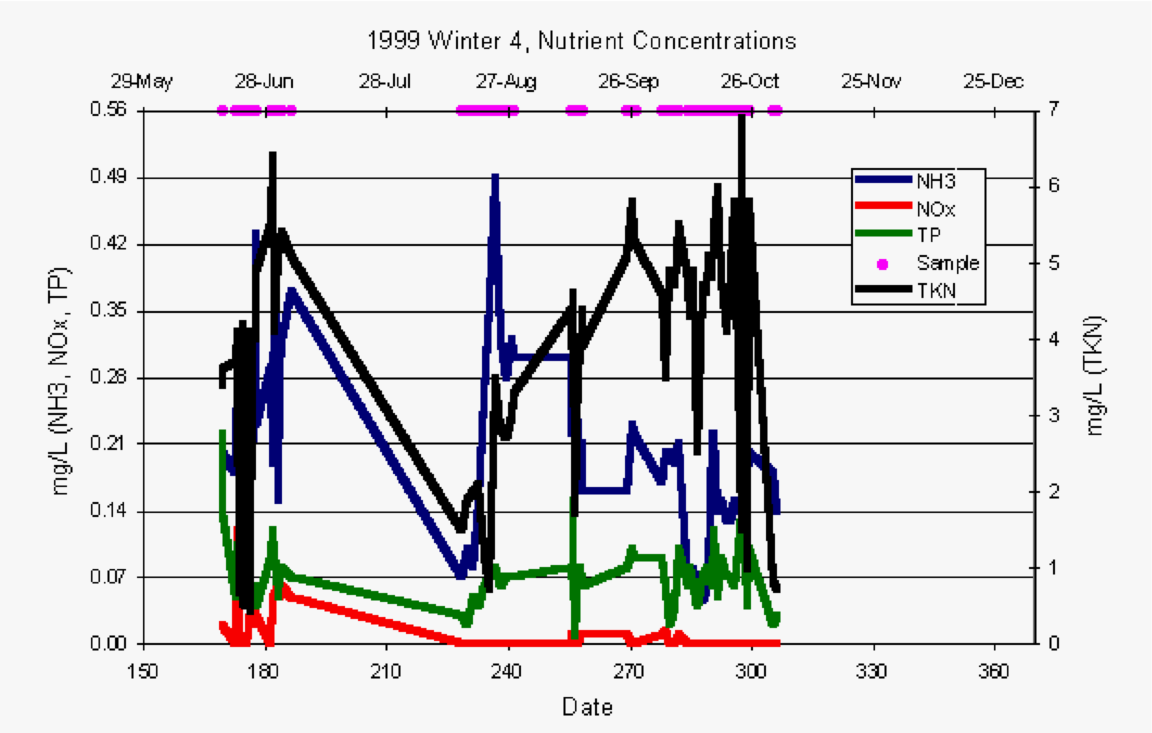


Figure 5.2.4.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 4 in 1999.

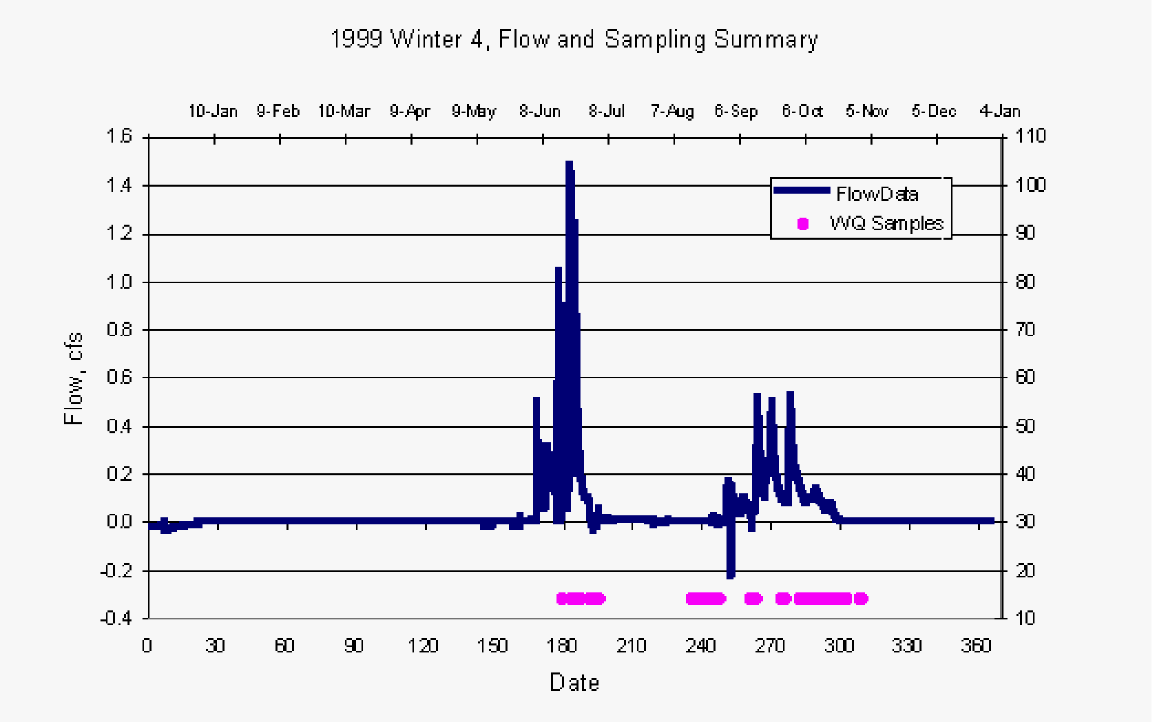


Figure 5.2.4.7. Collection dates and calculated runoff flow values for winter pasture 4 in 1999.

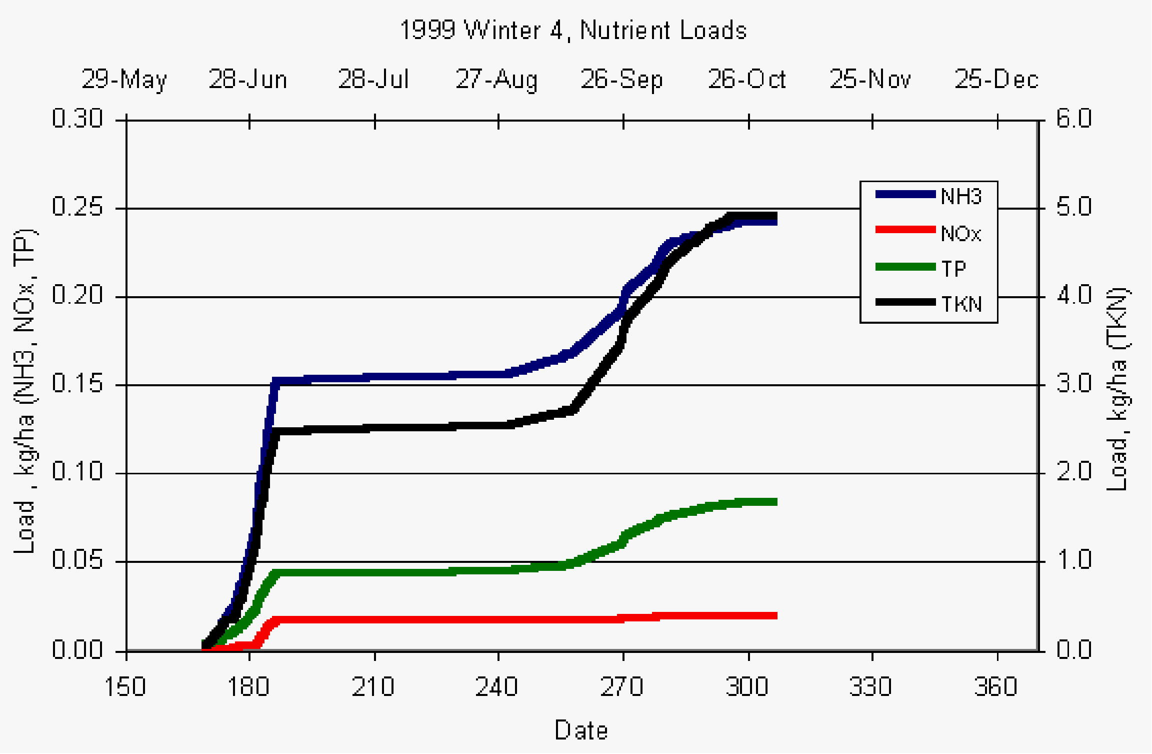


Figure 5.2.4.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 4 in 1999.

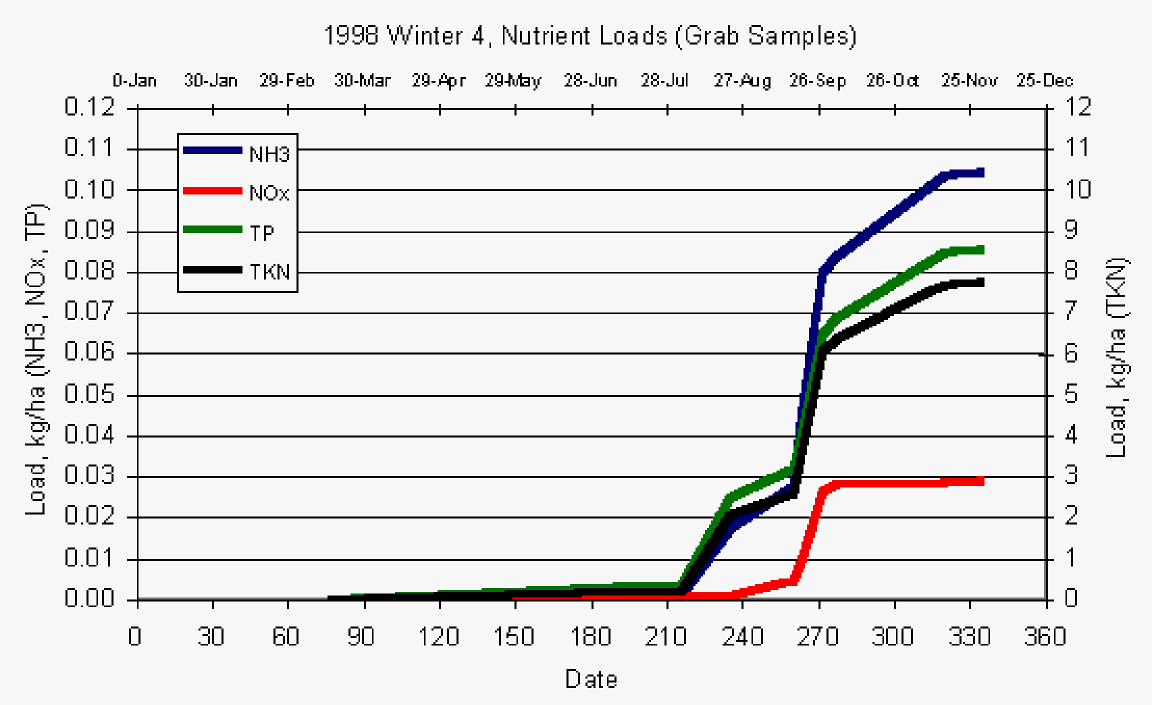


Figure 5.2.4.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 4 in 1998.

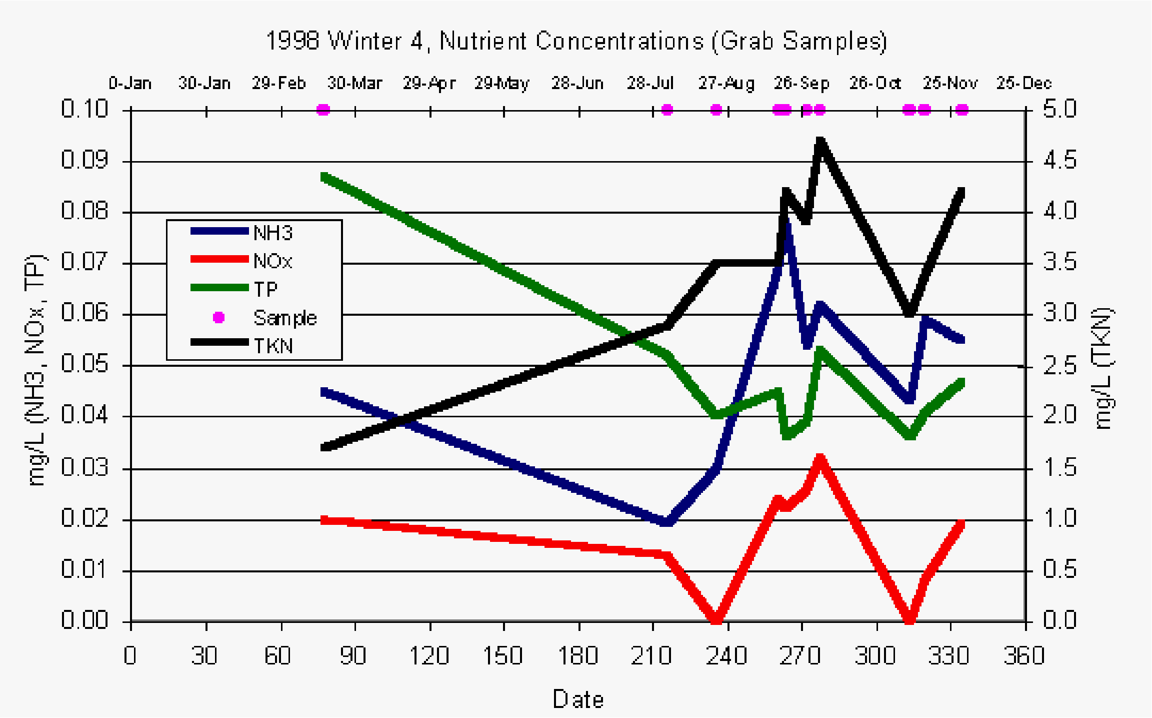


Figure 5.2.4.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 4 in 1998.

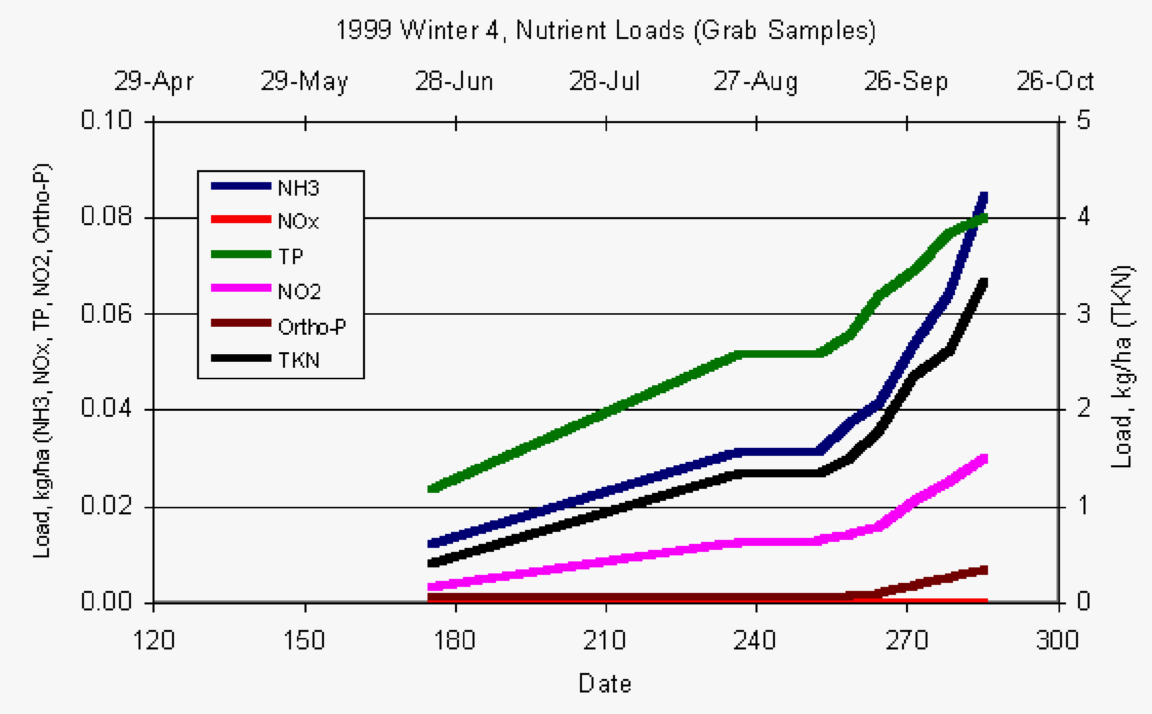


Figure 5.2.4.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 4 in 1999.

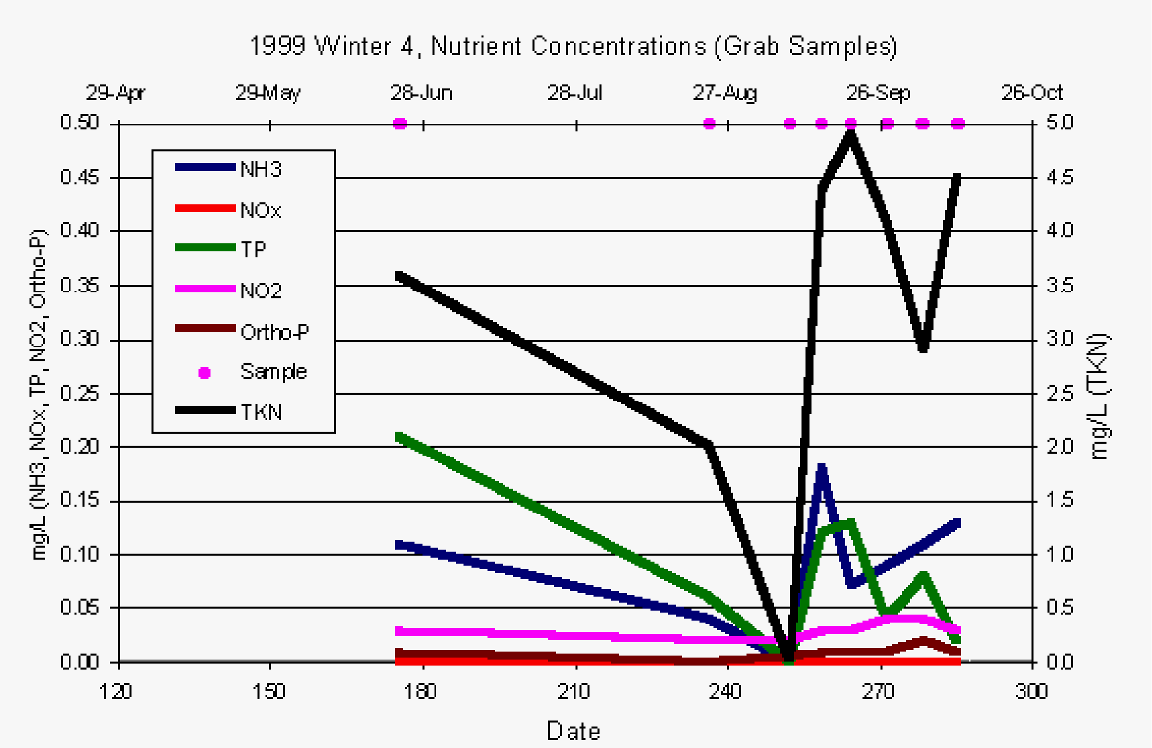


Figure 5.2.4.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 4 in 1999.

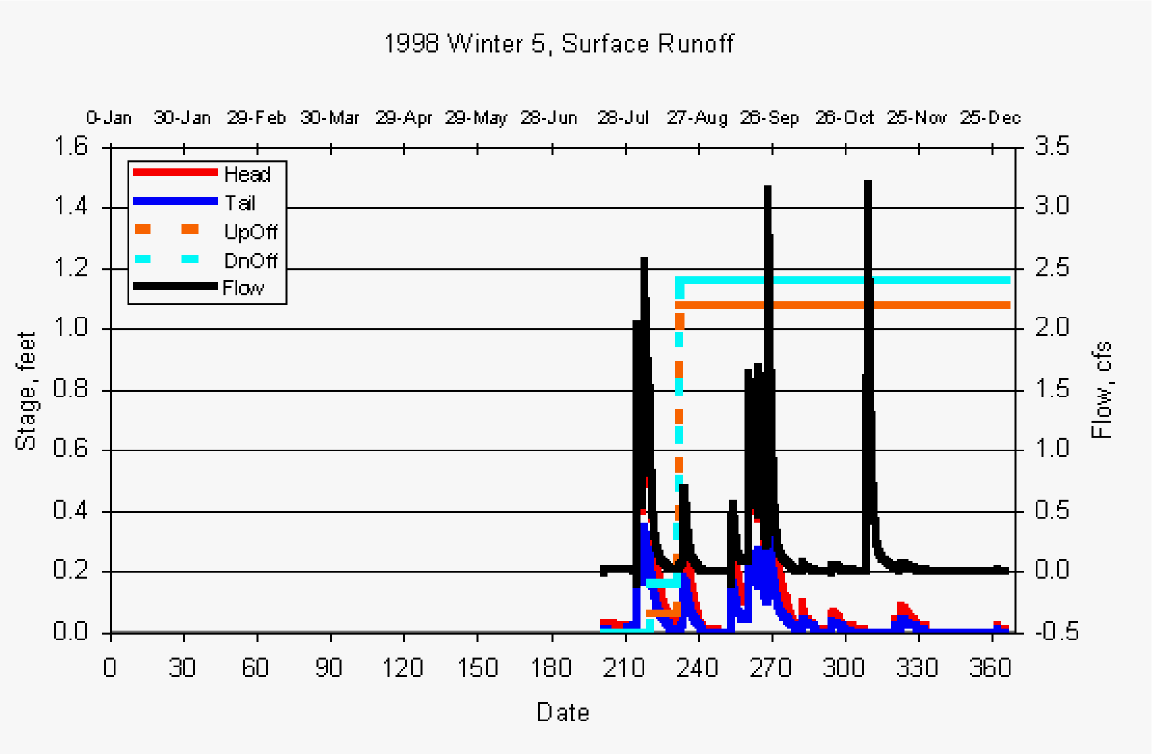


Figure 5.2.5.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 5 in 1998.

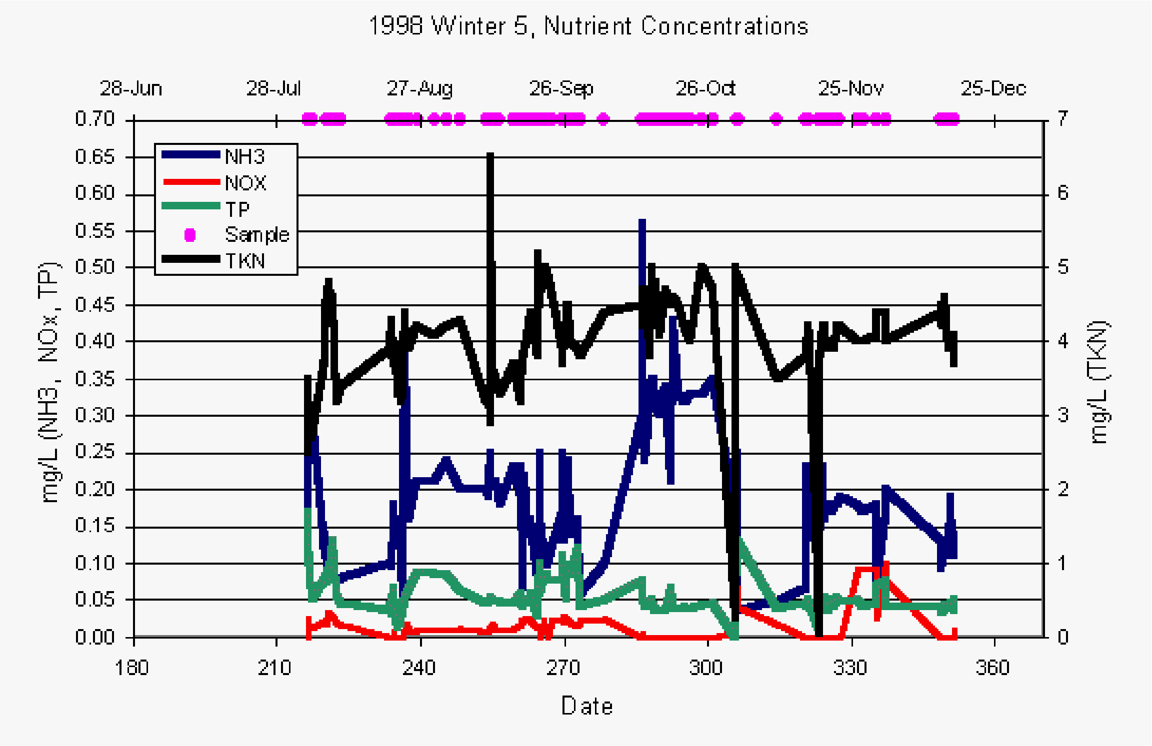


Figure 5.2.5.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 5 in 1998.

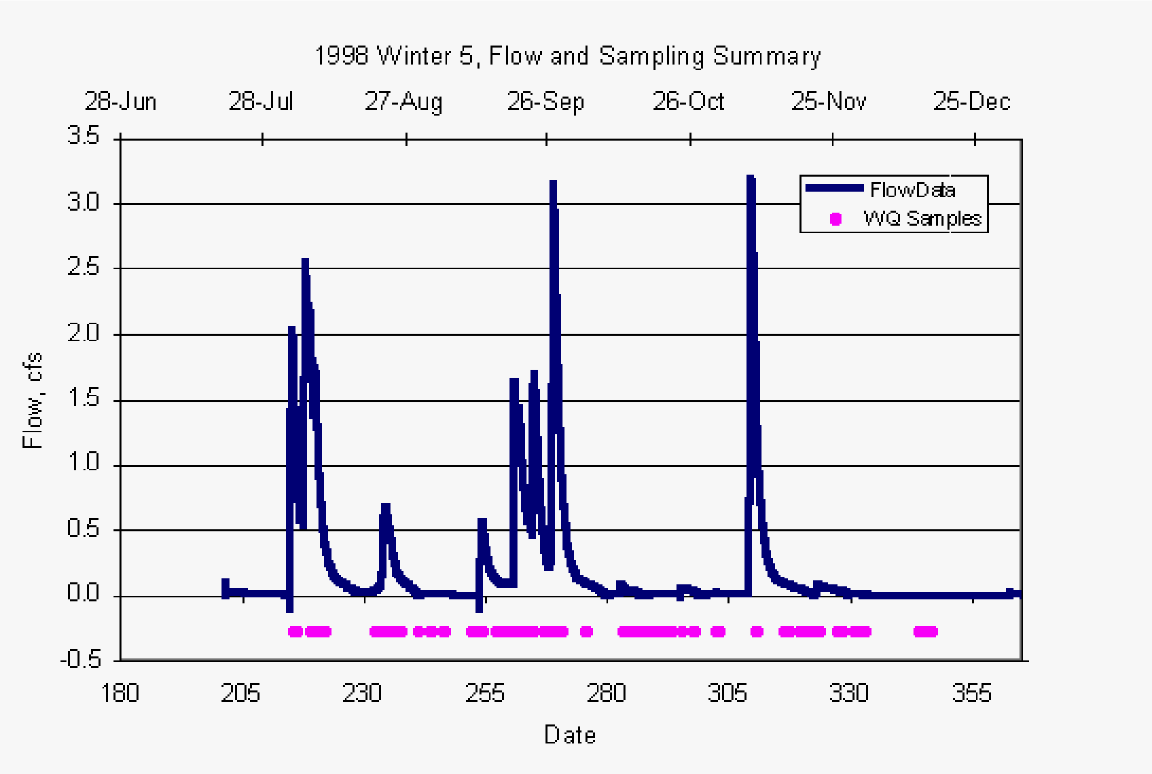


Figure 5.2.5.3. Collection dates and calculated runoff flow values for winter pasture 5 in 1998.

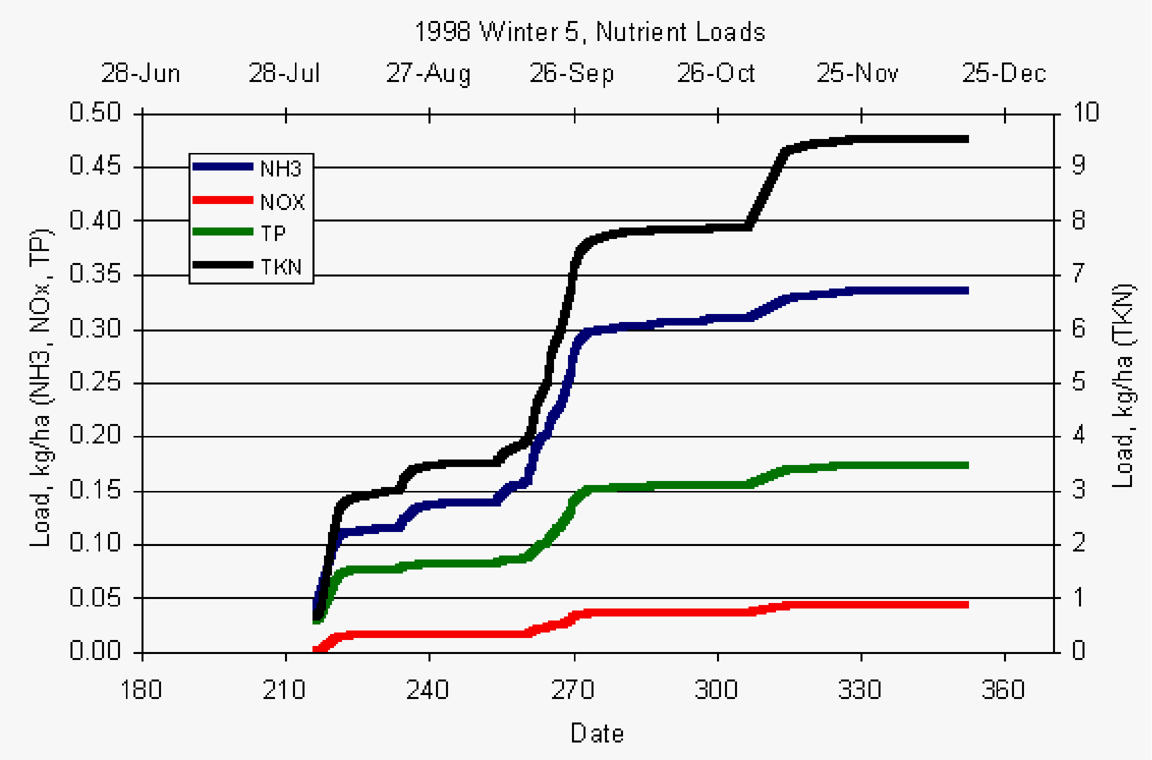


Figure 5.2.5.4. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 5 in 1998.

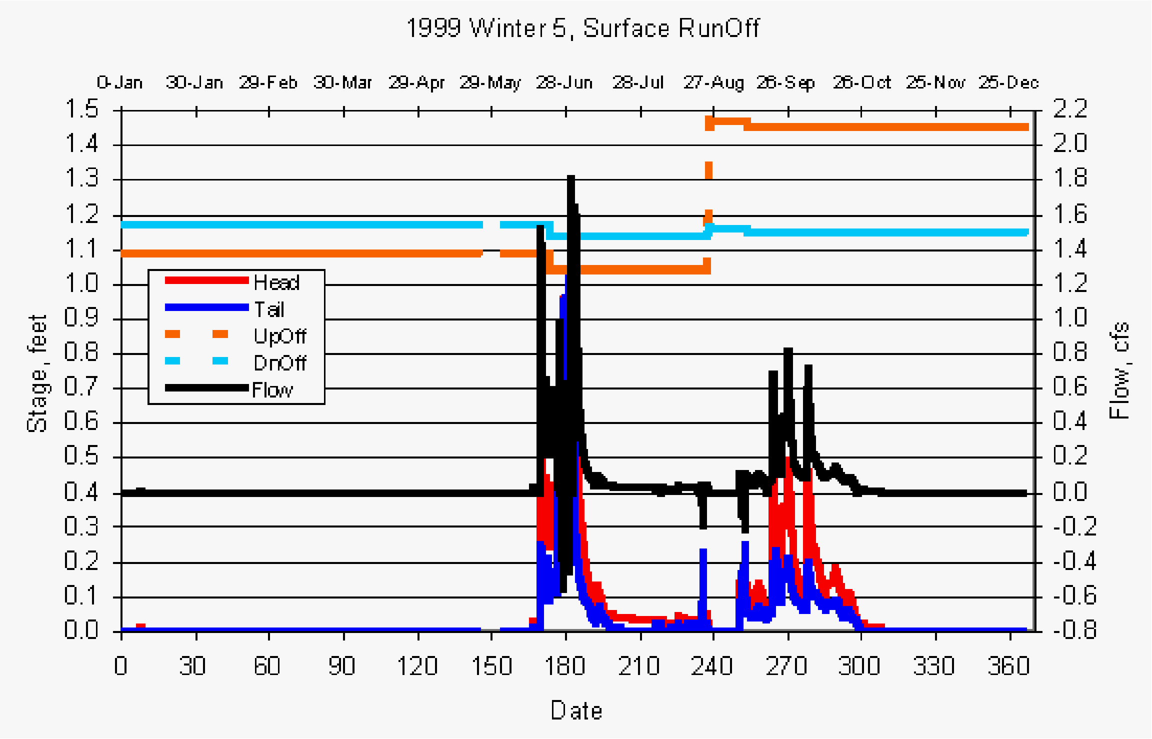


Figure 5.2.5.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 5 in 1999.

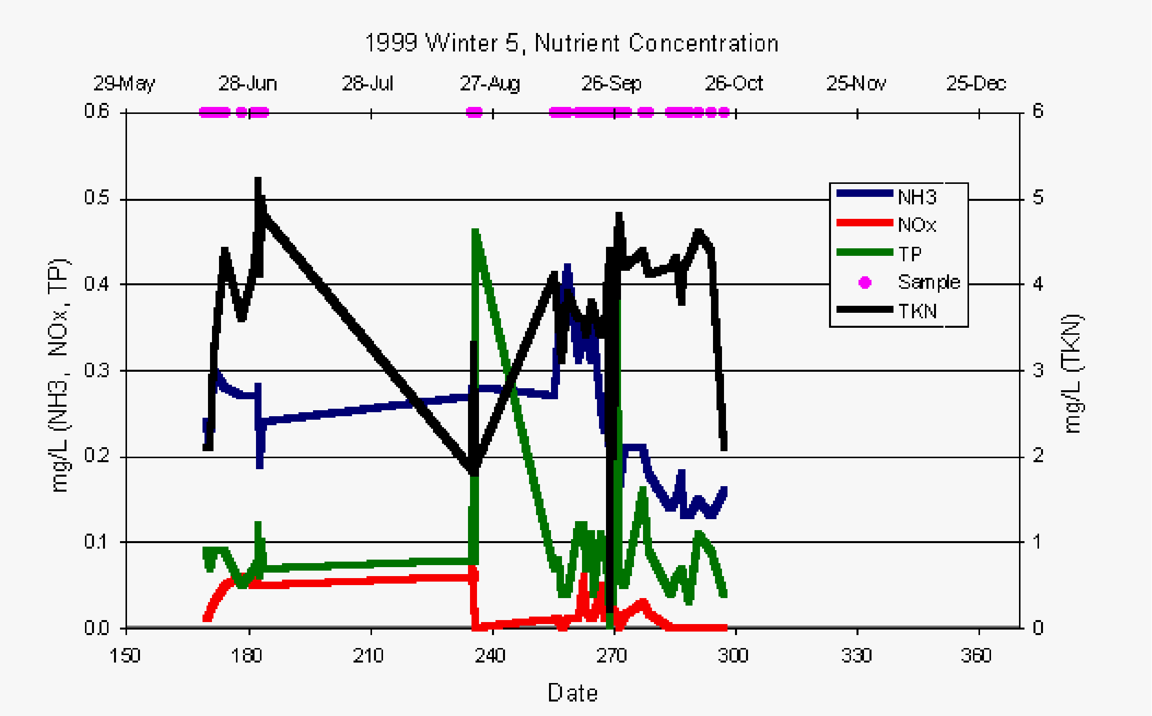


Figure 5.2.5.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 5 in 1999.

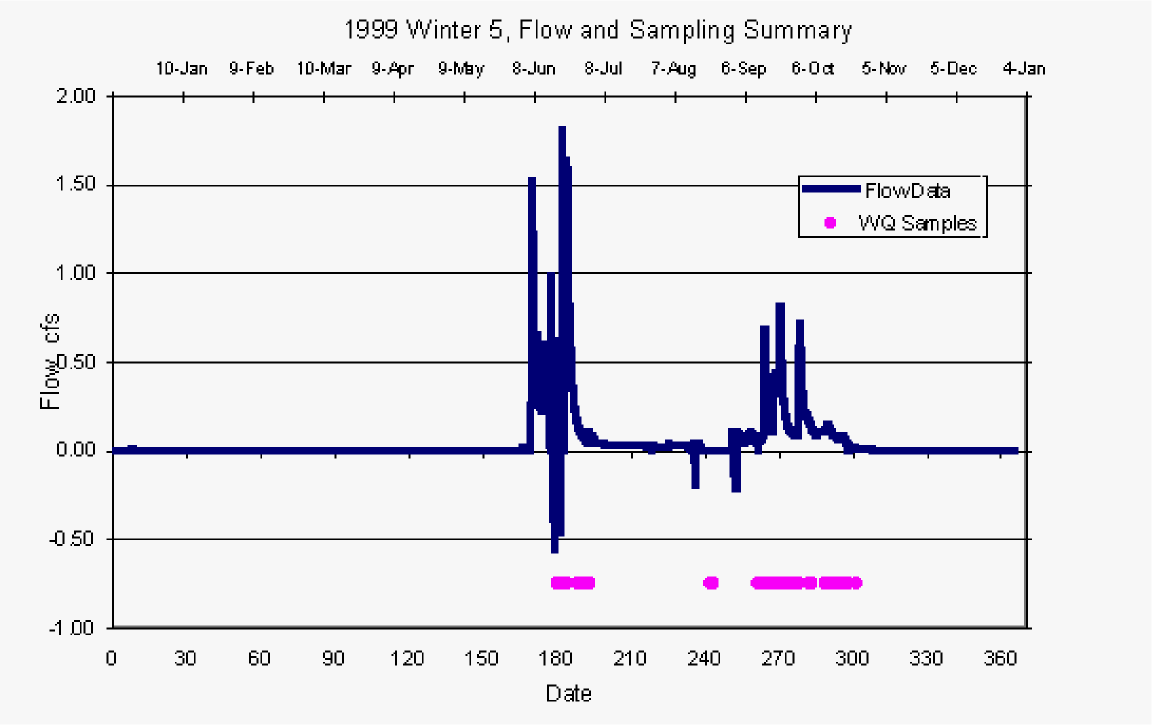


Figure 5.2.5.7. Collection dates and calculated runoff flow values for winter pasture 5 in 1999.

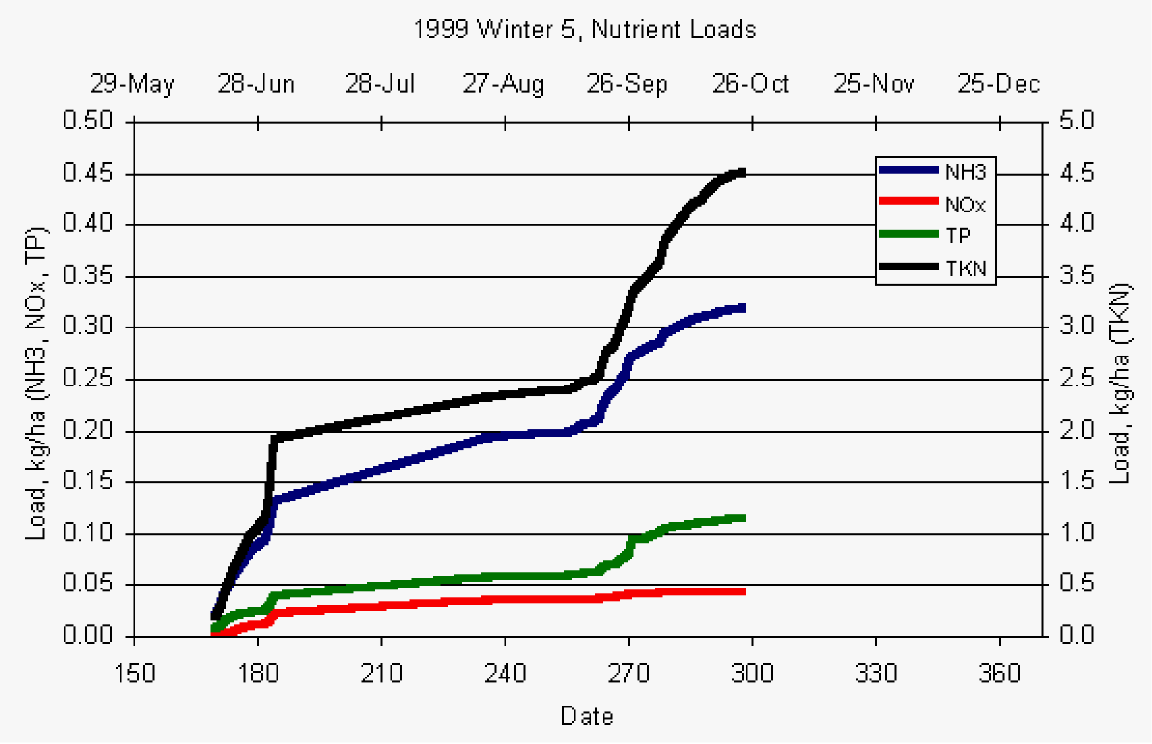


Figure 5.2.5.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 5 in 1999.

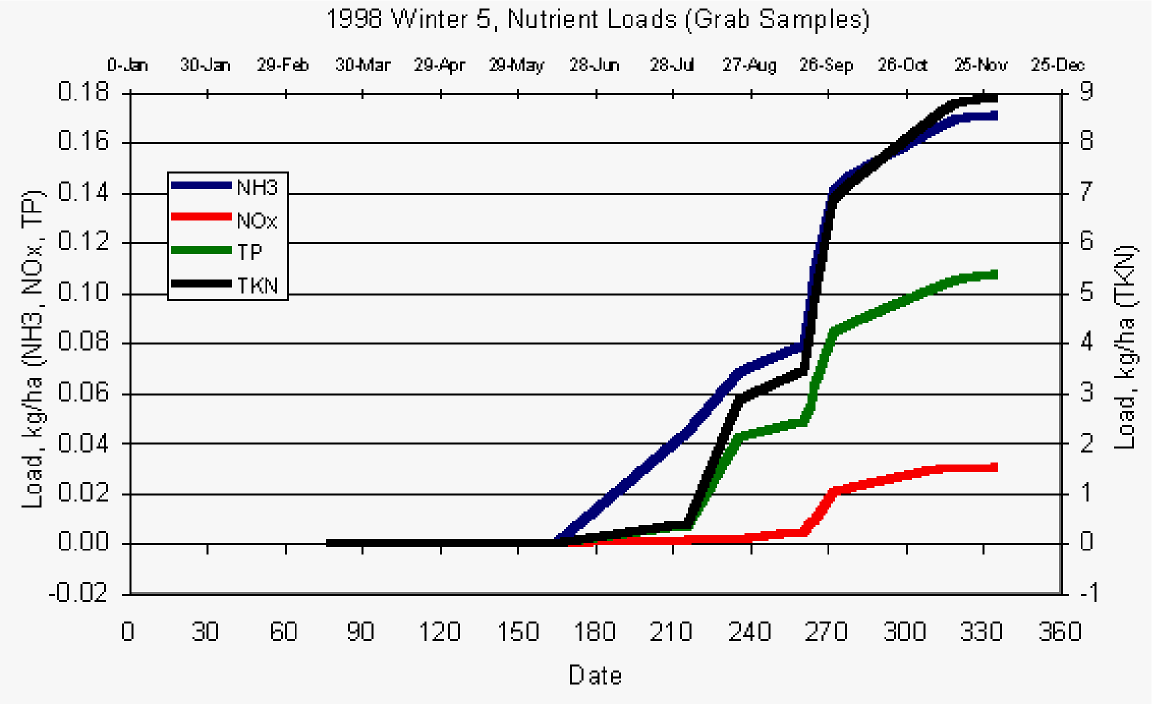


Figure 5.2.5.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 5 in 1998.

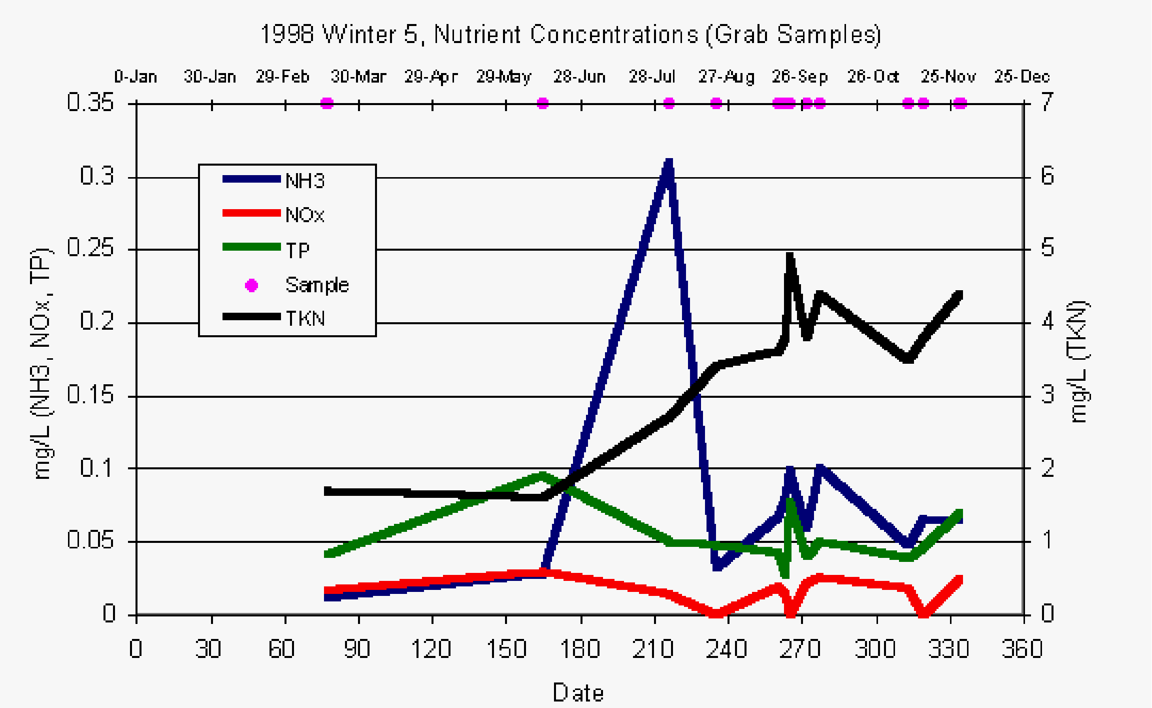


Figure 5.2.5.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 5 in 1998.

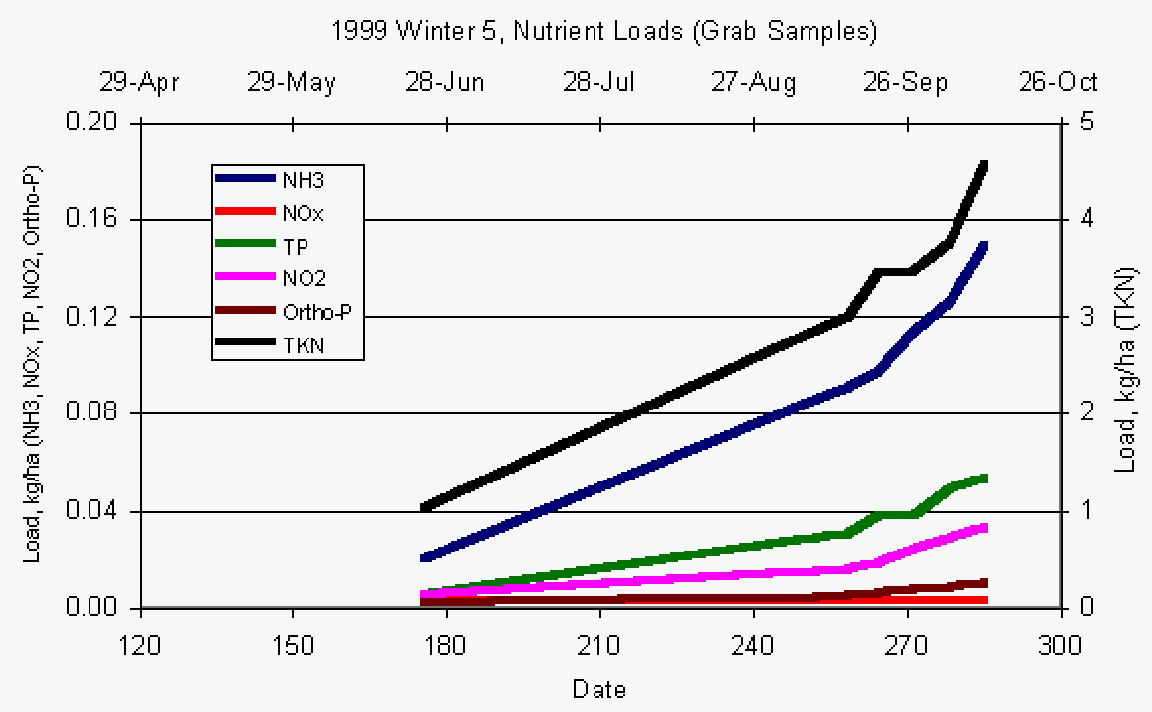


Figure 5.2.5.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 5 in 1999.

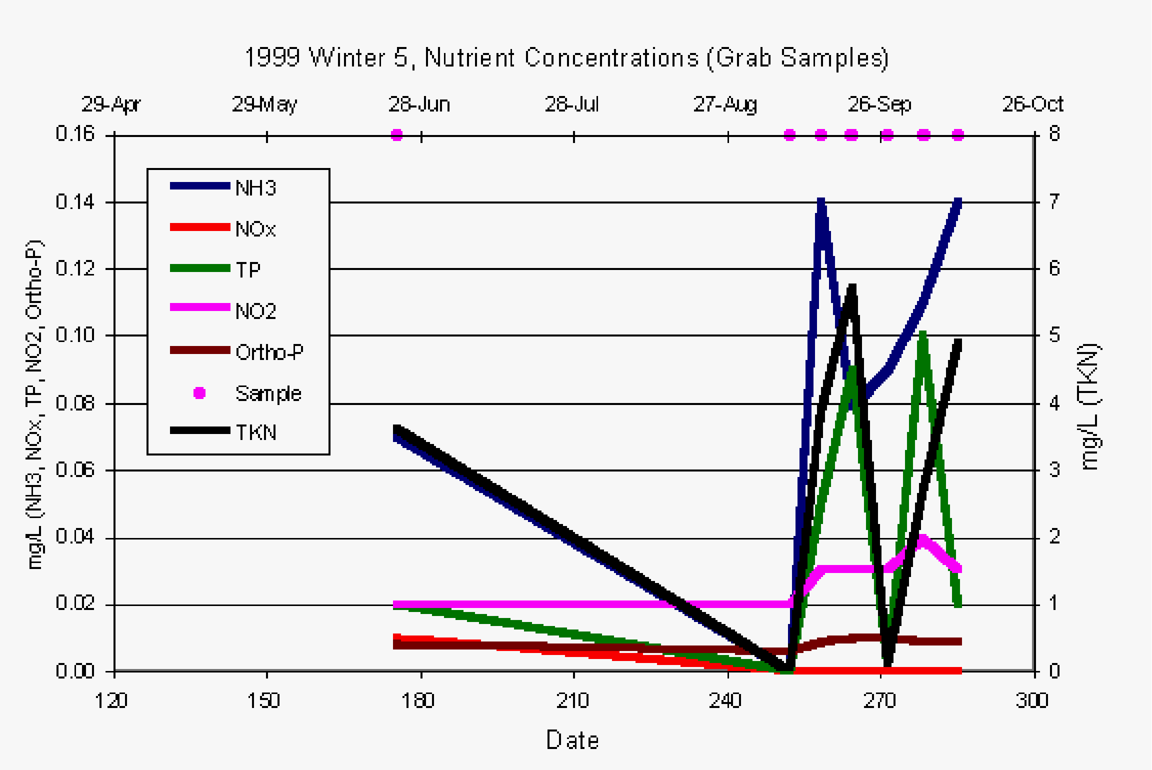


Figure 5.2.5.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 5 in 1999.

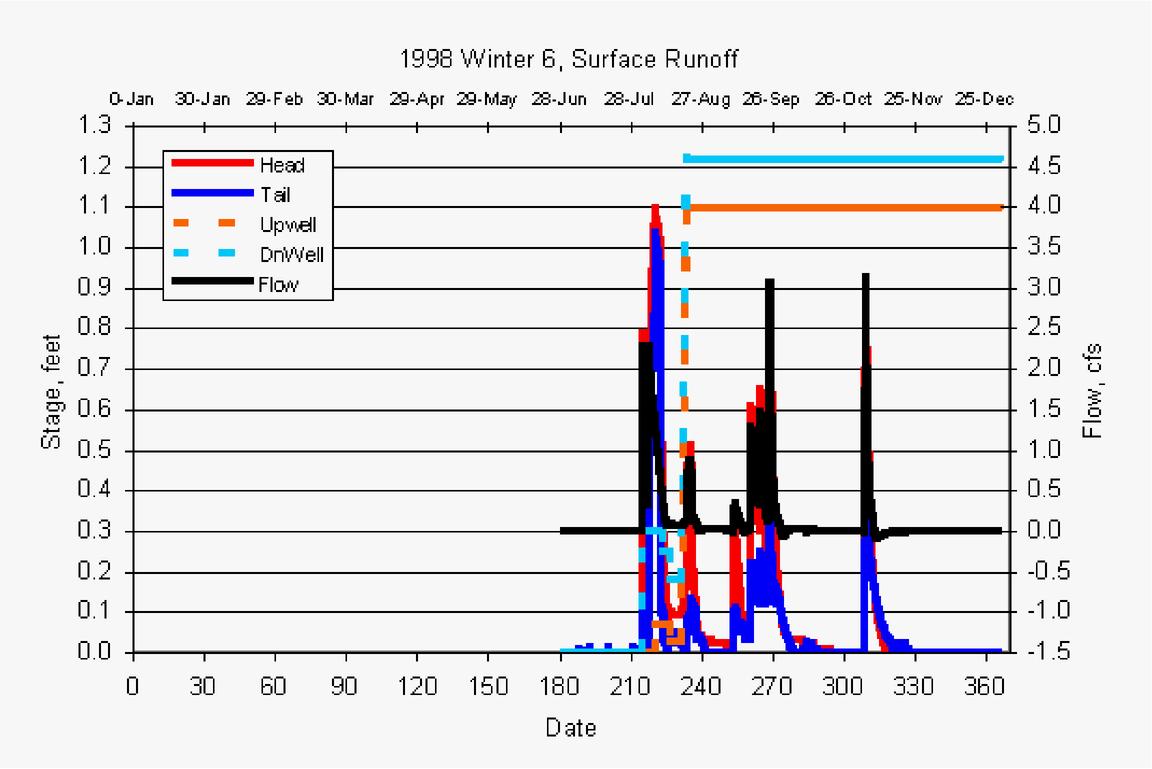


Figure 5.2.6.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 5 in 1998.

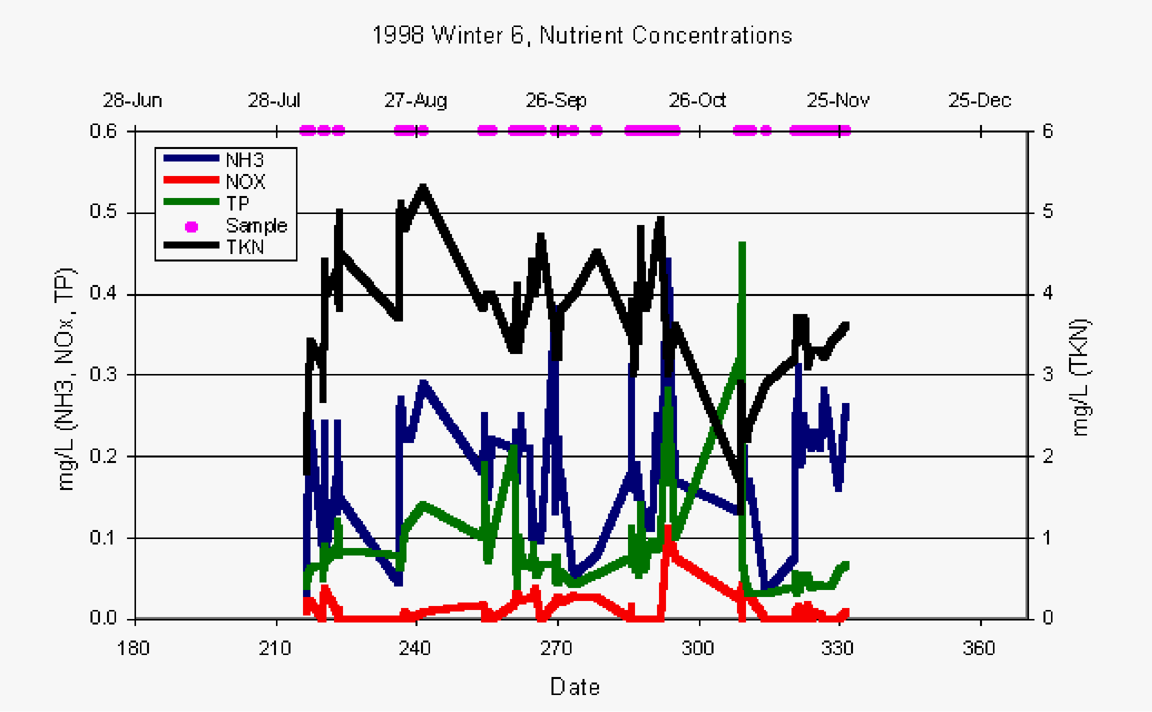


Figure 5.2.6.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 5 in 1998.

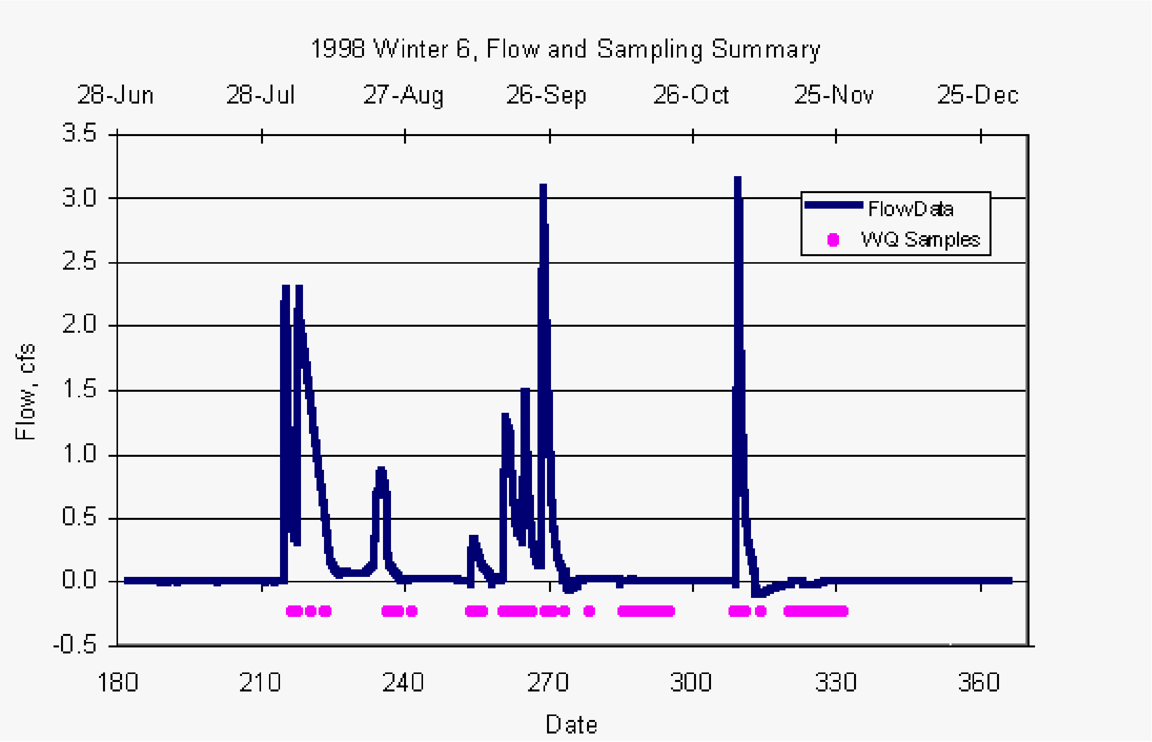


Figure 5.2.6.3. Collection dates and calculated runoff flow values for winter pasture 6 in 1998.

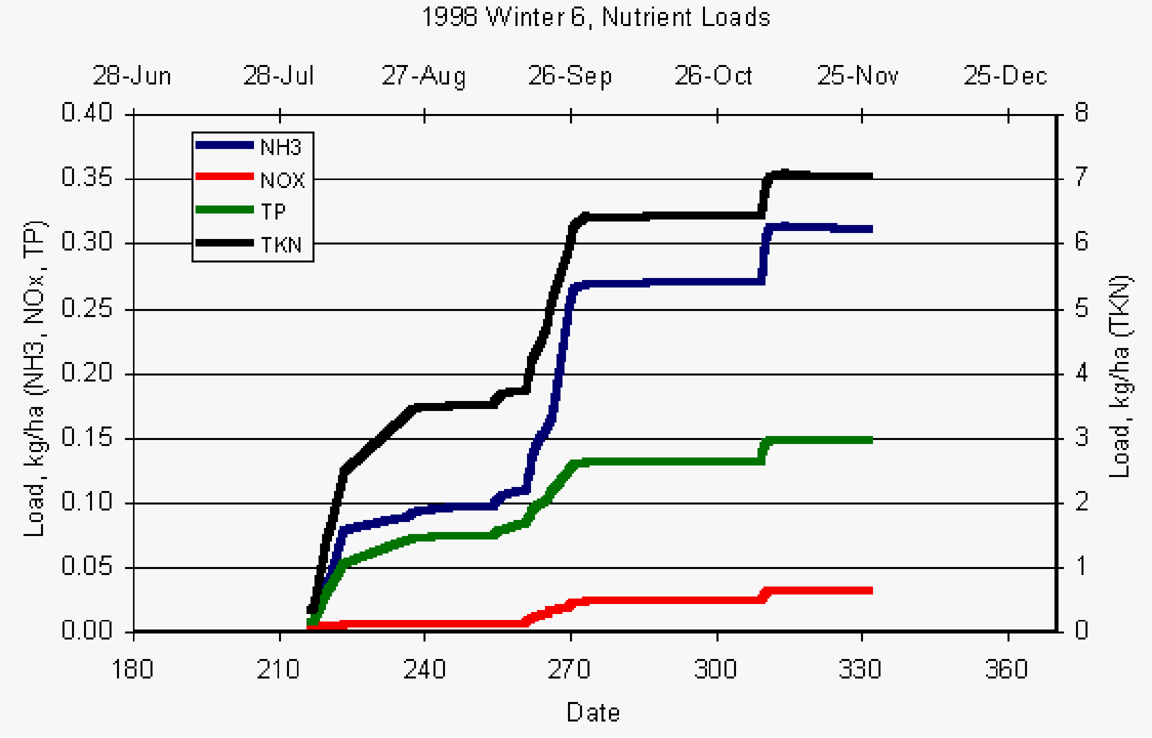


Figure 5.2.6.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 6 in 1998.

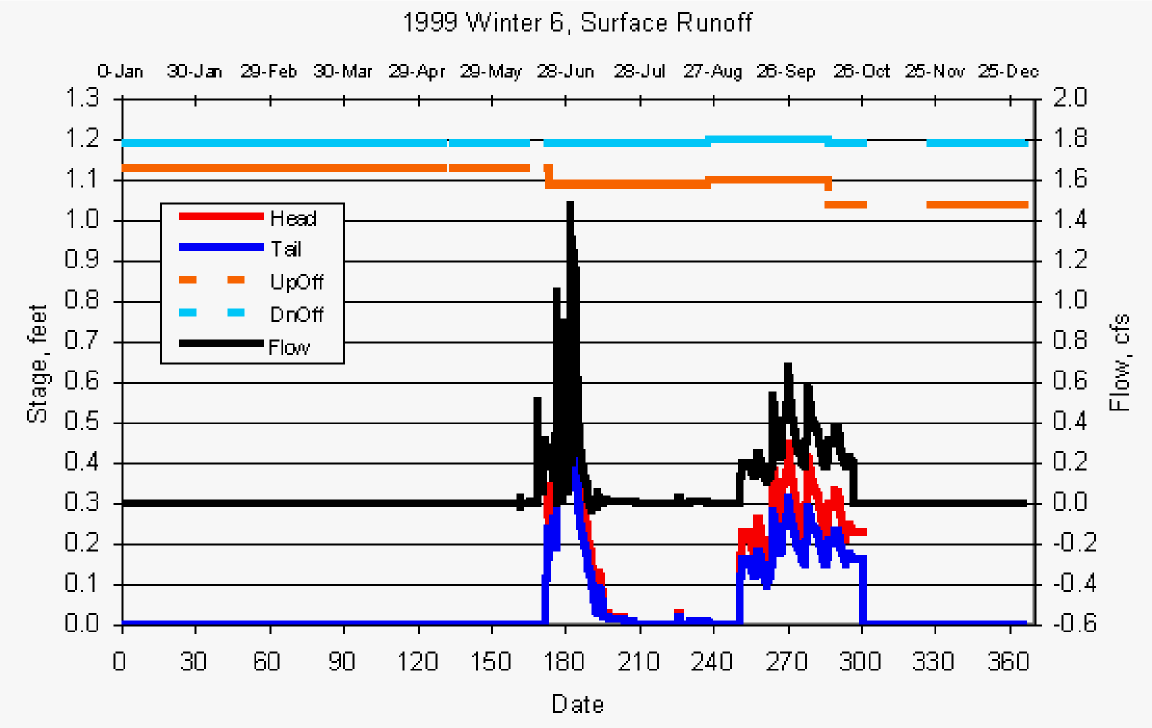


Figure 5.2.6.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 6 in 1999.

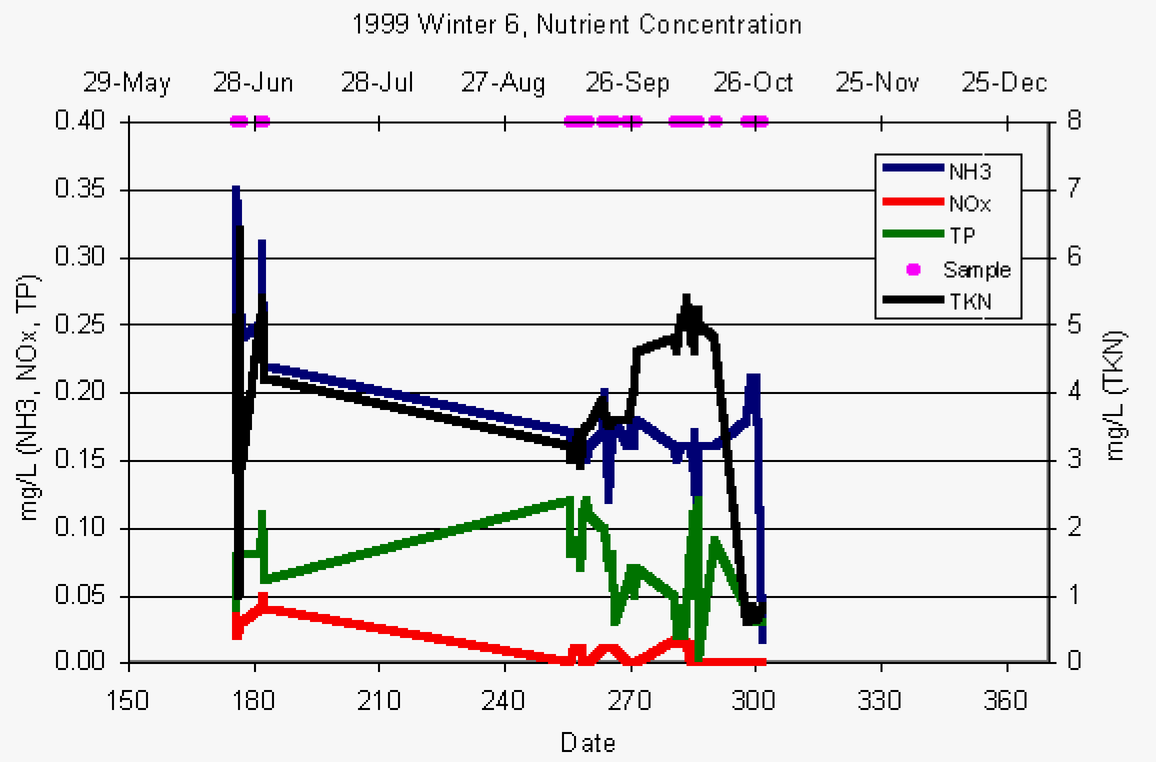


Figure 5.2.6.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 6 in 1999.

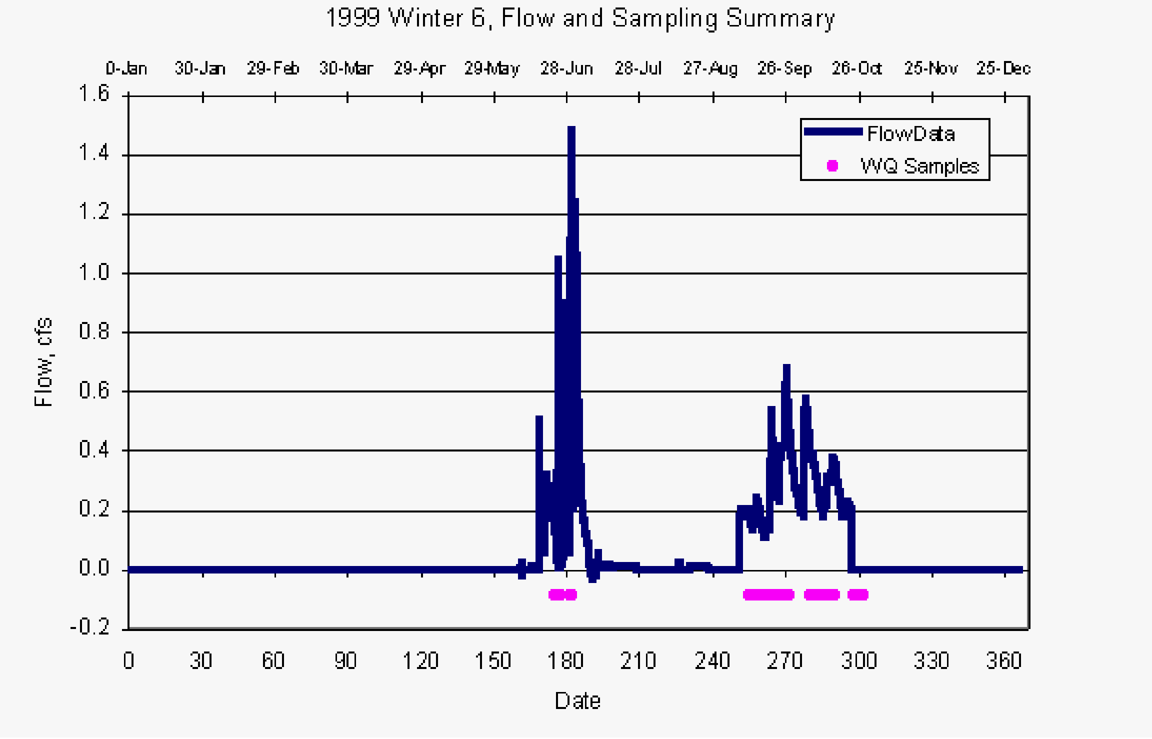


Figure 5.2.6.7. Collection dates and calculated runoff flow values for winter pasture 6 in 1999.

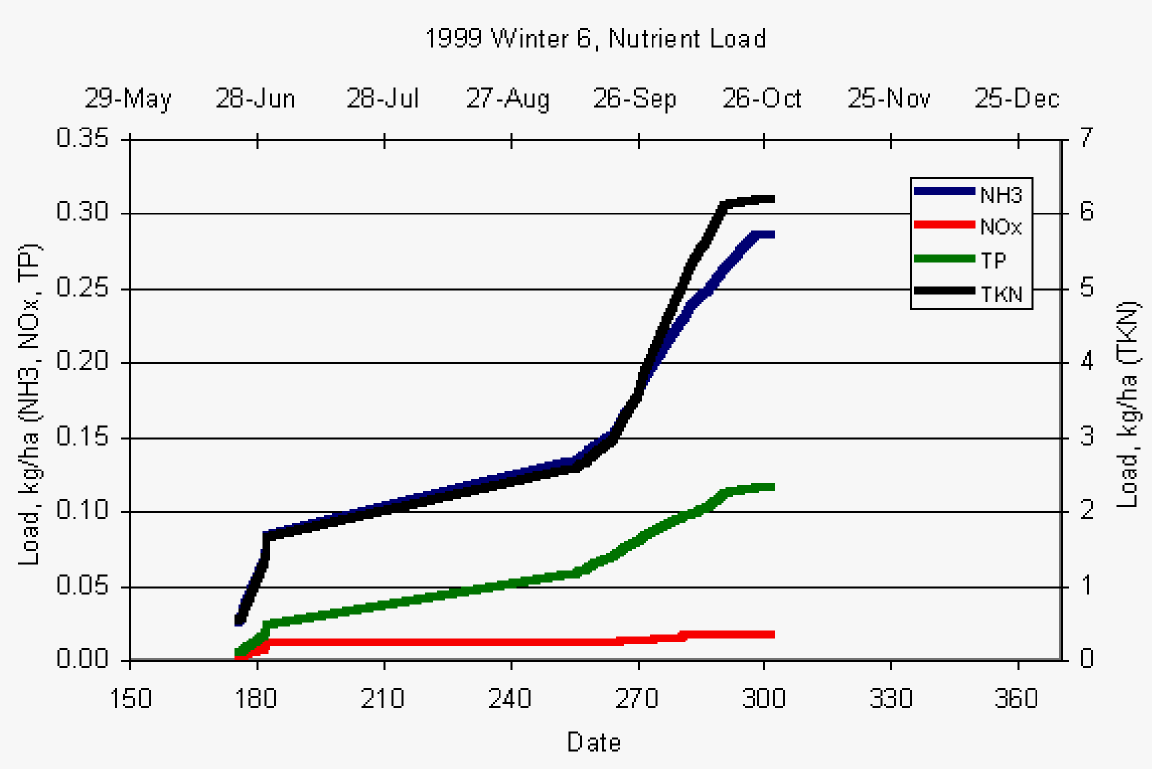


Figure 5.2.6.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 6 in 1999.

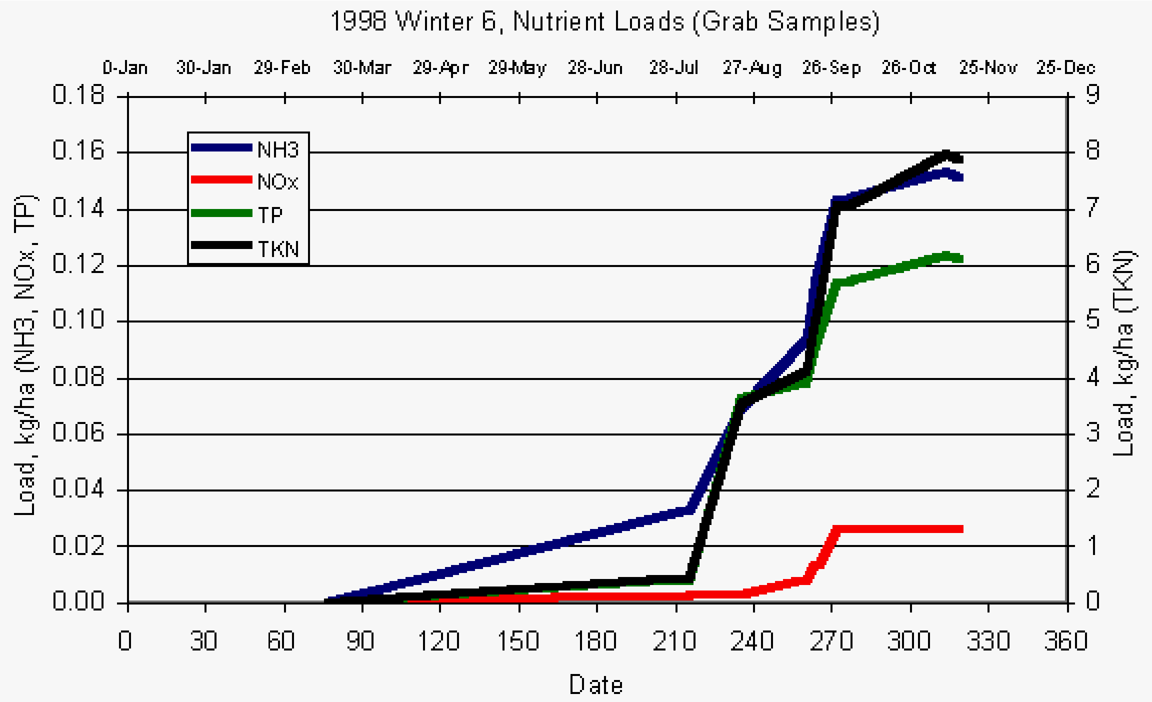


Figure 5.2.6.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 6 in 1998.

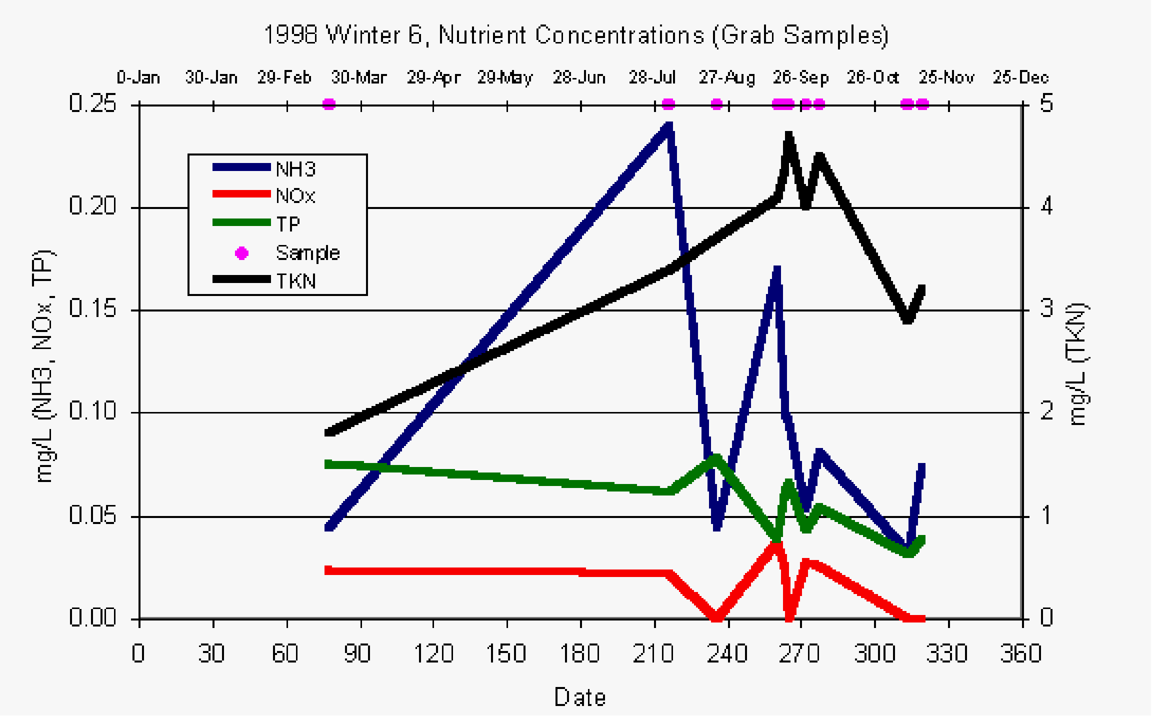


Figure 5.2.6.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 6 in 1998.

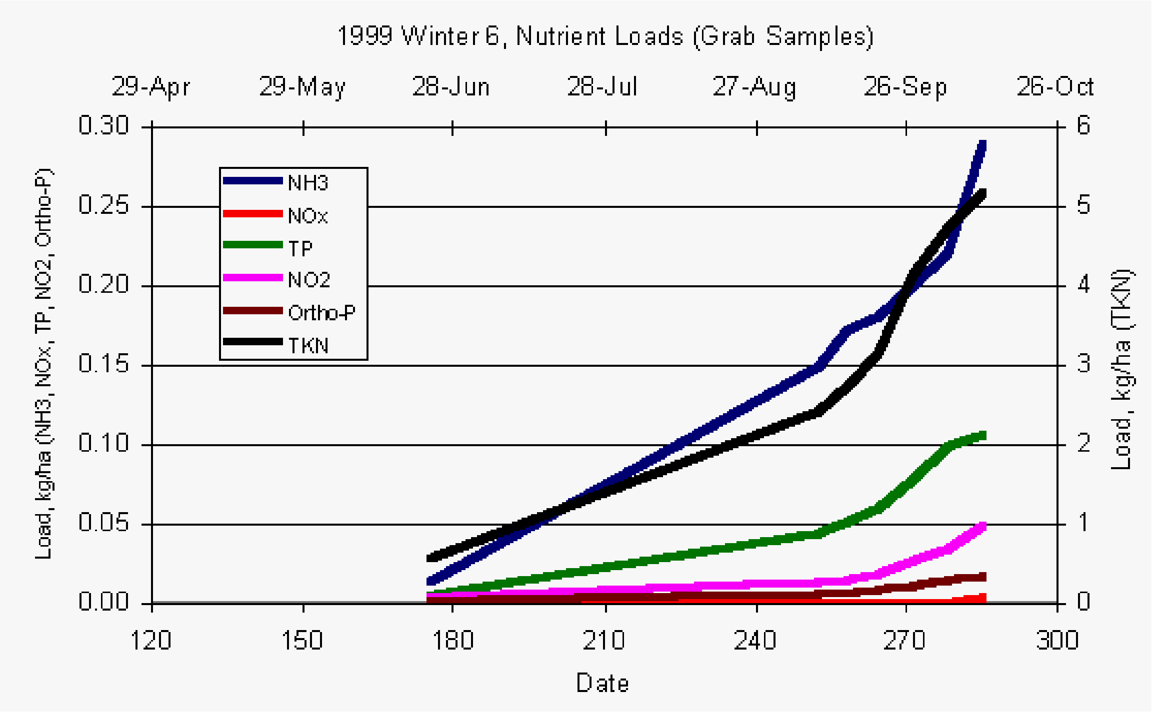


Figure 5.2.6.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 6 in 1999.

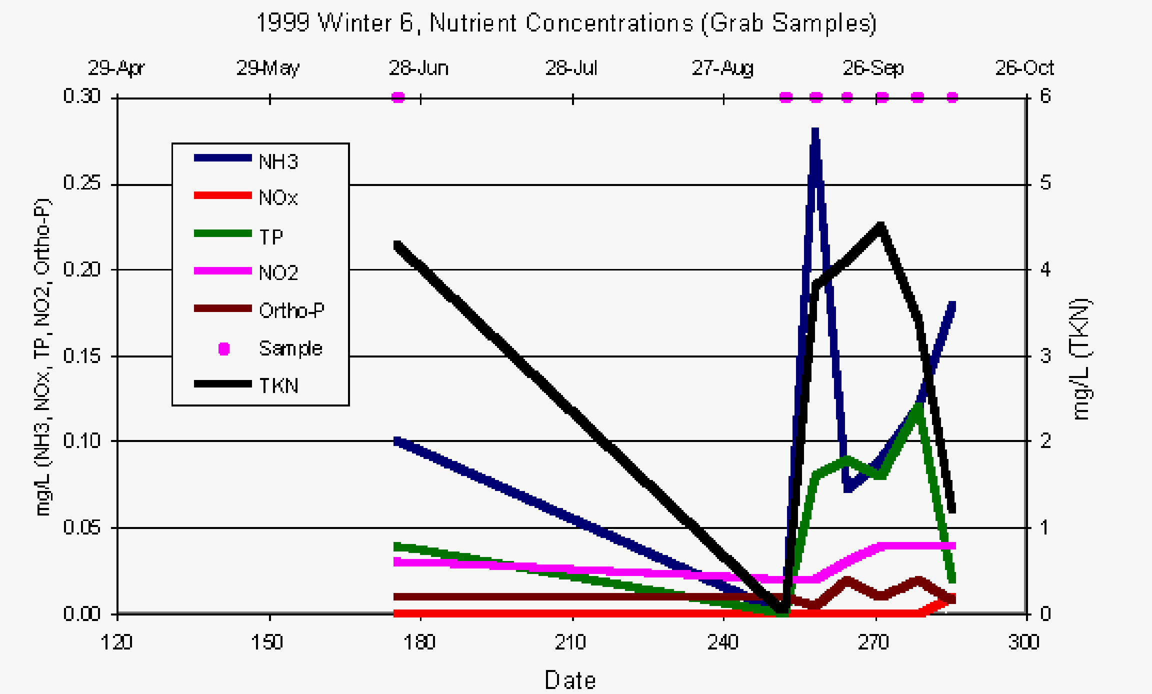


Figure 5.2.6.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 6 in 1999.

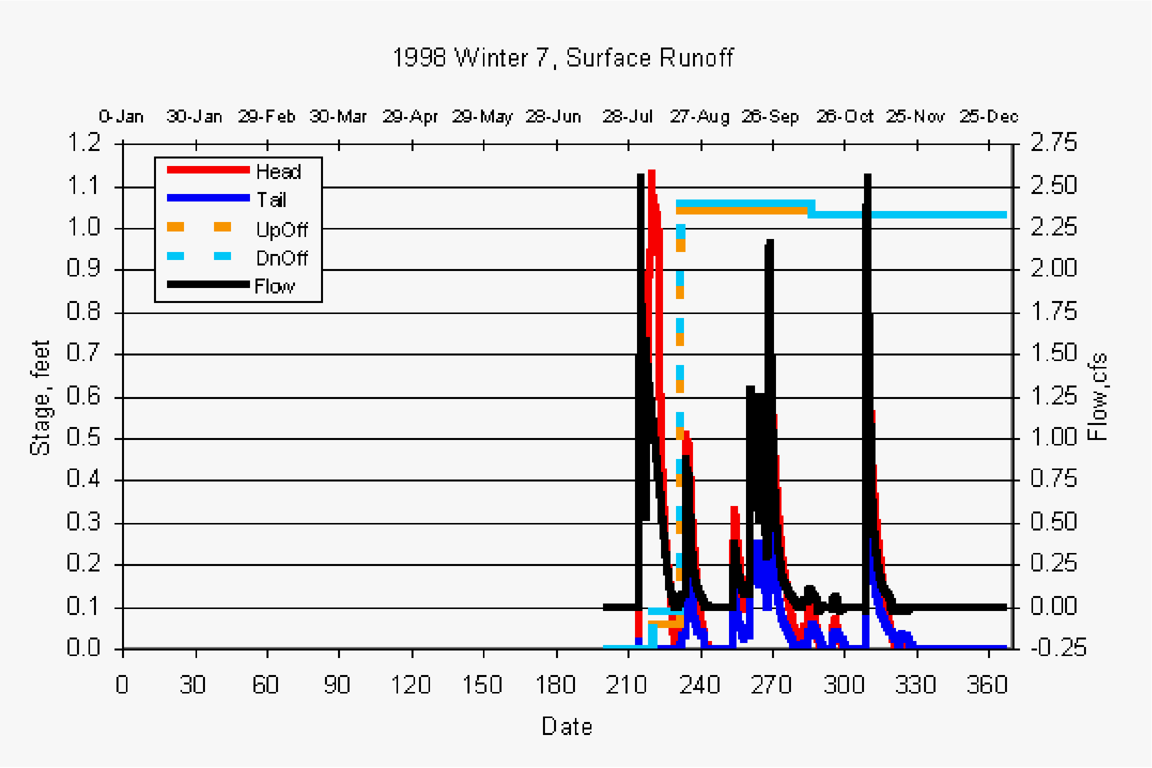


Figure 5.2.7.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 7 in 1998.

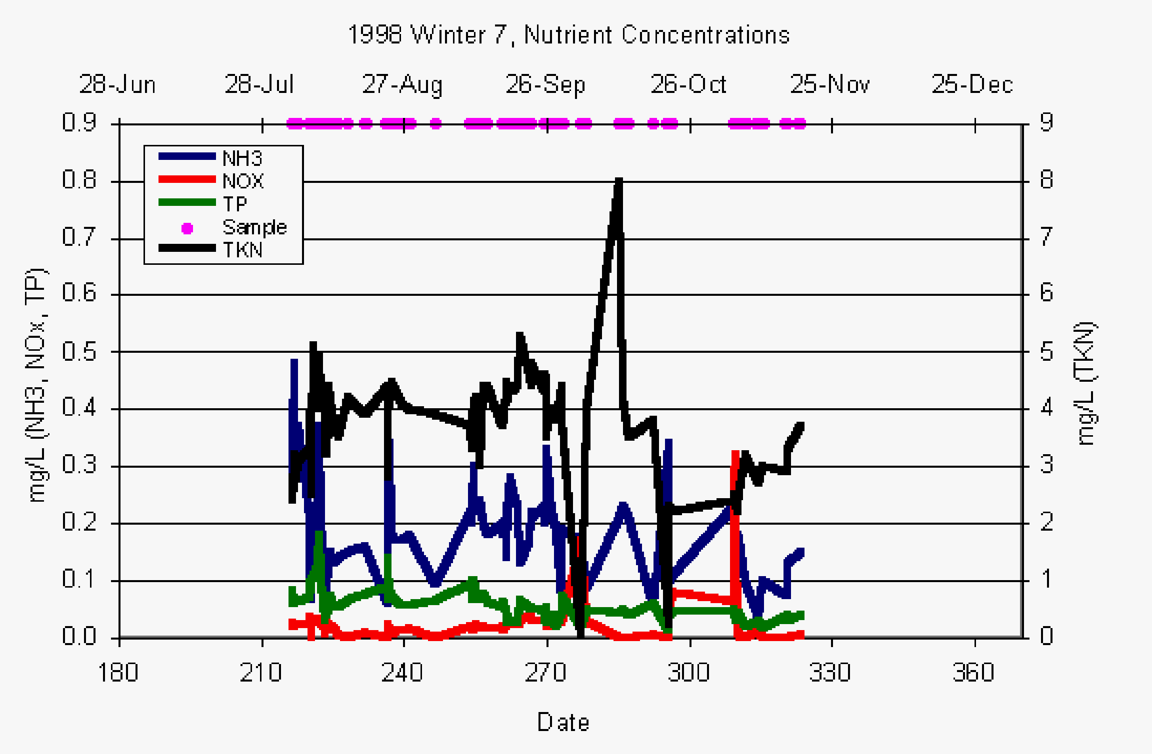


Figure 5.2.7.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 7 in 1998.

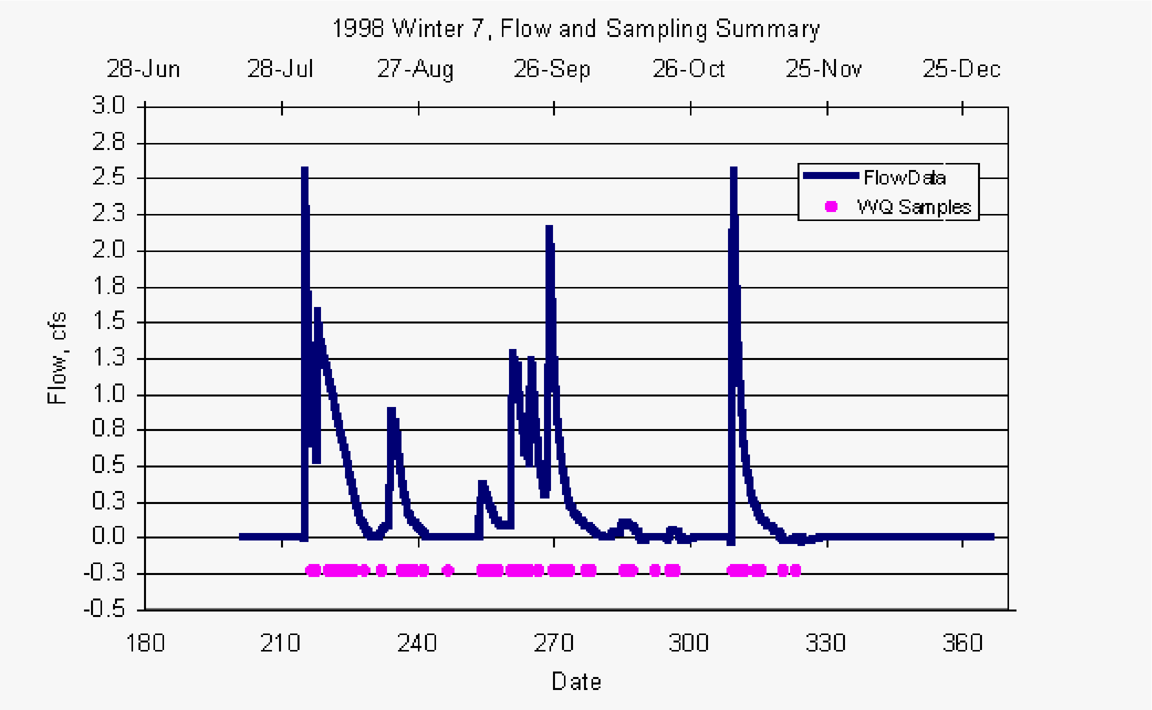
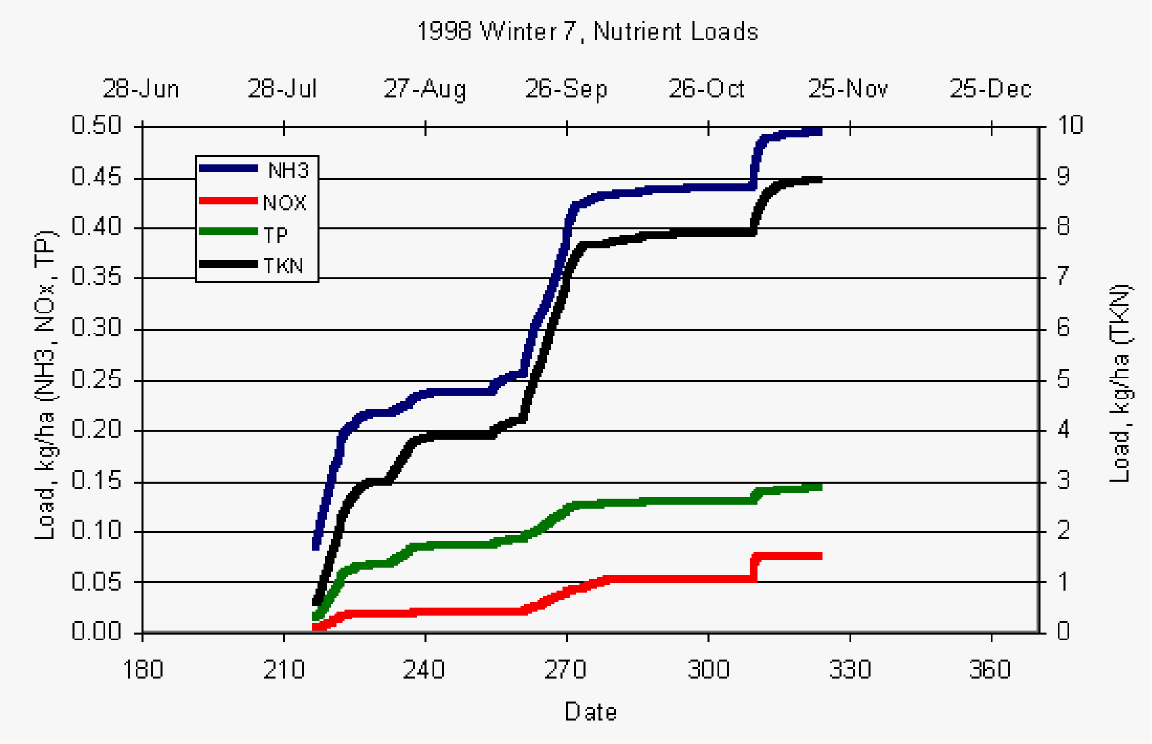


Figure 5.2.7.3. Collection dates and calculated runoff flow values for winter pasture 7 in 1998.



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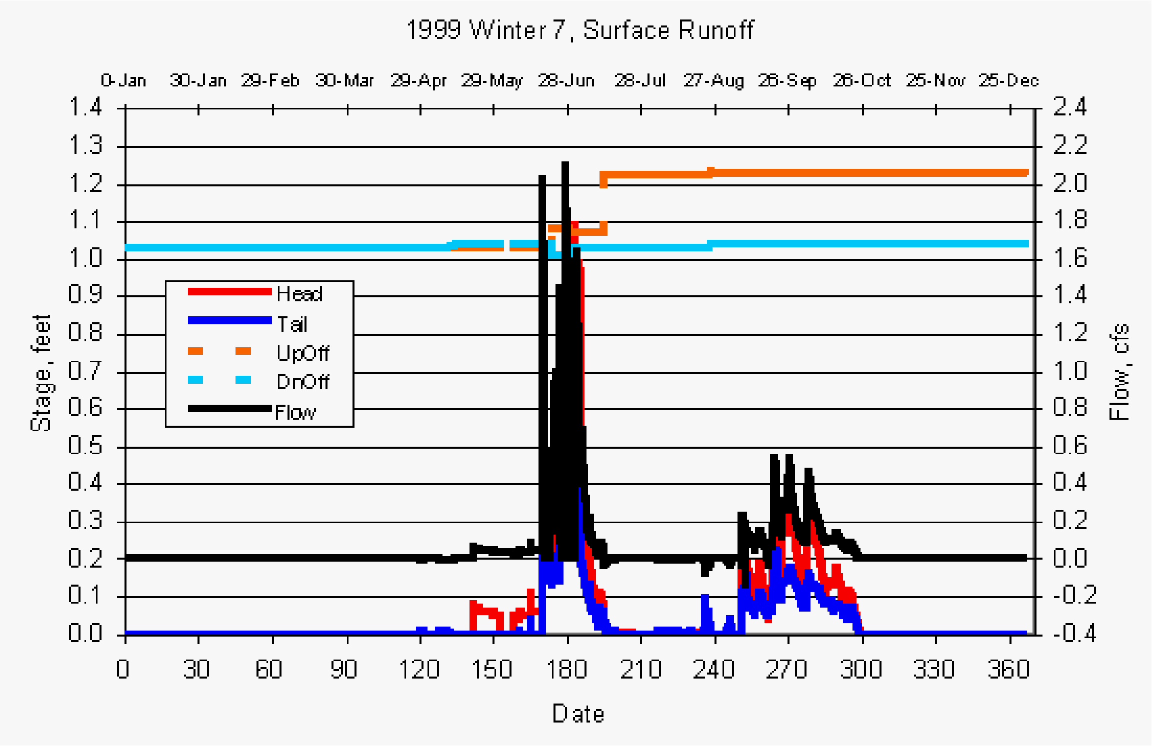

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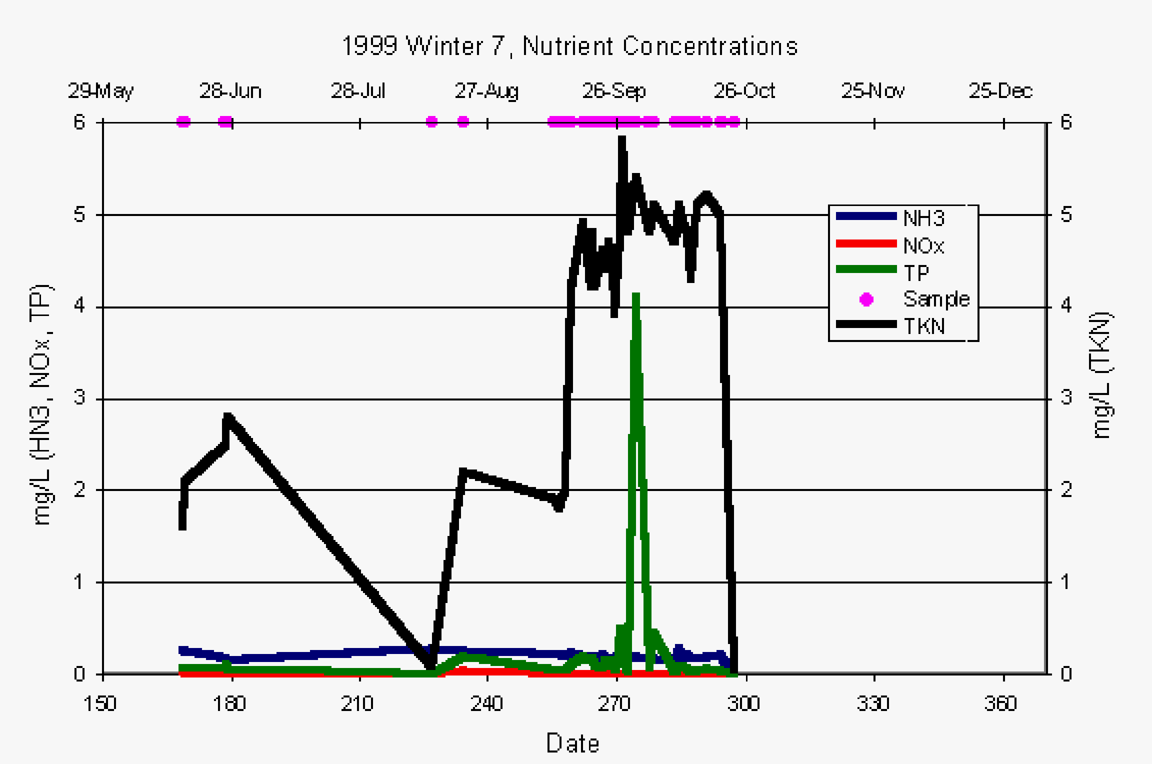


Figure 5.2.7.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 7 in 1999.

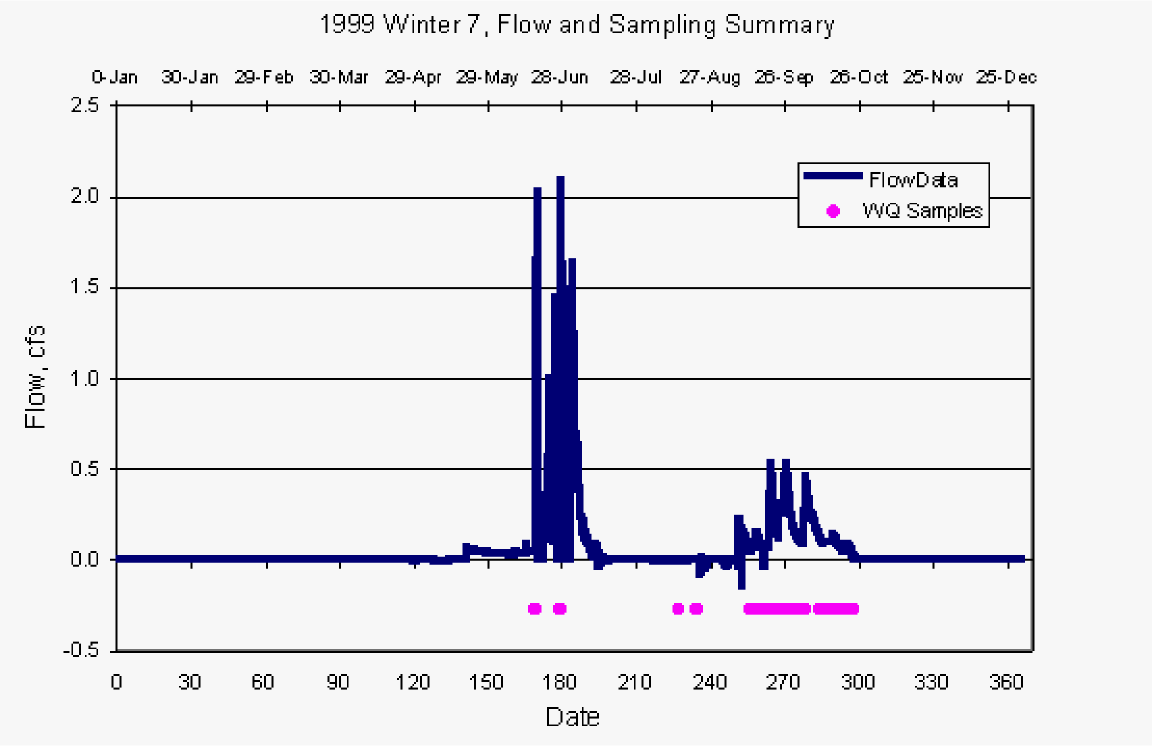


Figure 5.2.7.7. Collection dates and calculated runoff flow values for winter pasture 7 in 1999.

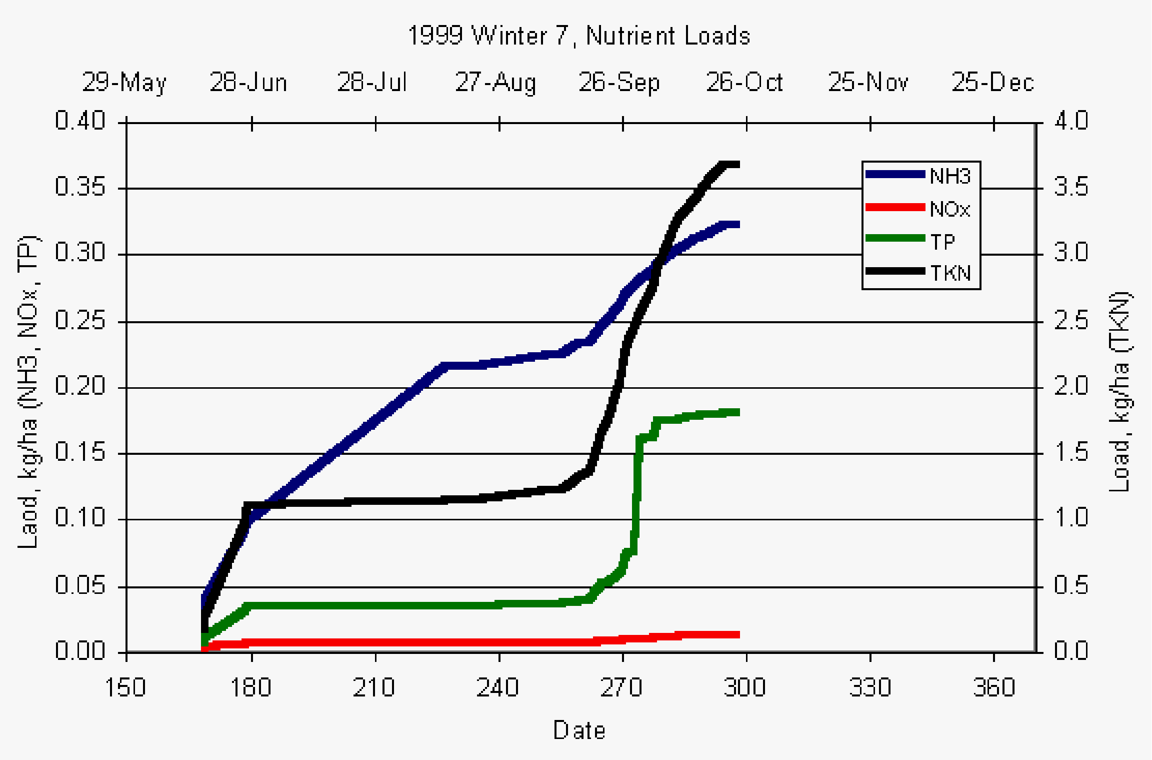


Figure 5.2.7.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 7 in 1999.

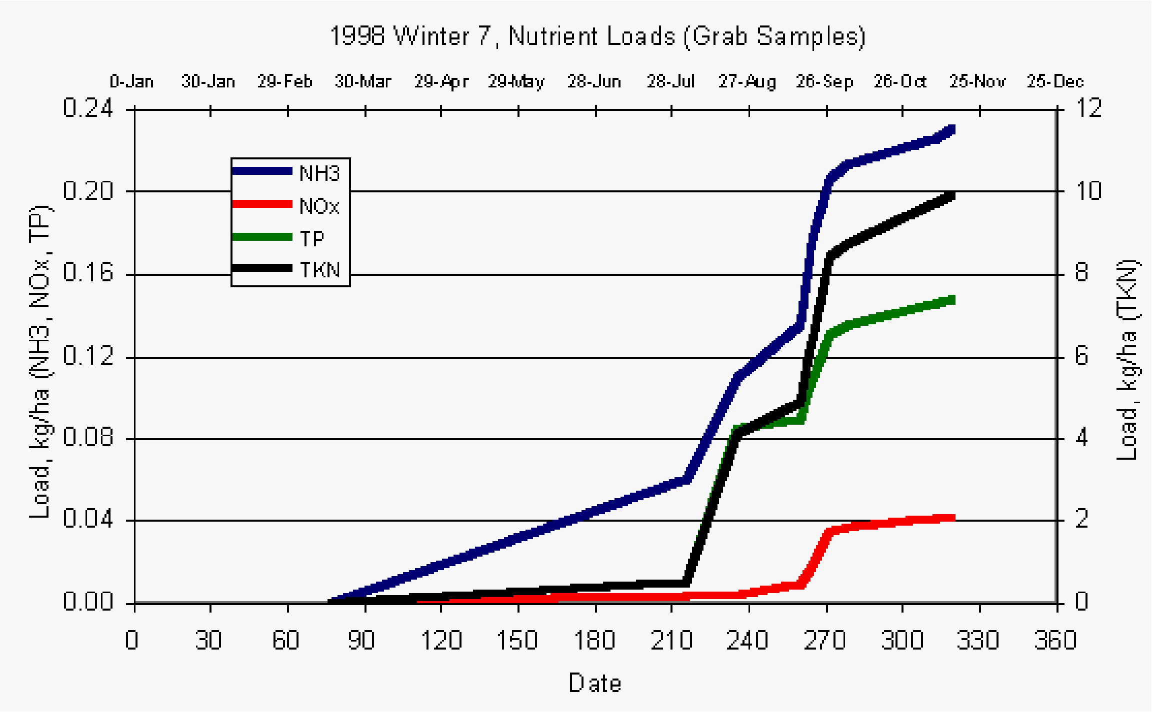


Figure 5.2.7.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 7 in 1998.

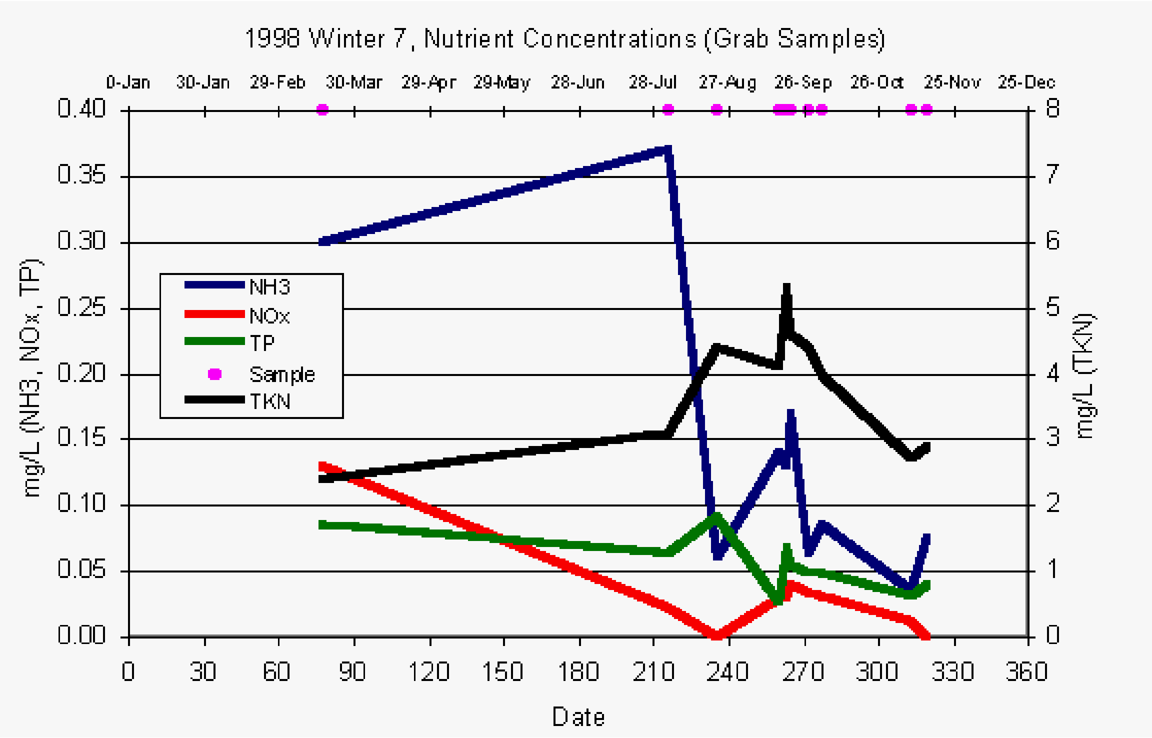


Figure 5.2.7.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 7 in 1998.

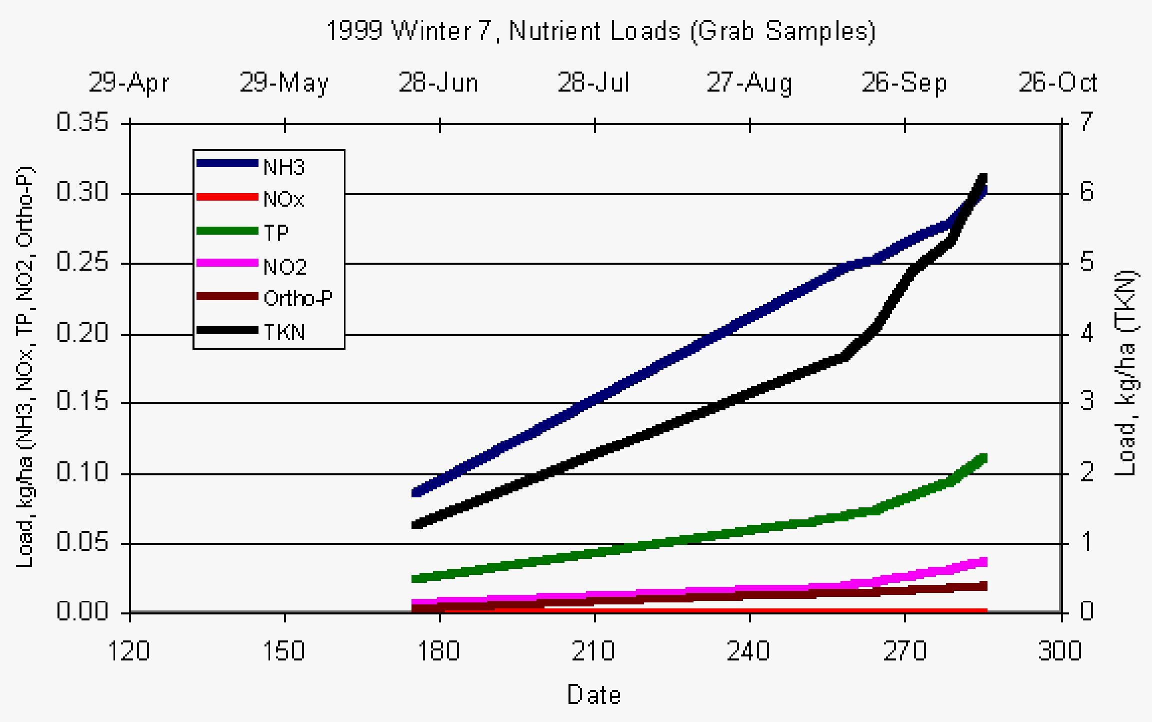


Figure 5.2.7.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 7 in 1999.

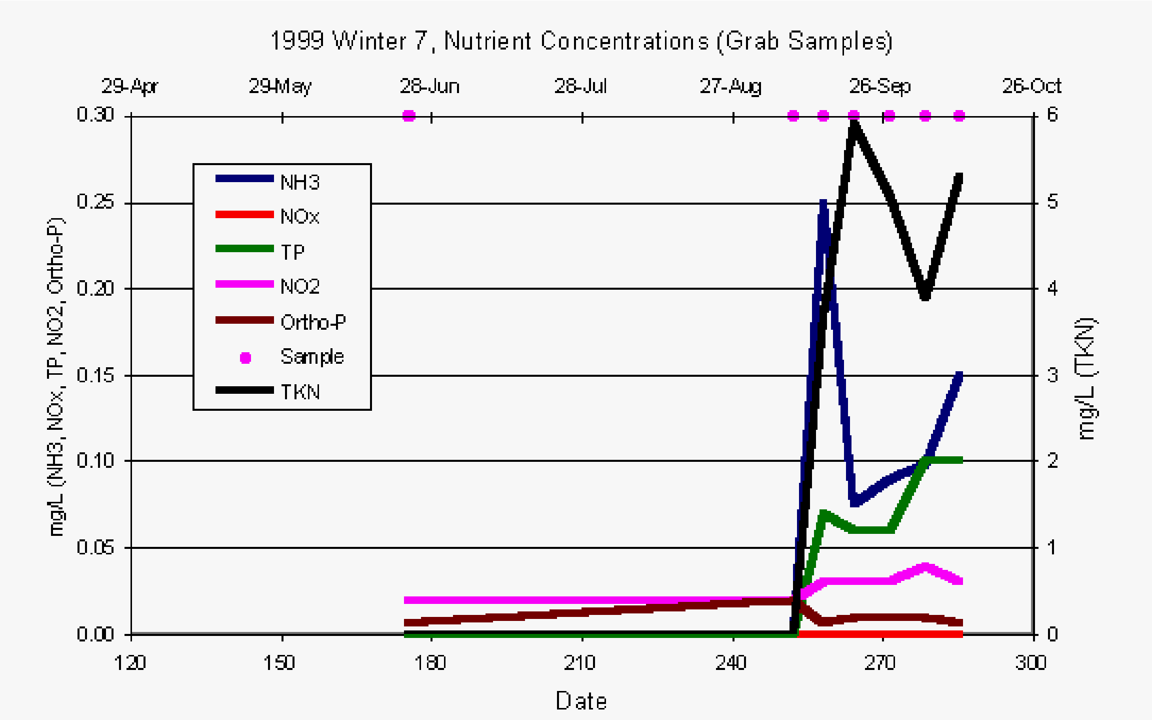


Figure 5.2.7.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 7 in 1999.

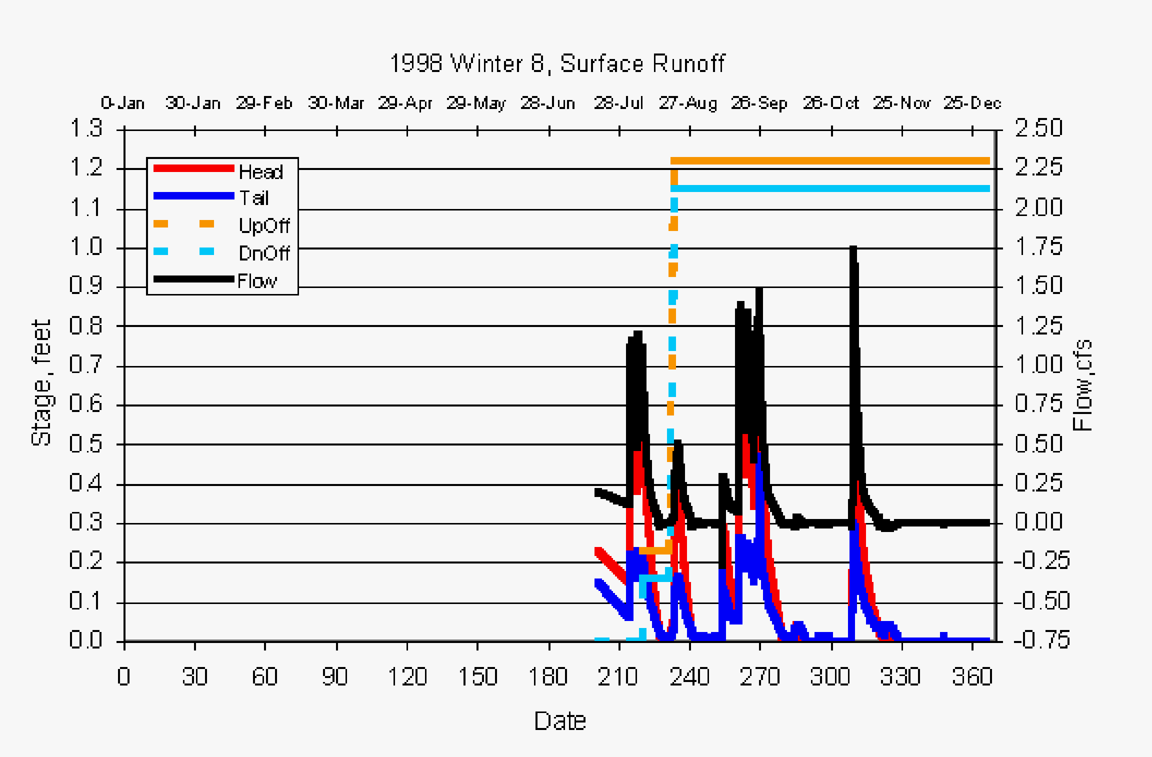


Figure 5.2.8.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 8 in 1998.

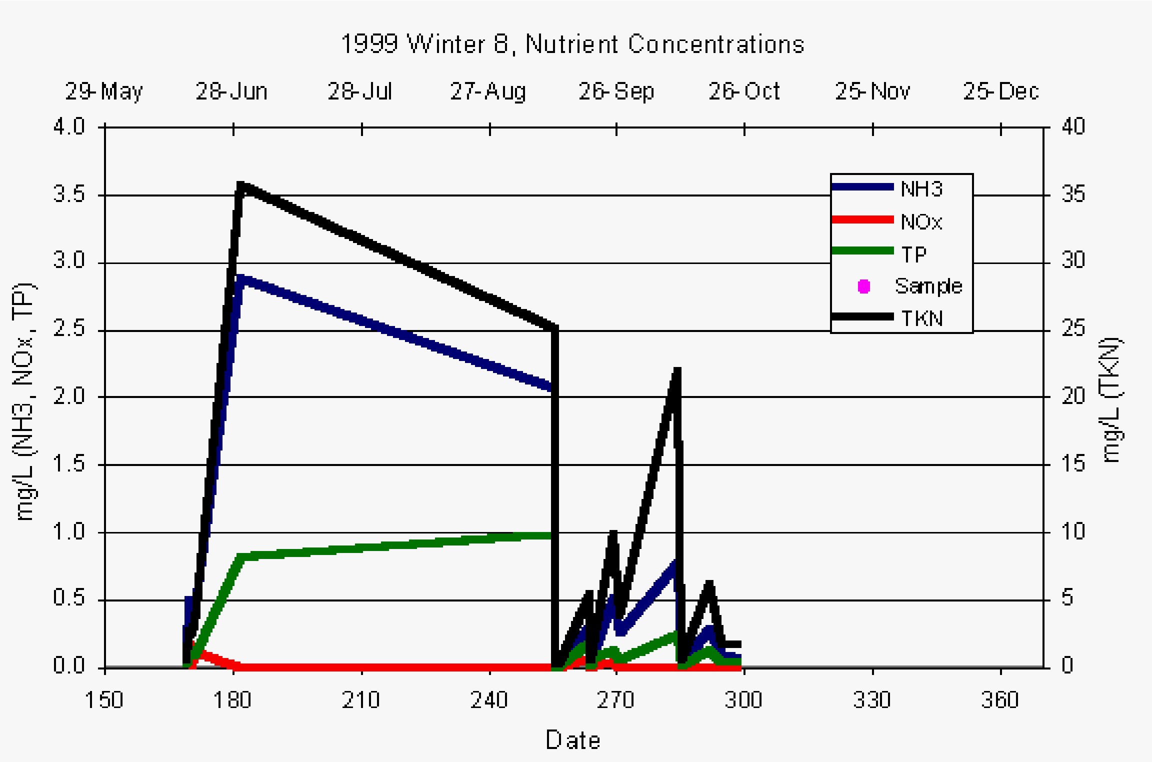


Figure 5.2.8.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 8 in 1998.

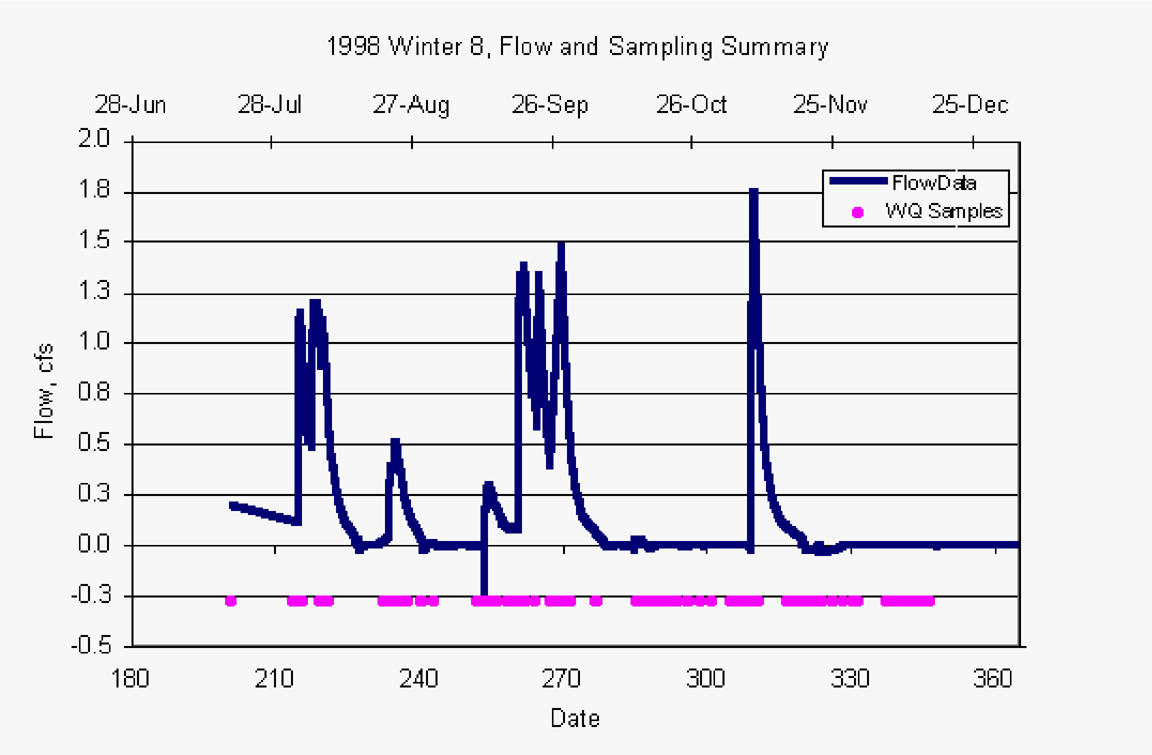


Figure 5.2.8.3. Collection dates and calculated runoff flow values for winter pasture 8 in 1998.

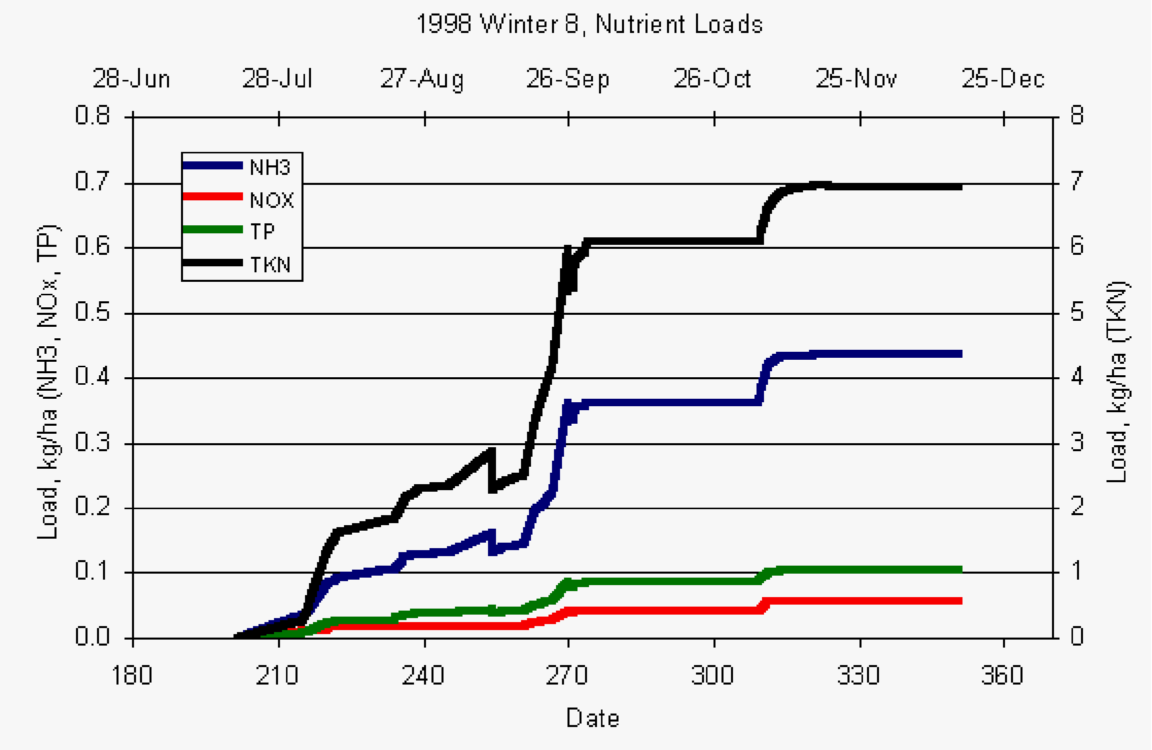


Figure 5.2.8.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 8 in 1998.

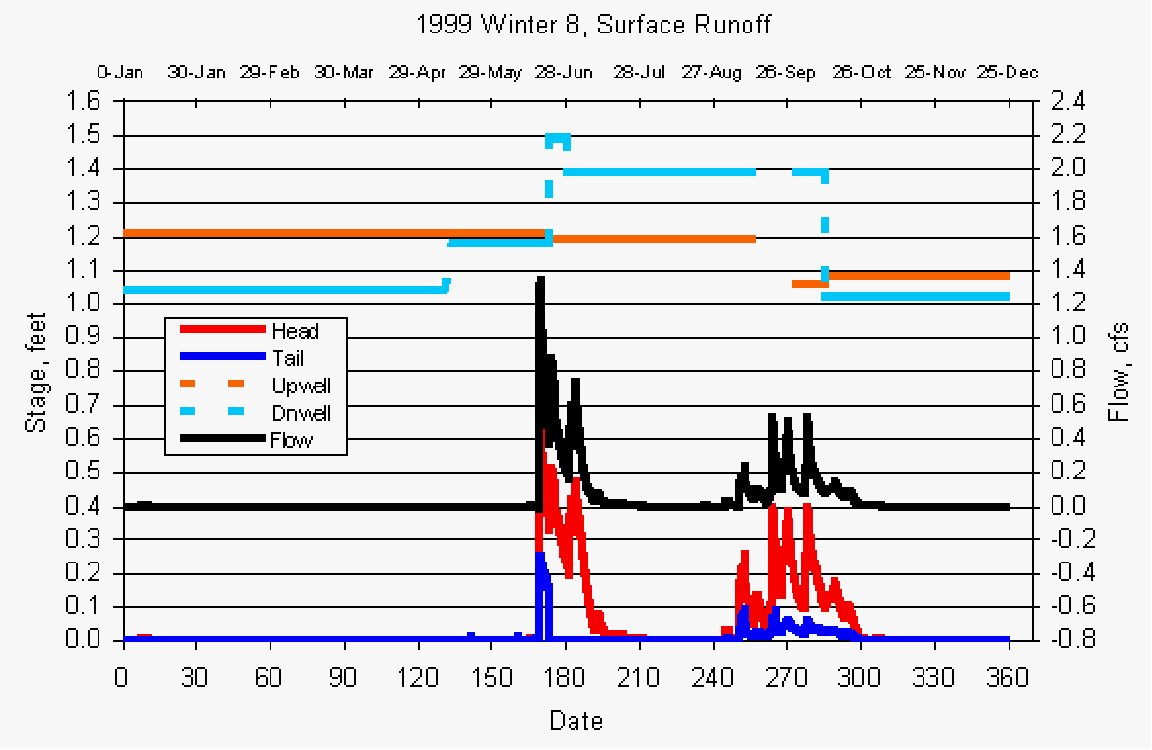


Figure 5.2.8.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at winter pasture 8 in 1999.

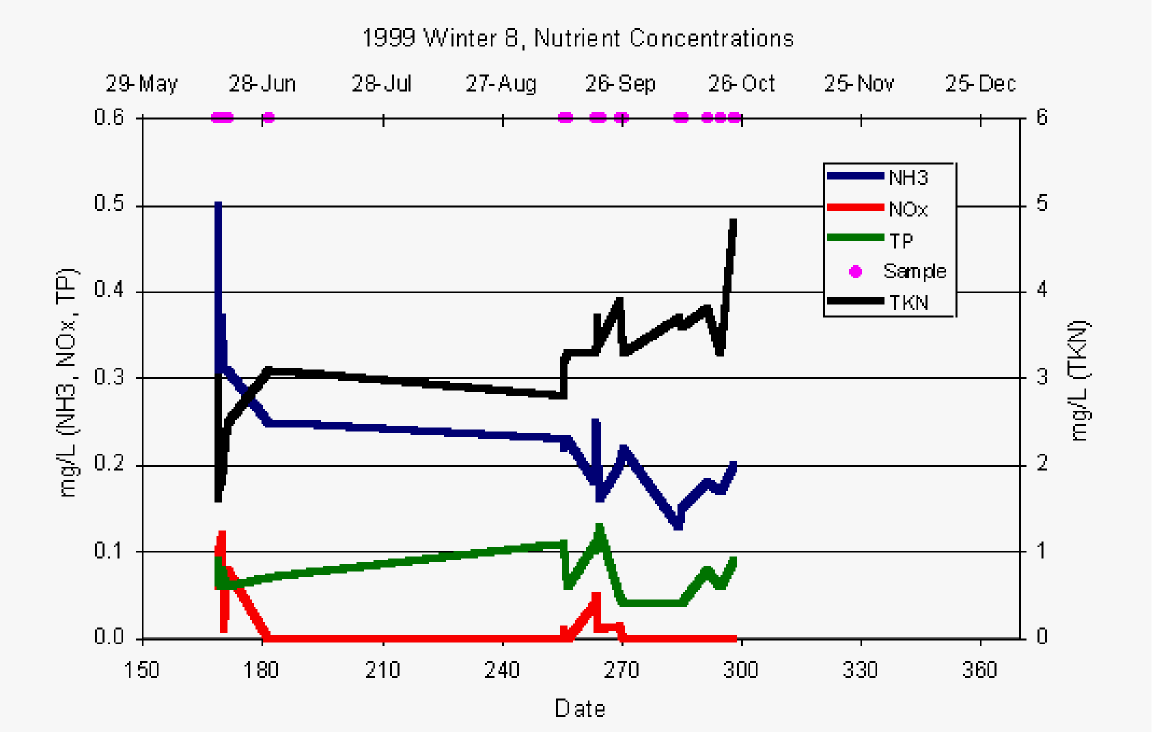


Figure 5.2.8.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from winter pasture 8 in 1999.

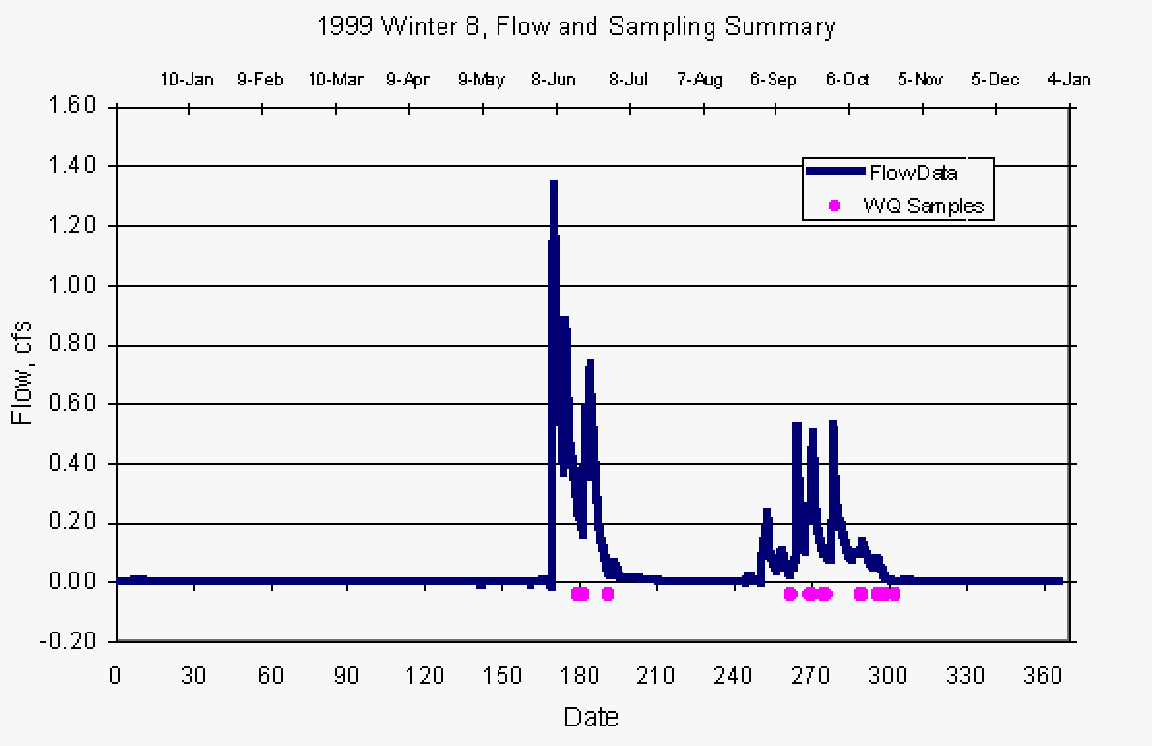


Figure 5.2.8.7. Collection dates and calculated runoff flow values for winter pasture 8 in 1999.

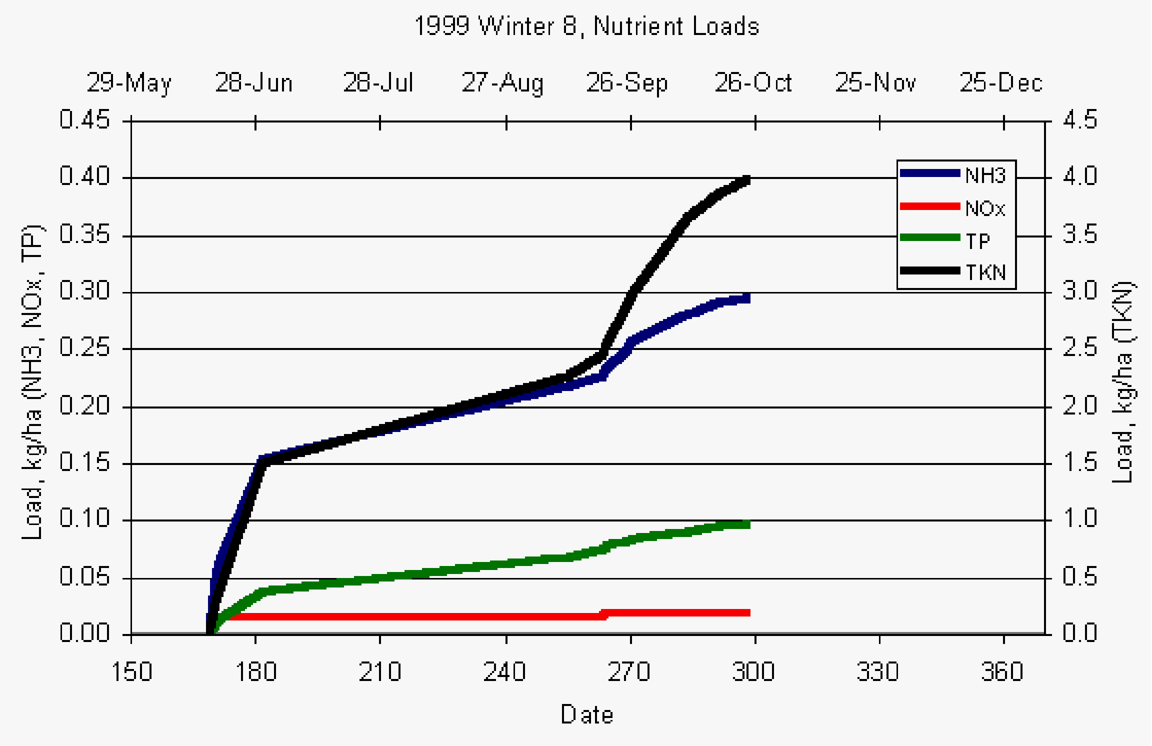


Figure 5.2.8.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at winter pasture 8 in 1999.

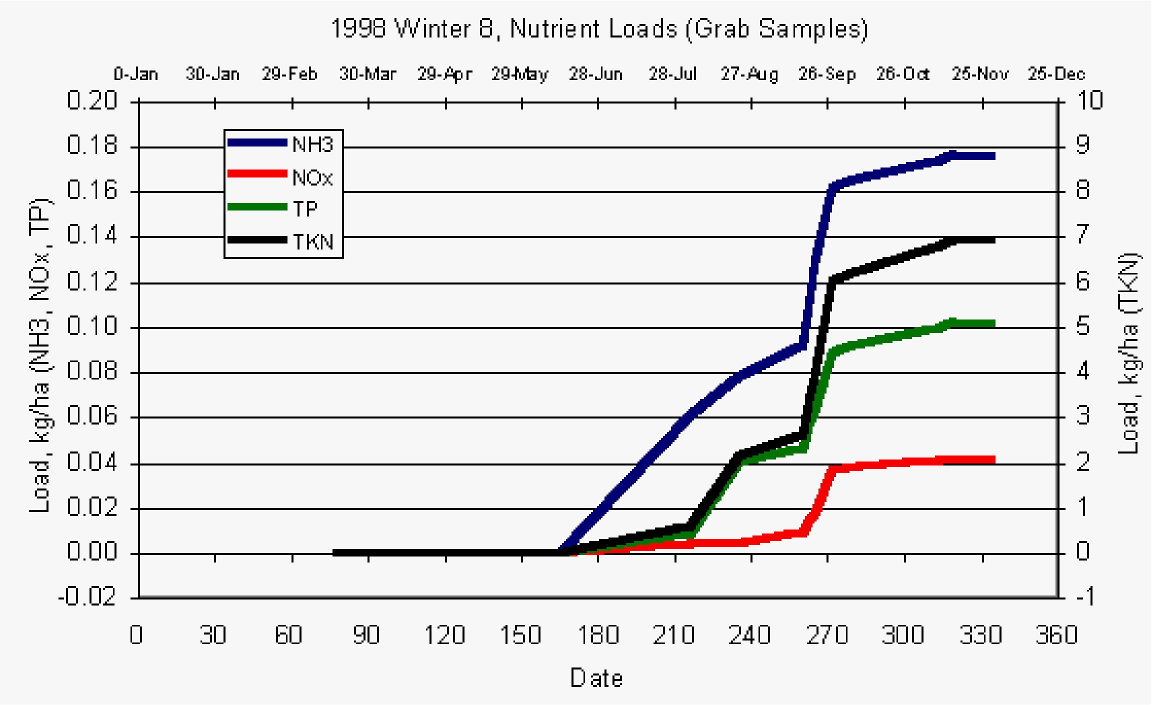


Figure 5.2.8.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 8 in 1998.

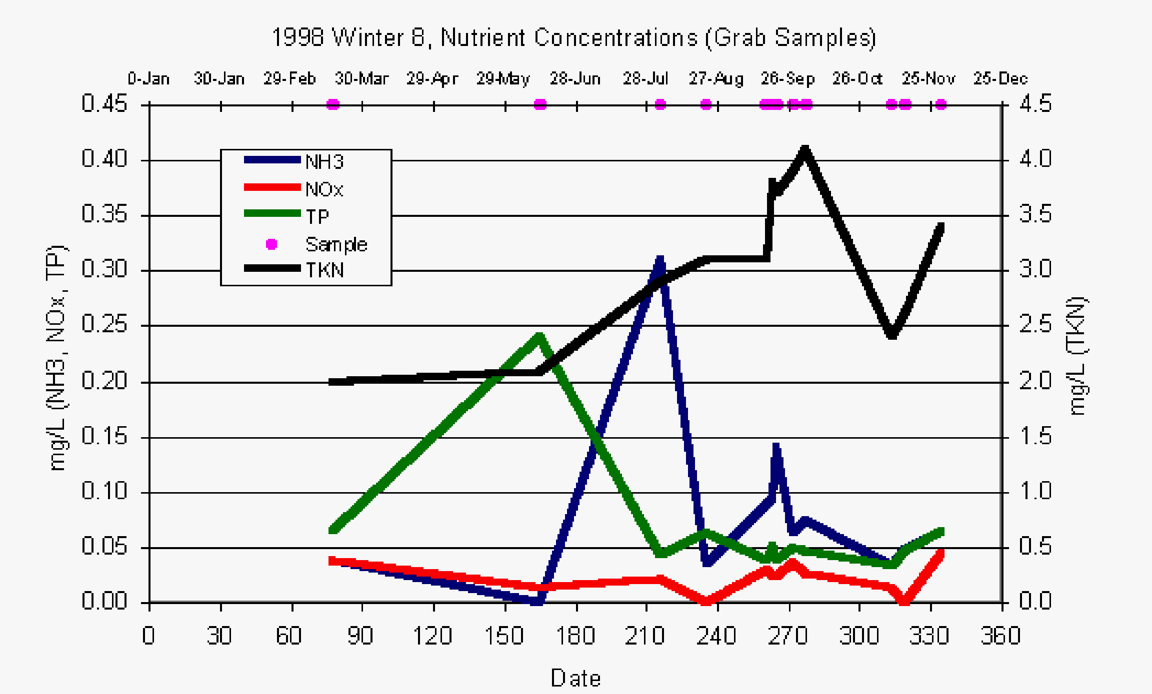


Figure 5.2.8.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 8 in 1998.

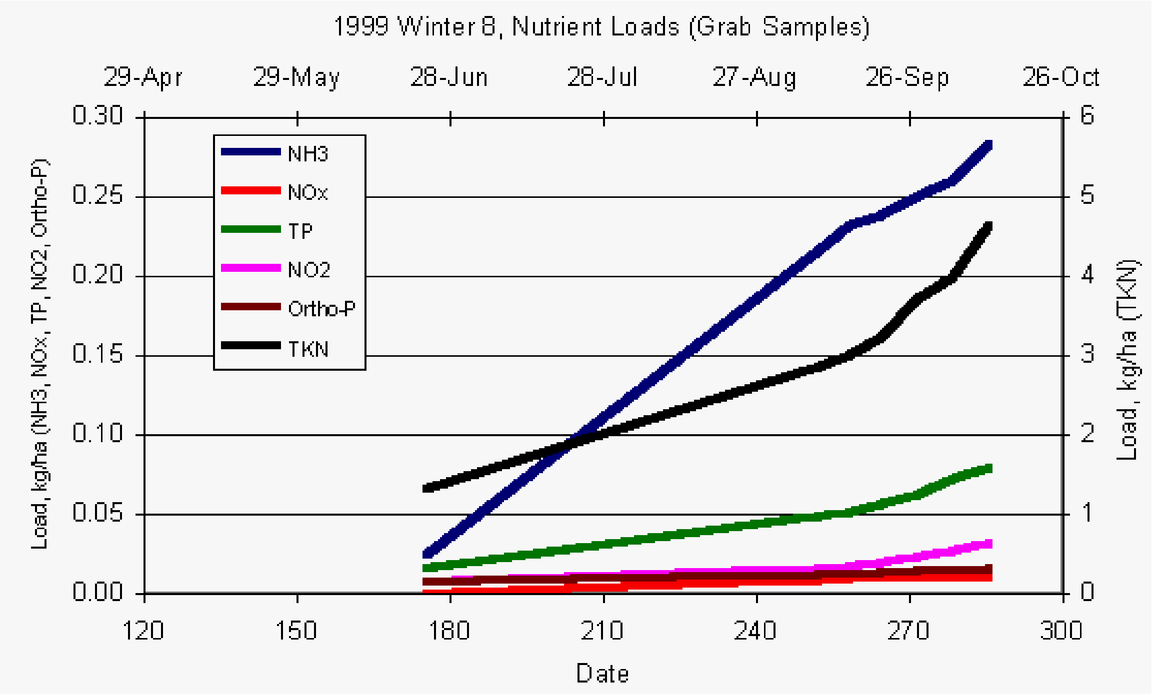


Figure 5.2.8.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at winter pasture 8 in 1999.

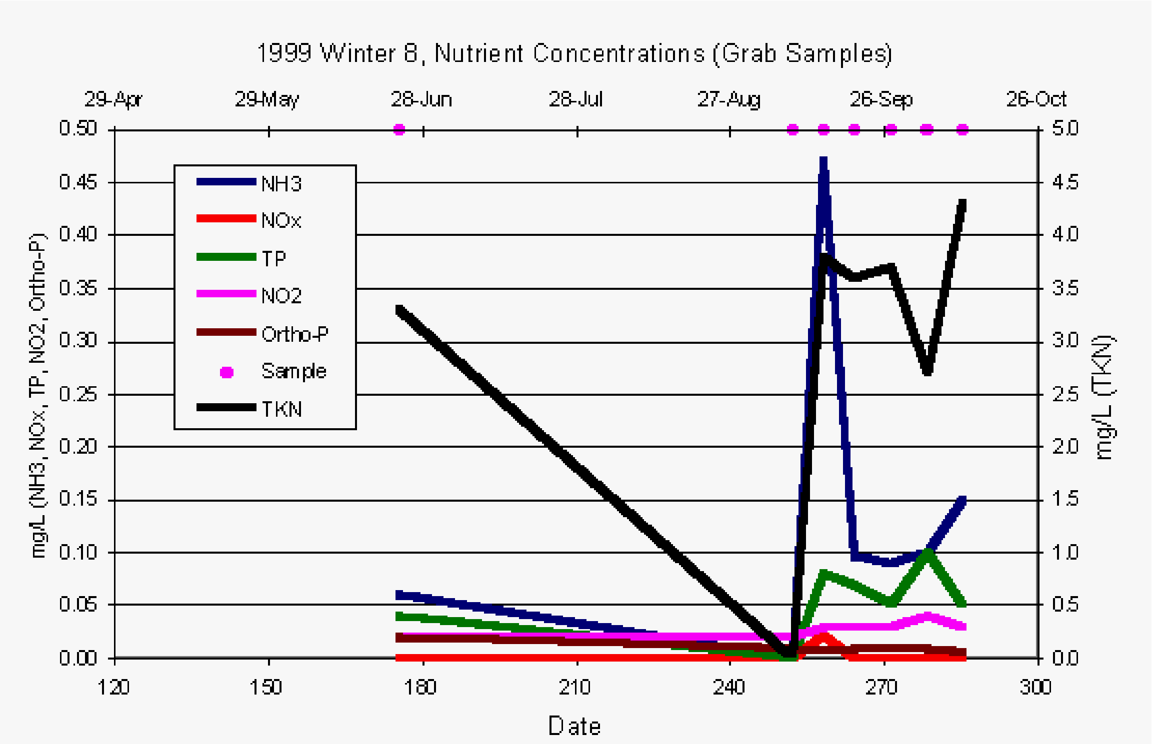


Figure 5.2.8.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from winter pasture 8 in 1999.

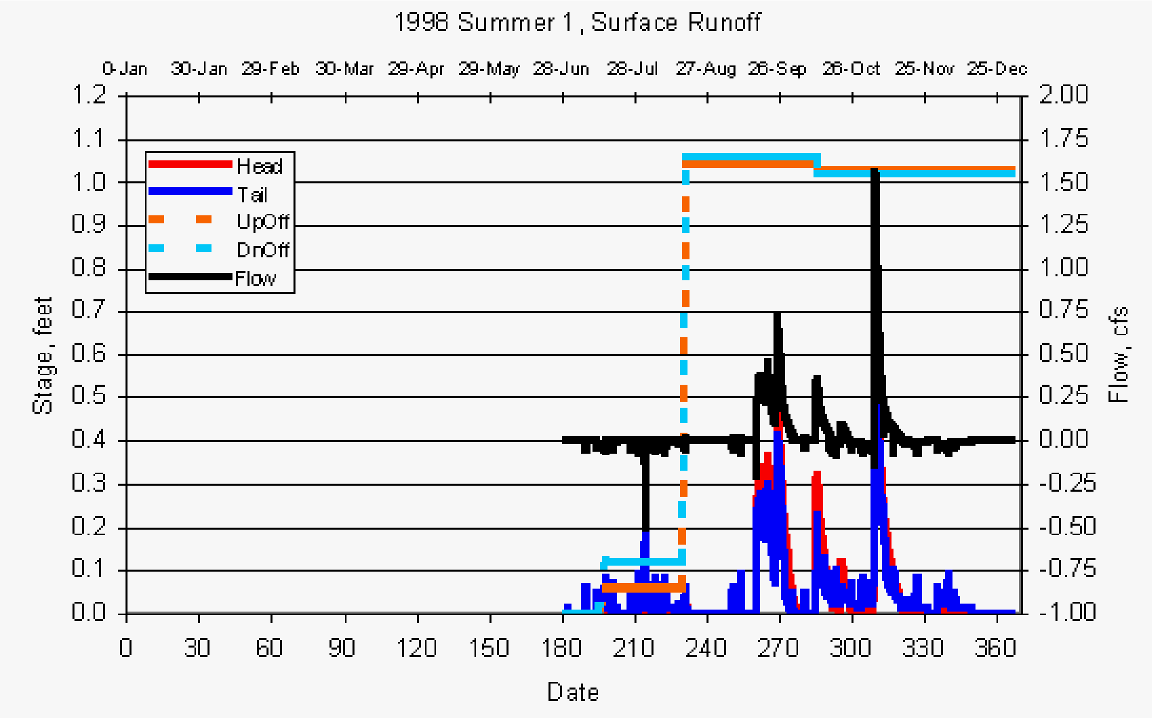


Figure 5.2.9.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 1 in 1998.

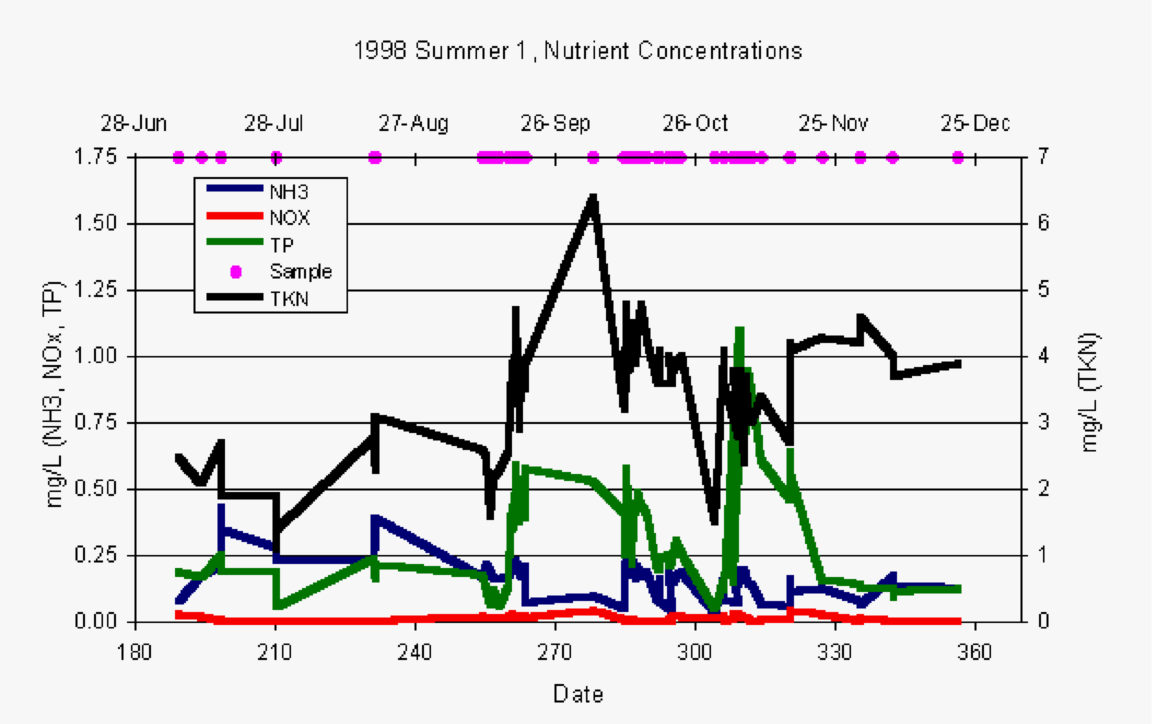


Figure 5.2.9.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 1 in 1998.

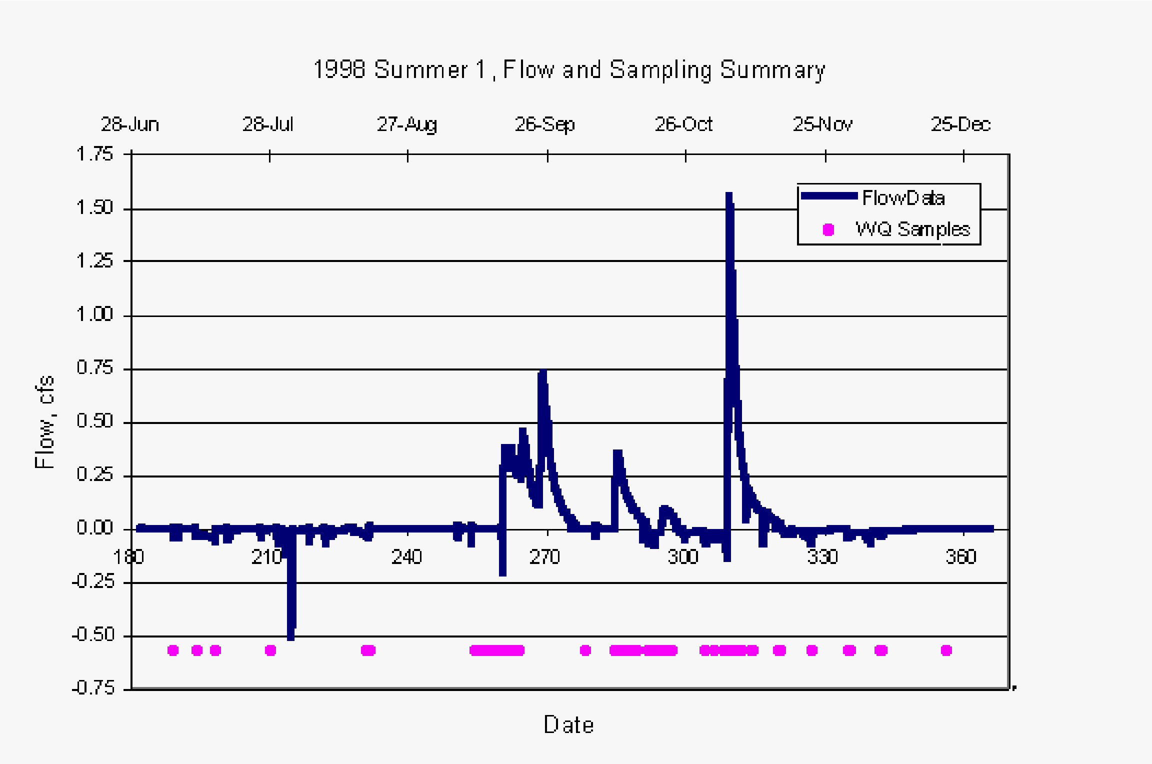


Figure 5.2.9.3. Collection dates and calculated runoff flow values for summer pasture 1 in 1998.

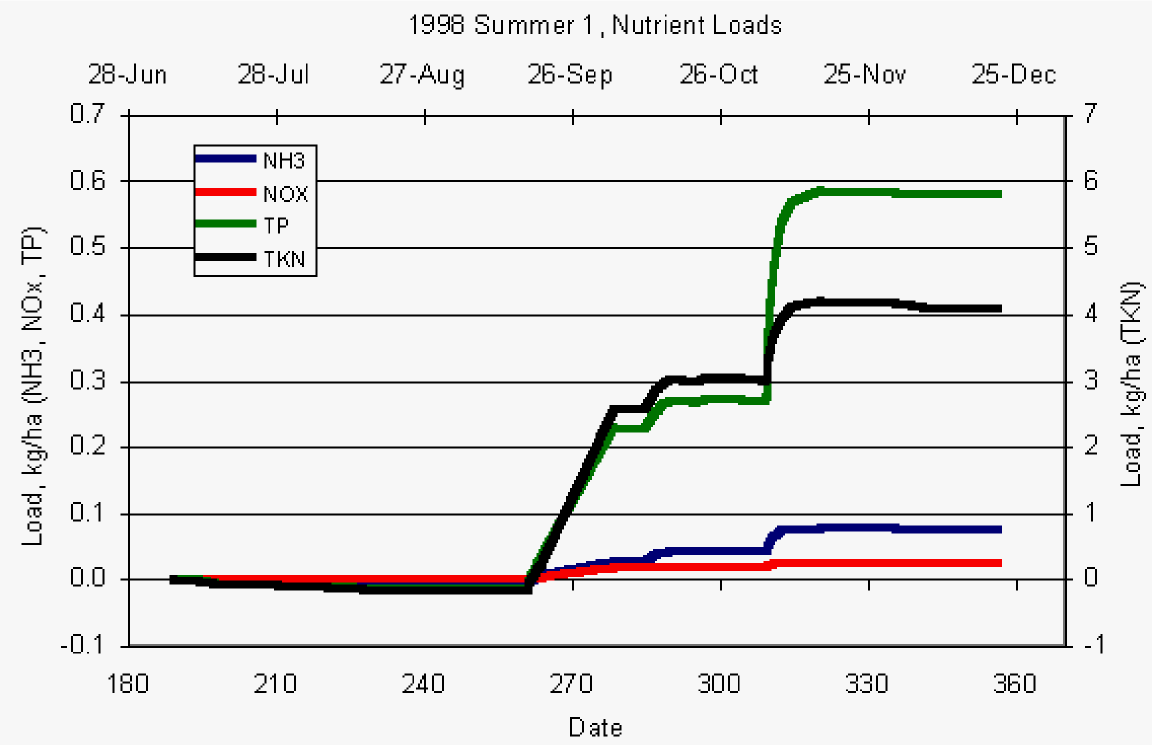


Figure 5.2.9.4. Nutrient loads in kg/ha of elemental N and P as calculated using auto samples at summer pasture 1 in 1998.

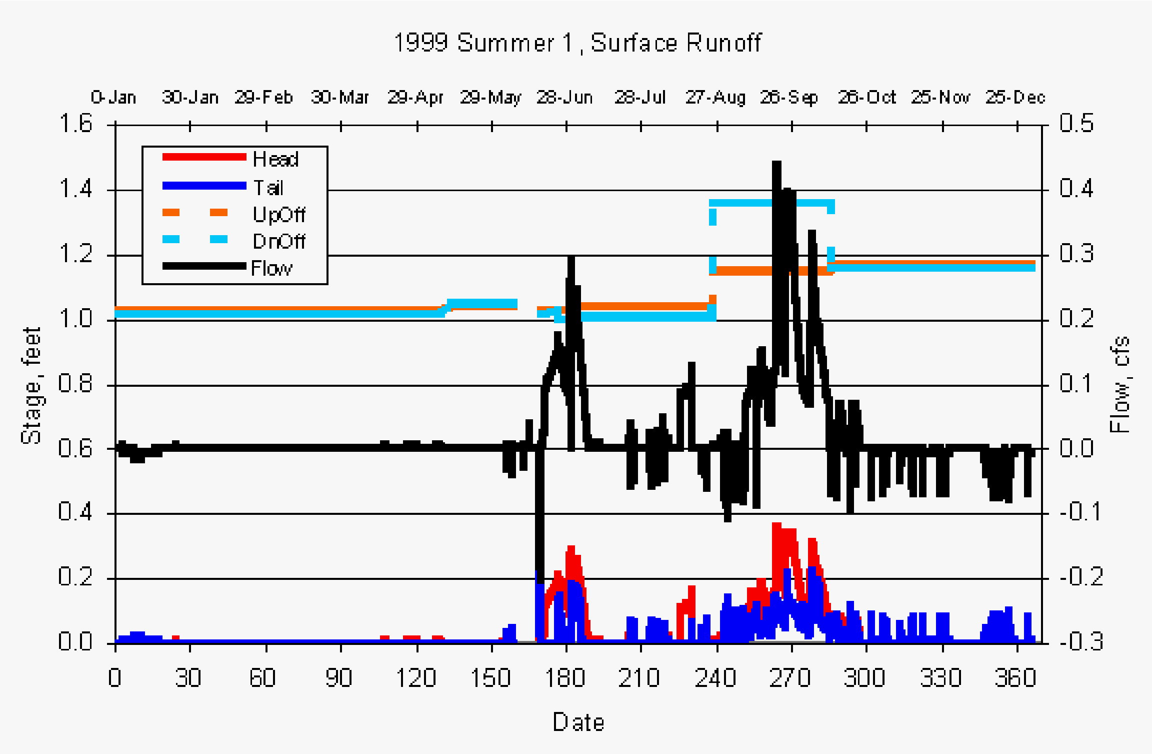


Figure 5.2.9.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 1 in 1999.

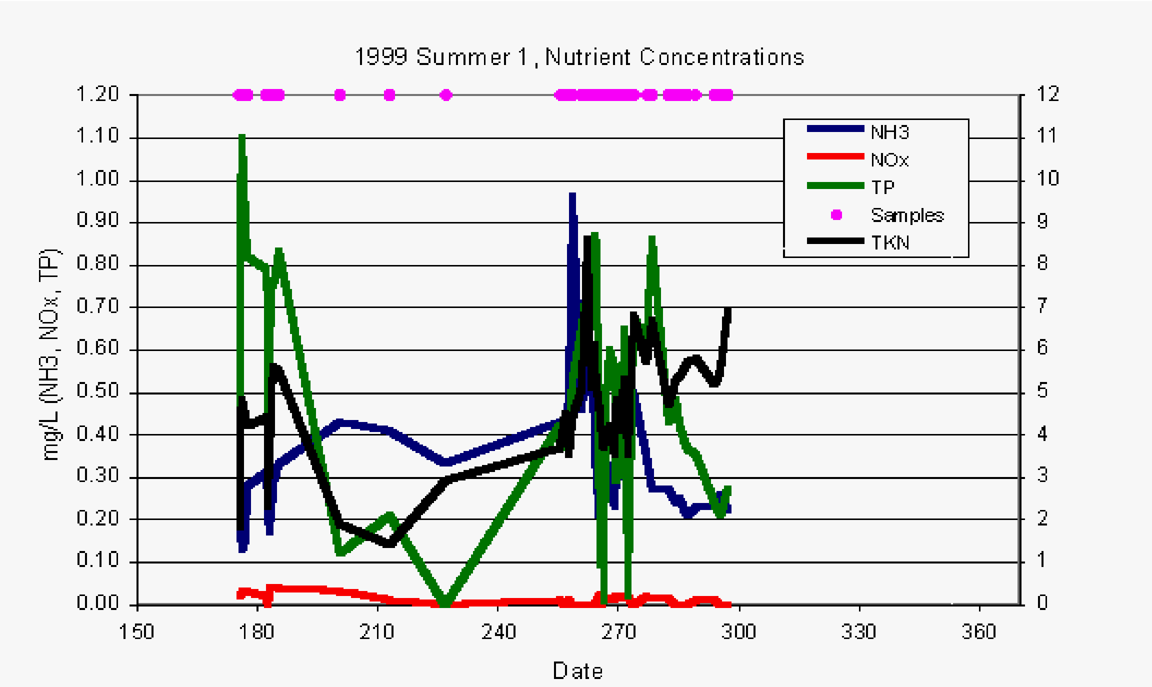


Figure 5.2.9.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 1 in 1999.

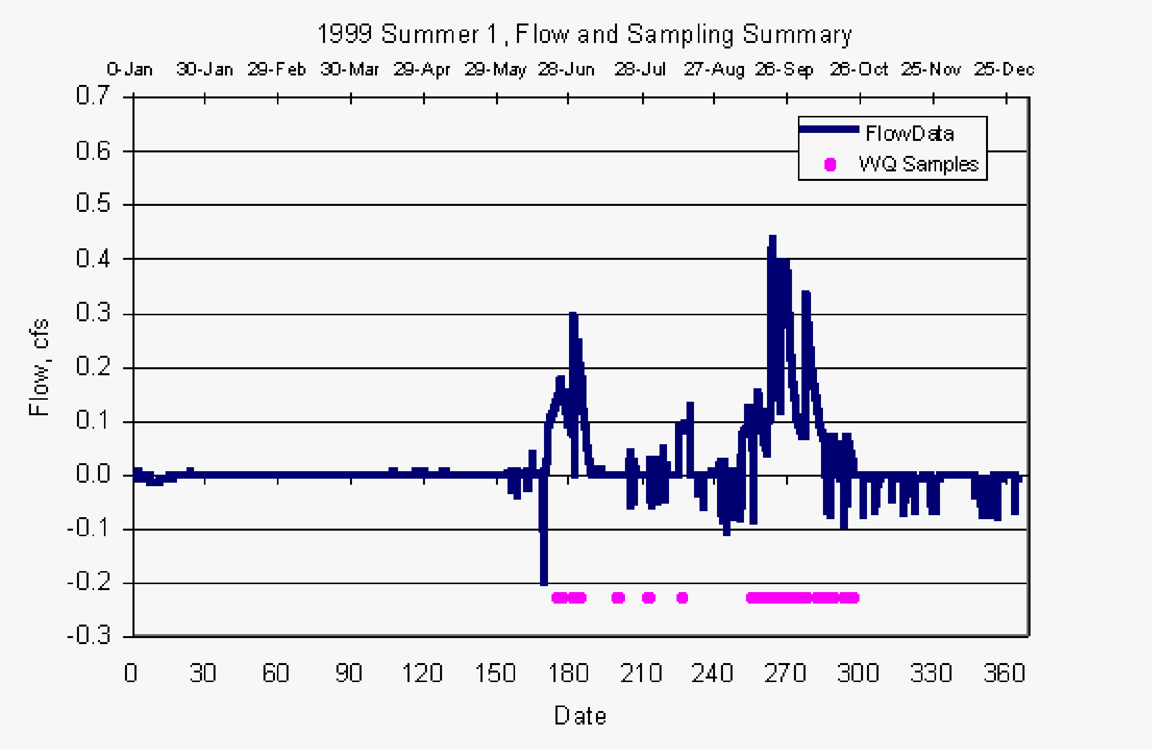


Figure 5.2.9.7. Collection dates and calculated runoff flow values for summer pasture 1 in 1999.

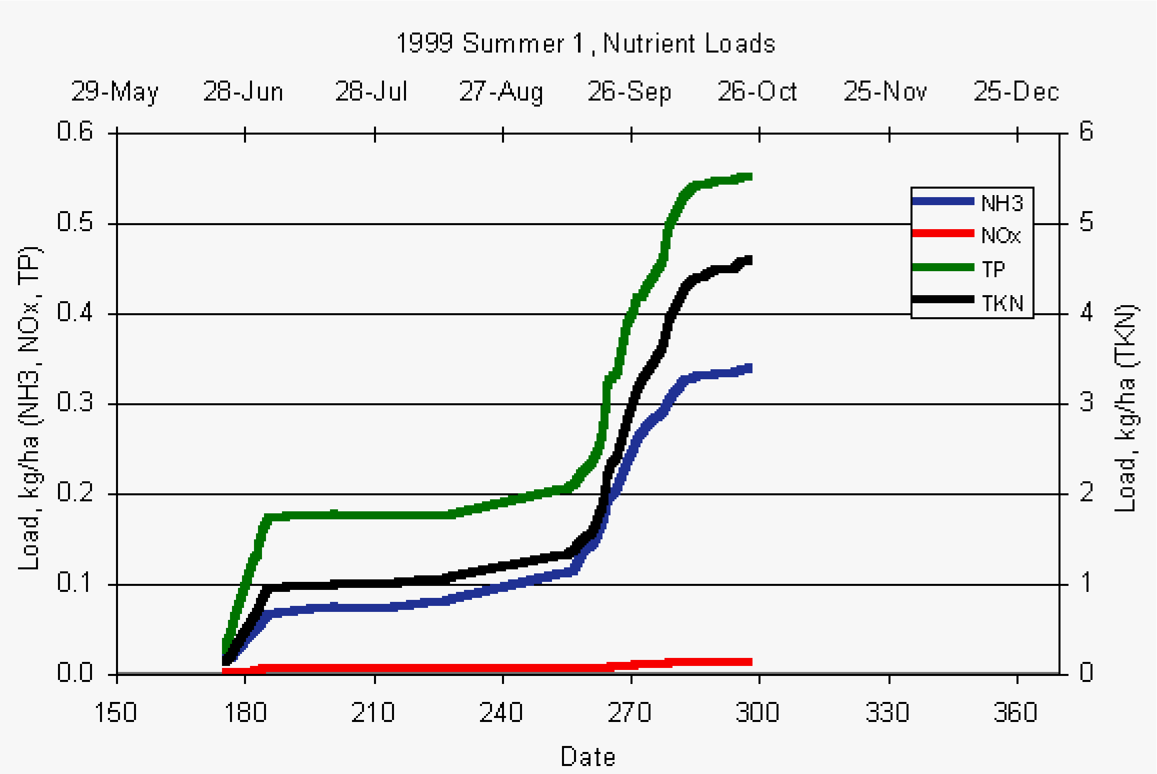


Figure 5.2.9.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 1 in 1999.

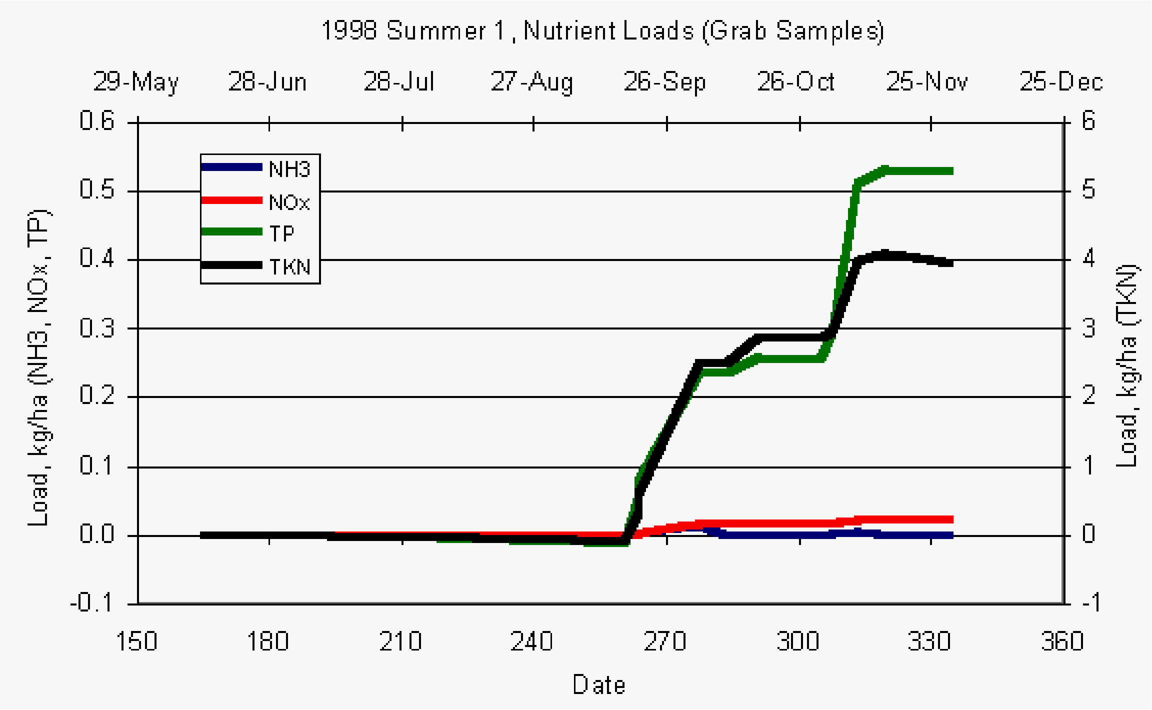


Figure 5.2.9.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 1 in 1998.

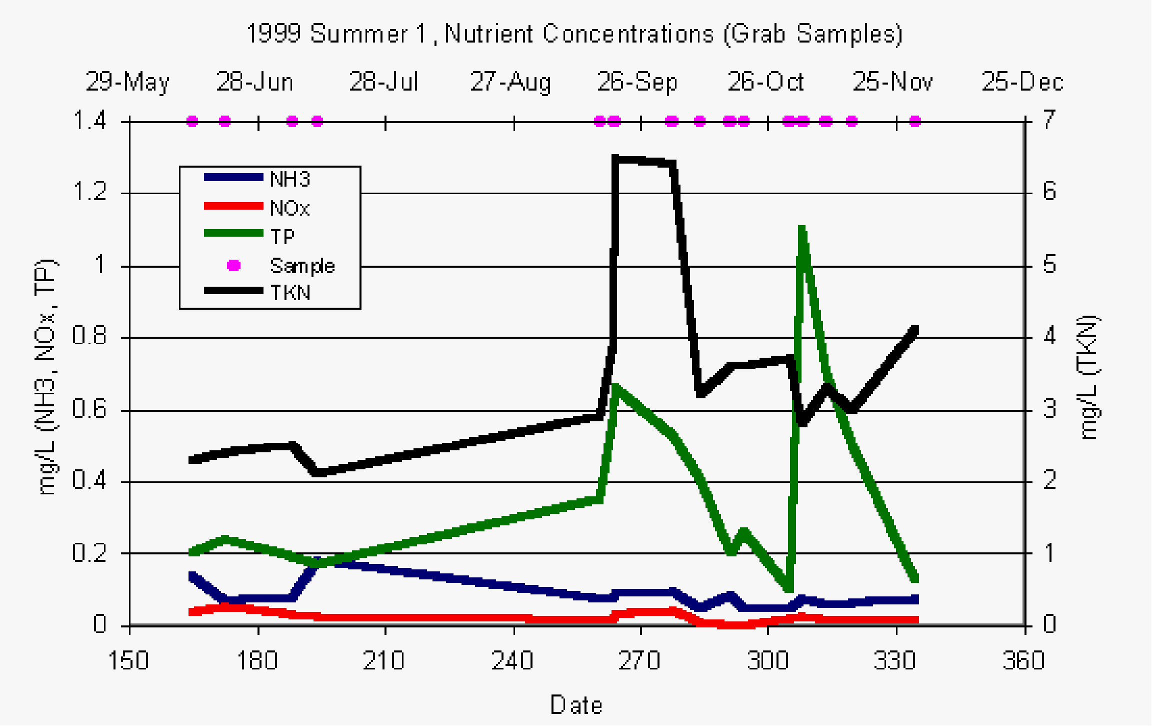


Figure 5.2.9.11. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 1 in 1998.

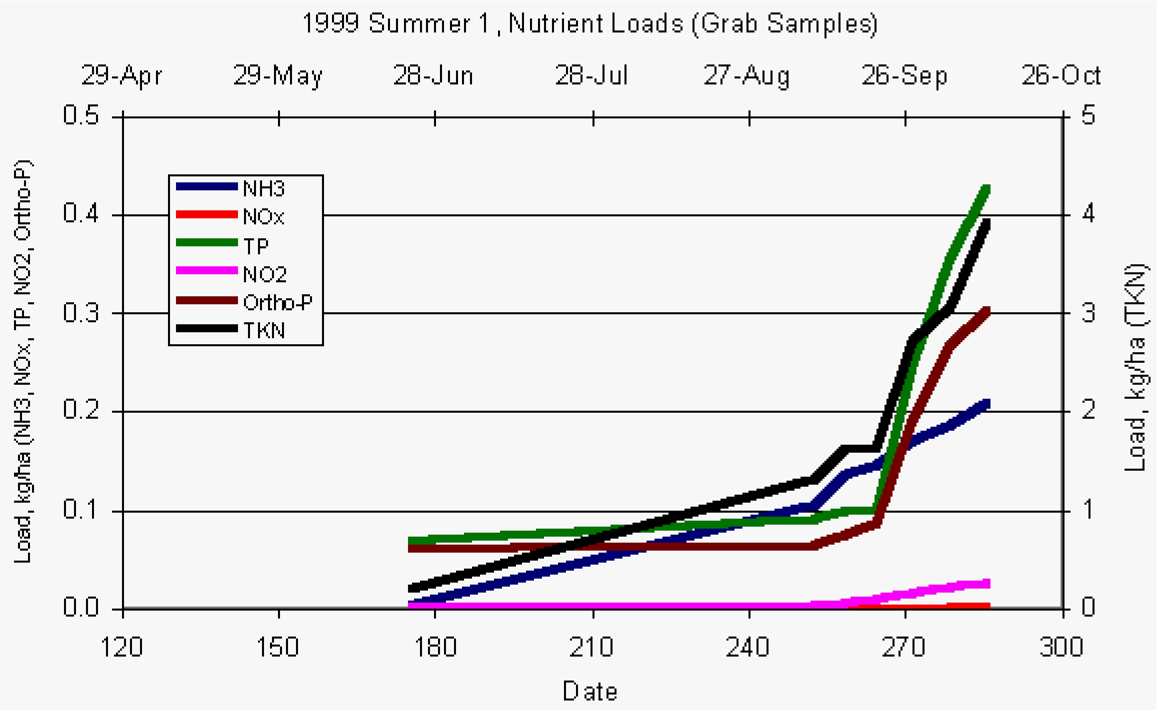


Figure 5.3.9.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 1 in 1999.

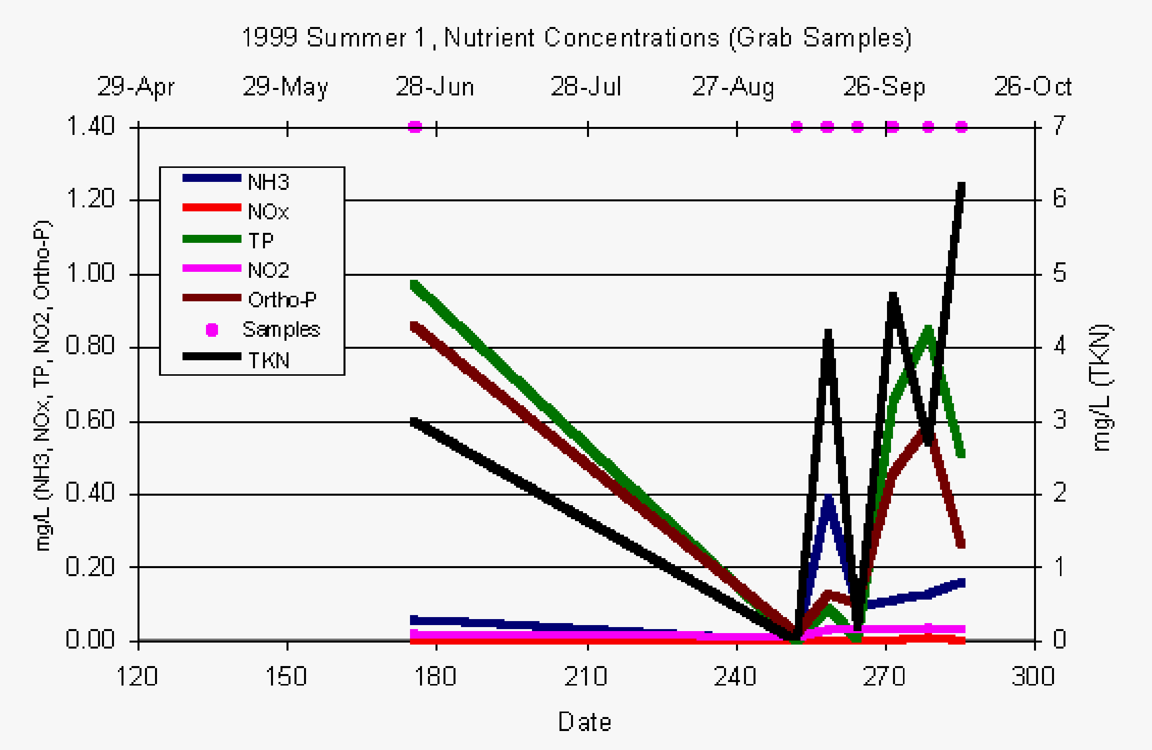


Figure 5.3.9.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 1 in 1999.

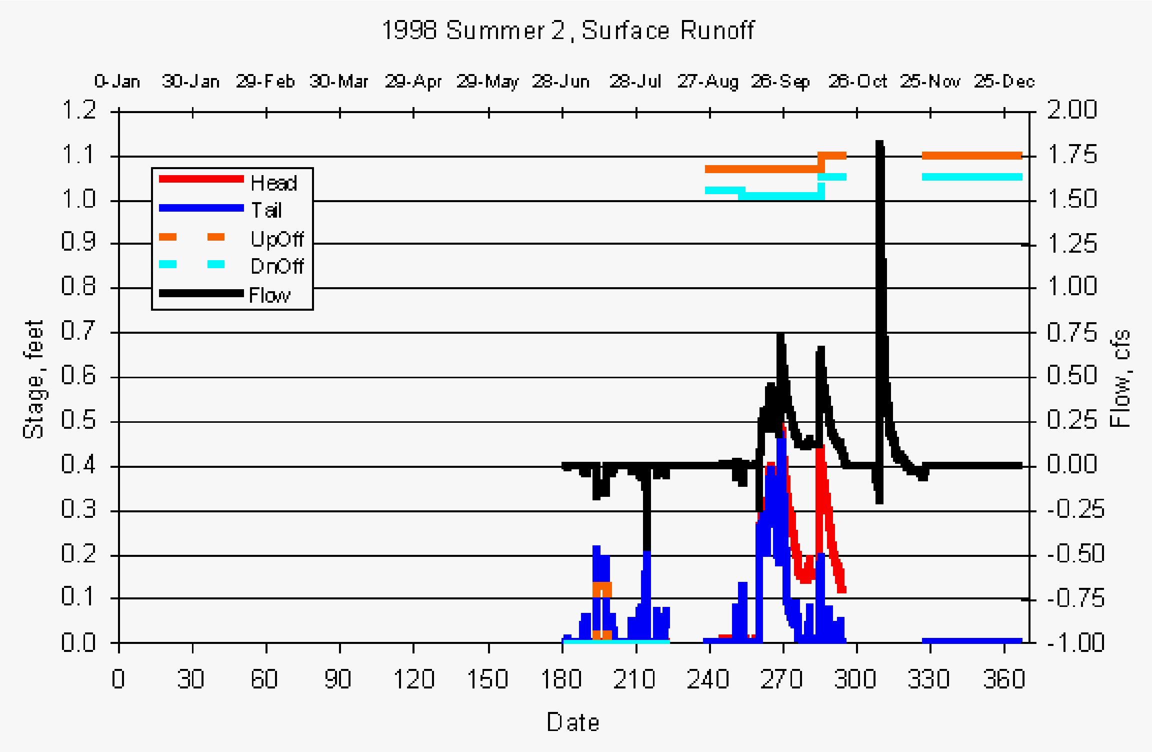


Figure 5.2.10.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 2 in 1998.

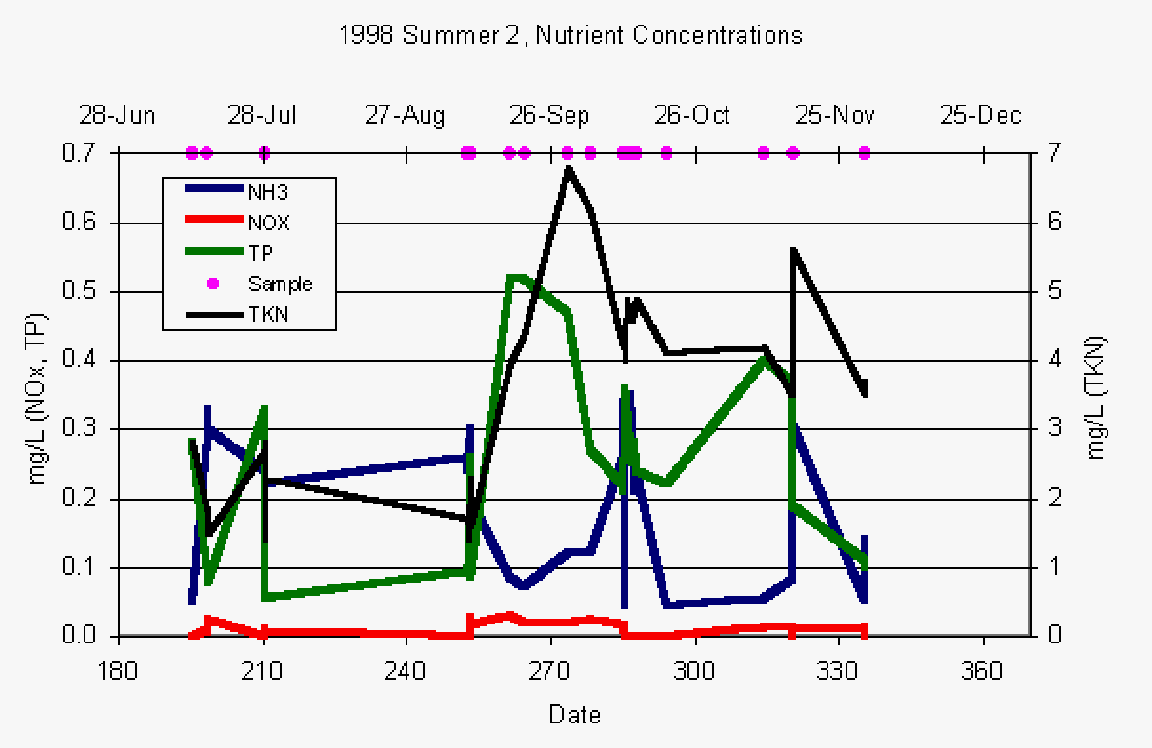


Figure 5.2.10.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 2 in 1998.

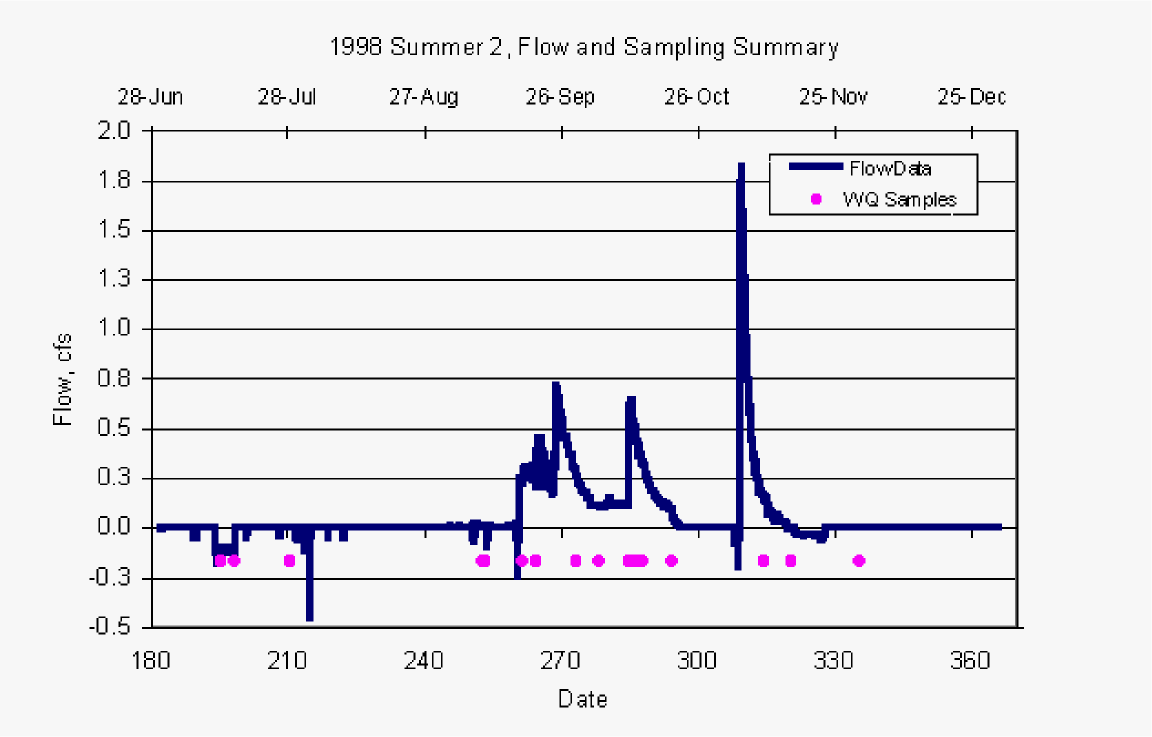


Figure 5.2.10.3. Collection dates and calculated runoff flow values for summer pasture 2 in 1998.

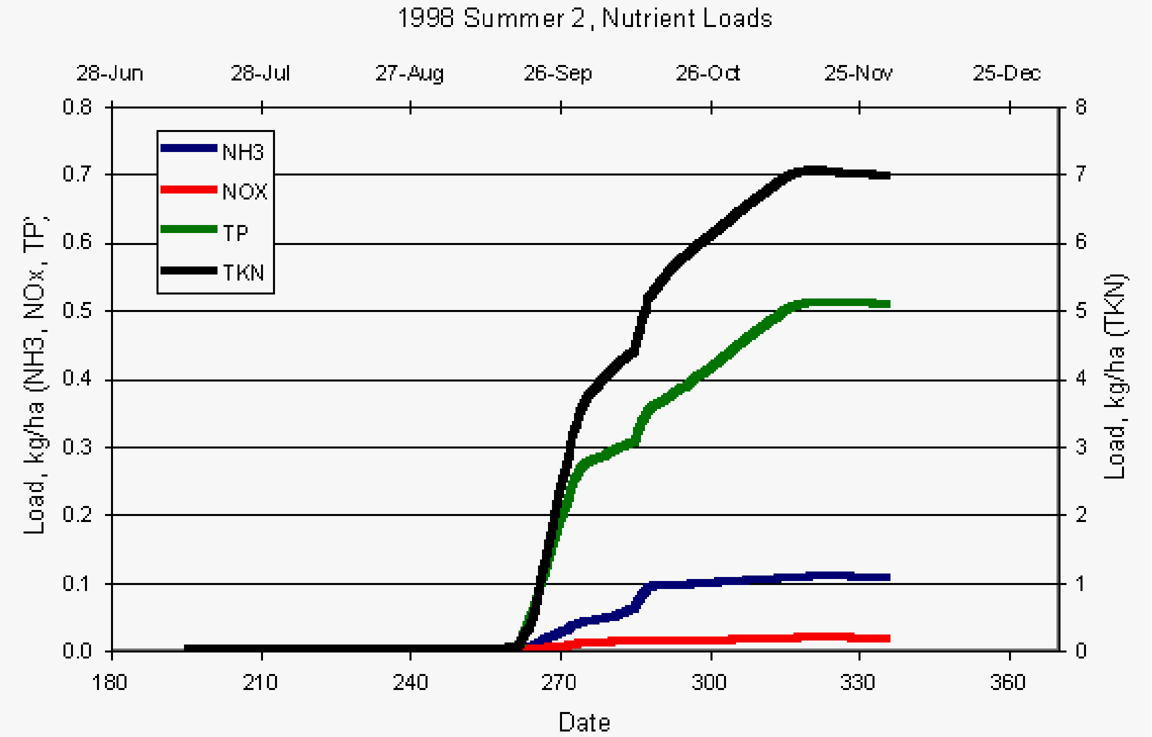


Figure 5.2.10.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 2 in 1998.

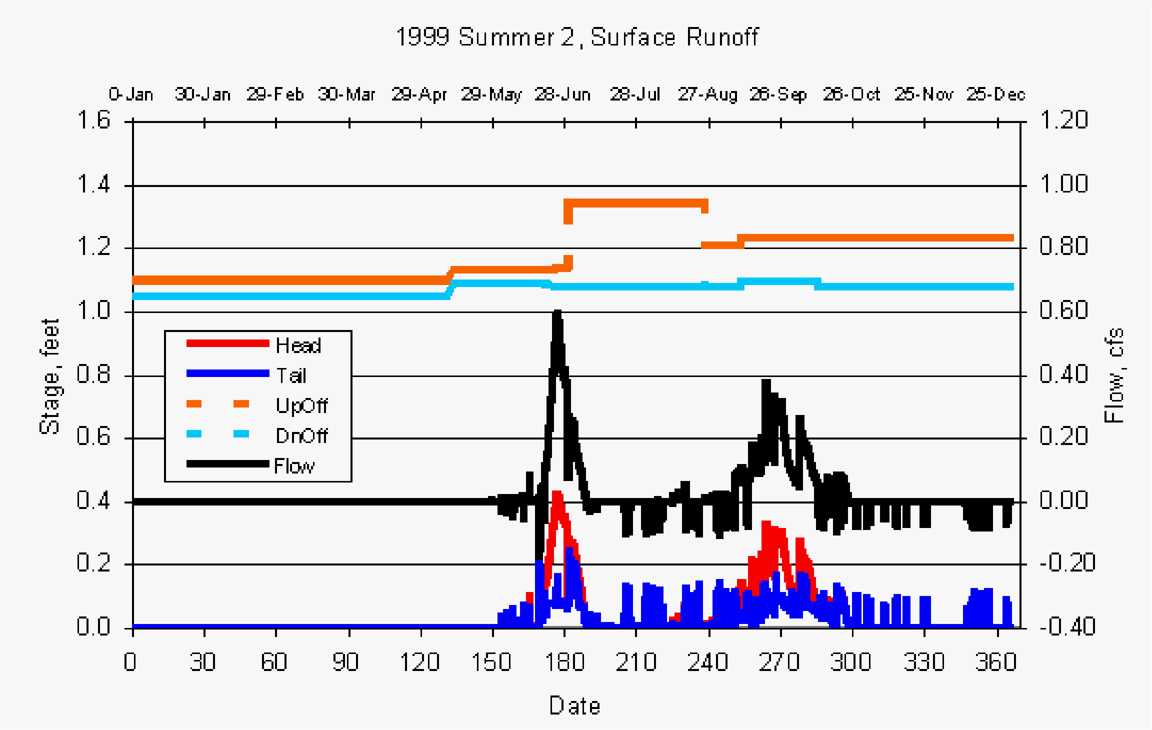


Figure 5.2.10.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 2 in 1999.

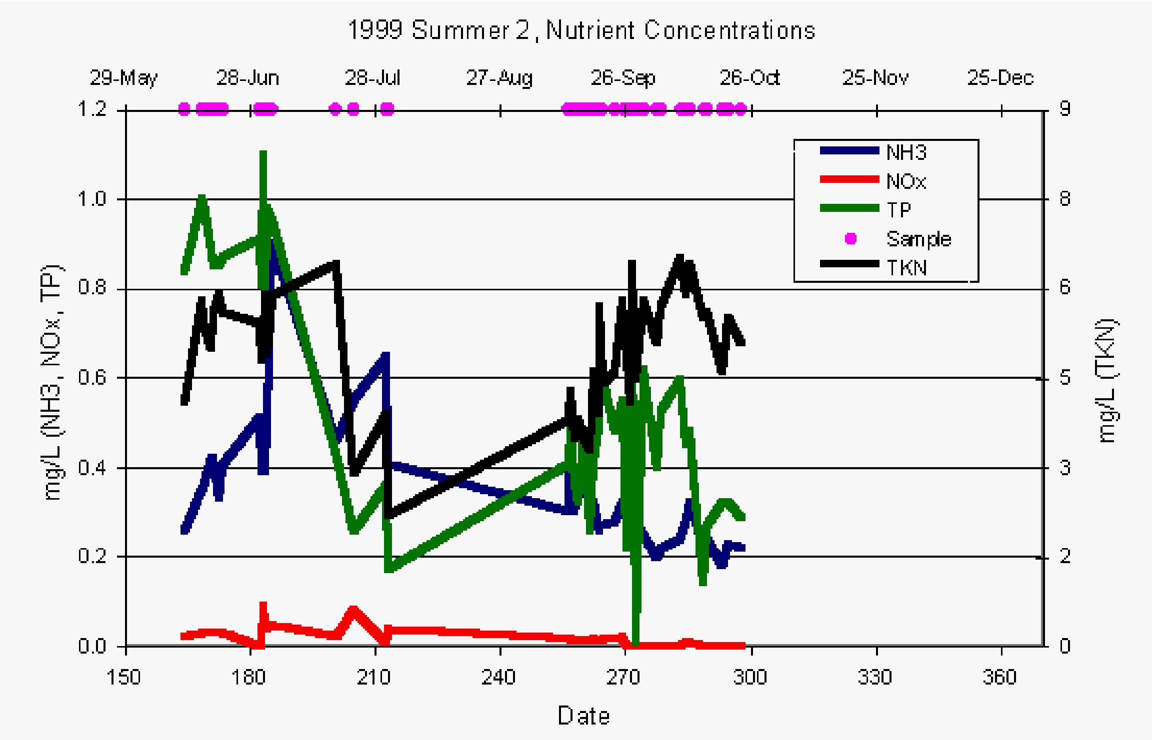


Figure 5.2.10.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 2 in 1999.

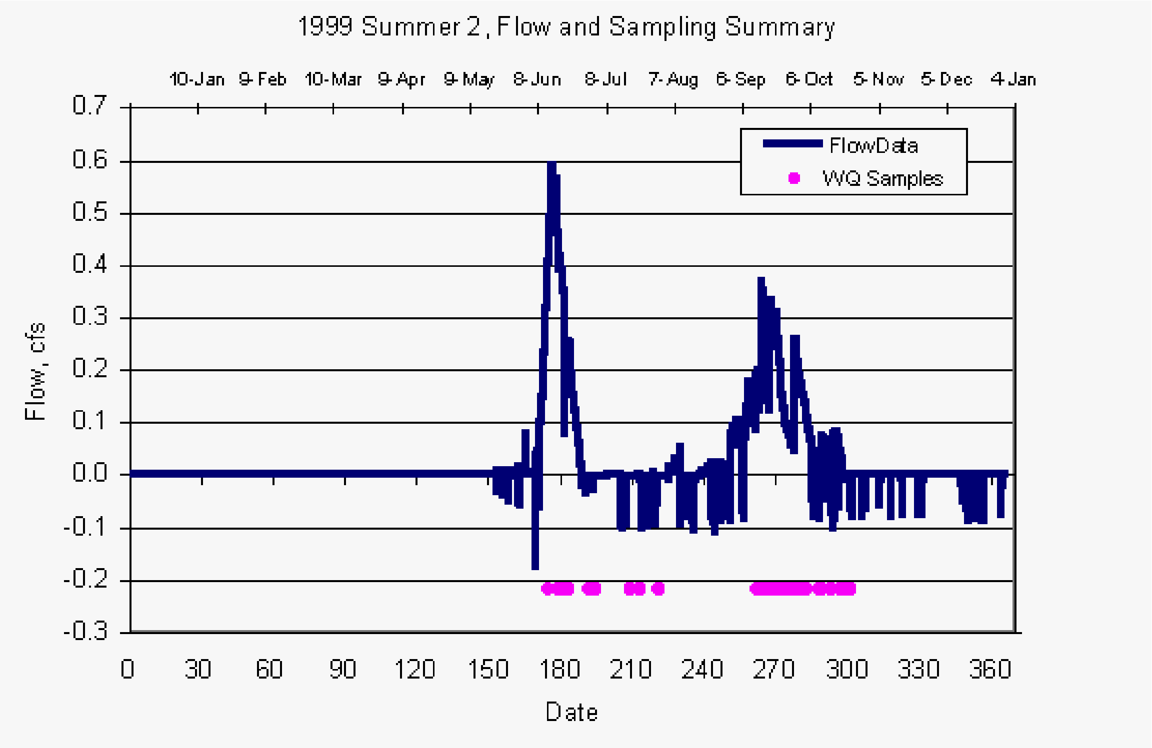


Figure 5.2.10.7. Collection dates and calculated runoff flow values for summer pasture 2 in 1999.

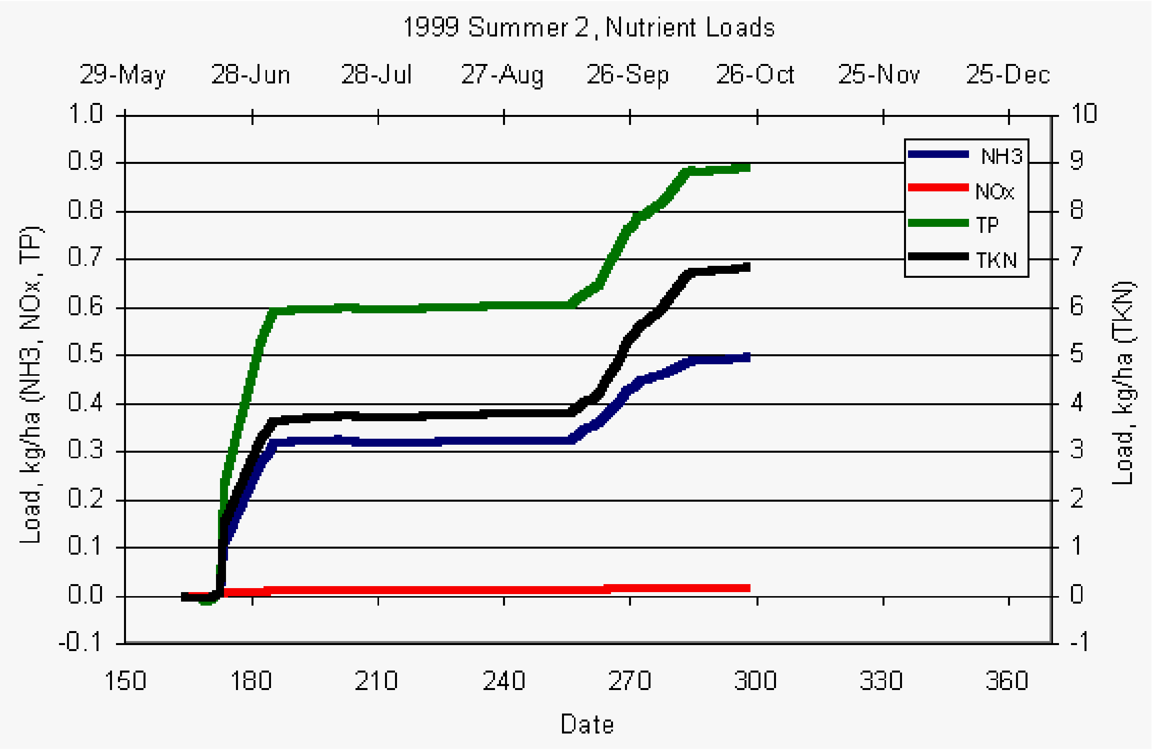


Figure 5.2.10.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 2 in 1999.

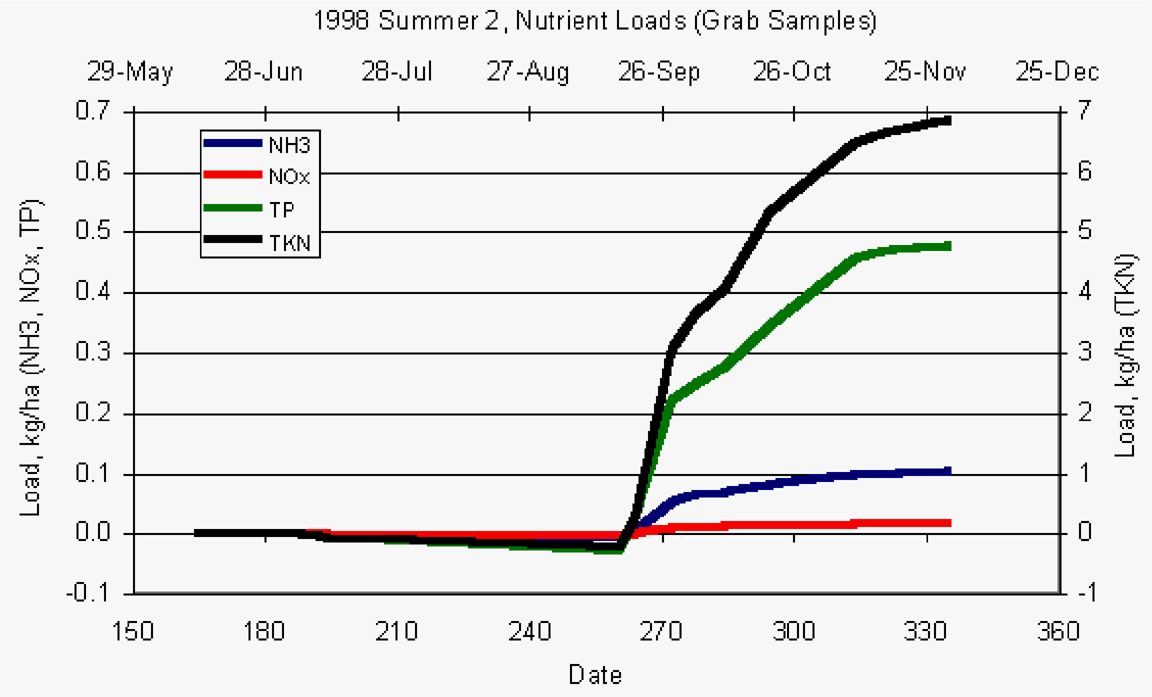


Figure 5.2.10.9. . Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 2 in 1998.

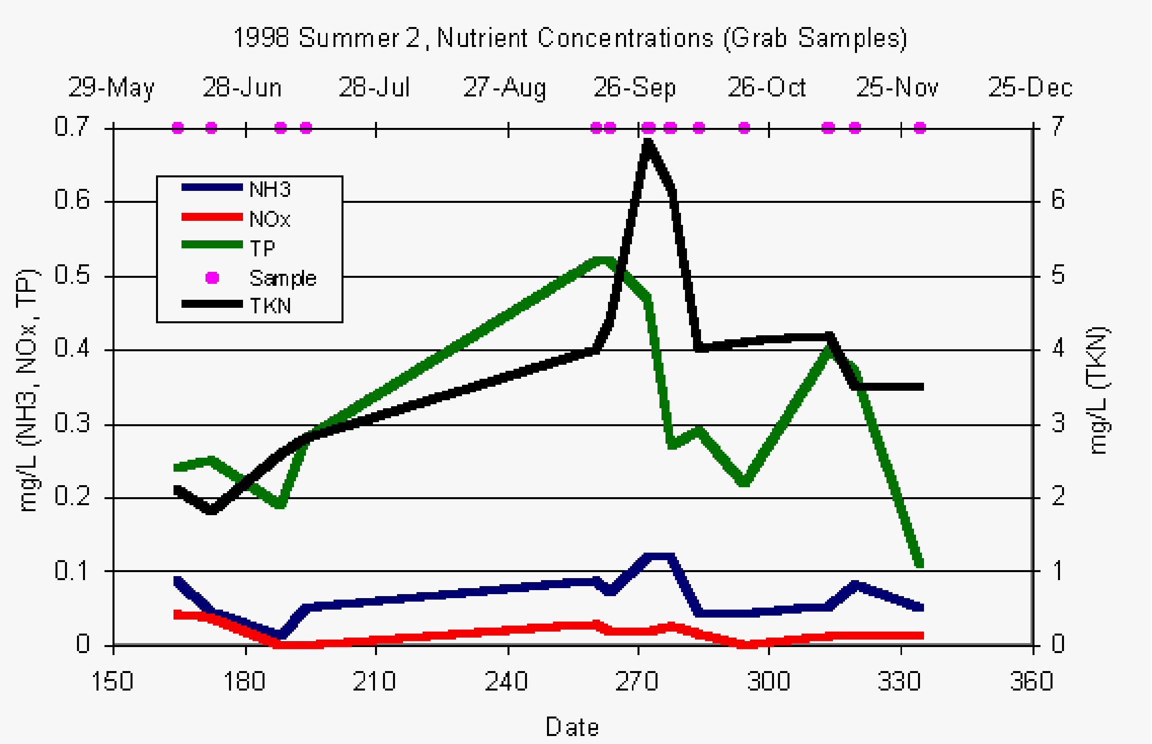


Figure 5.2.10.10. . Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 2 in 1998.

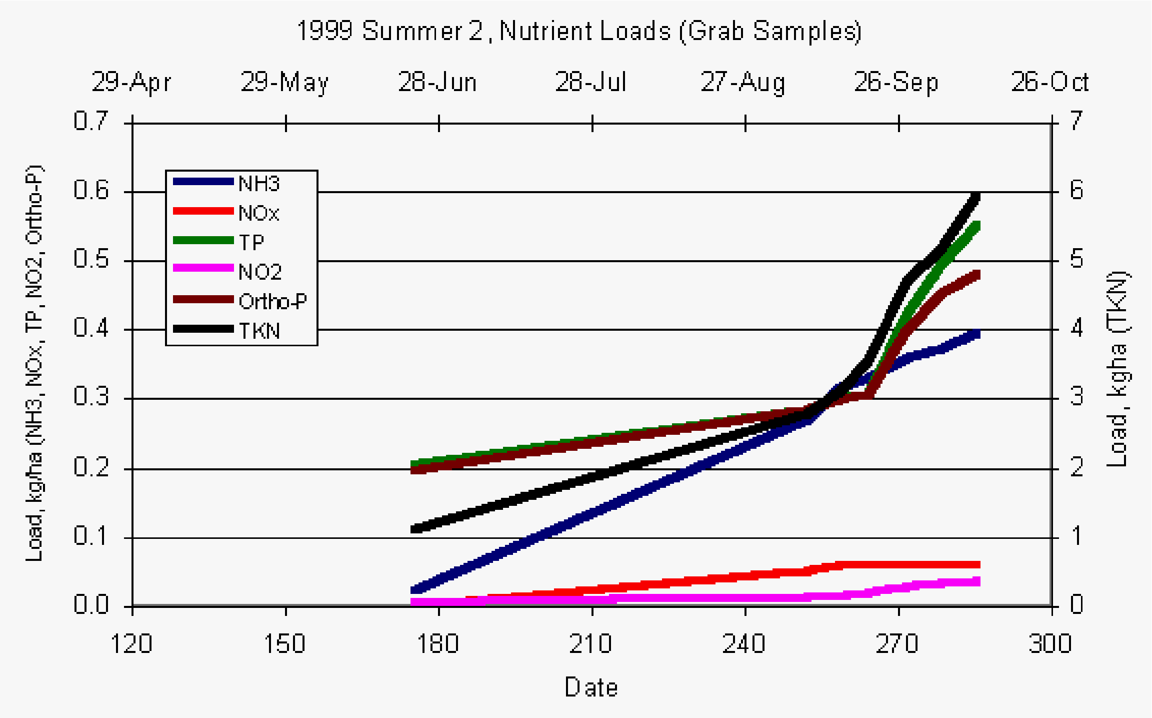


Figure 5.2.10.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 2 in 1999.

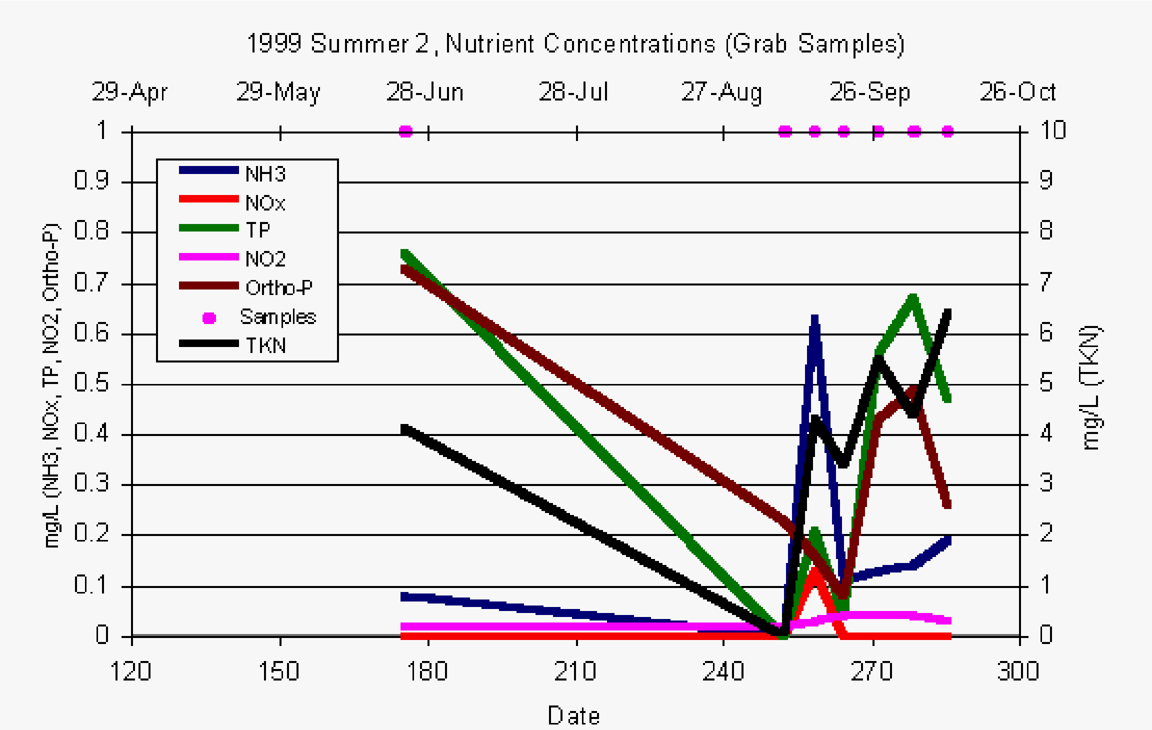


Figure 5.2.10.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 2 in 1999.

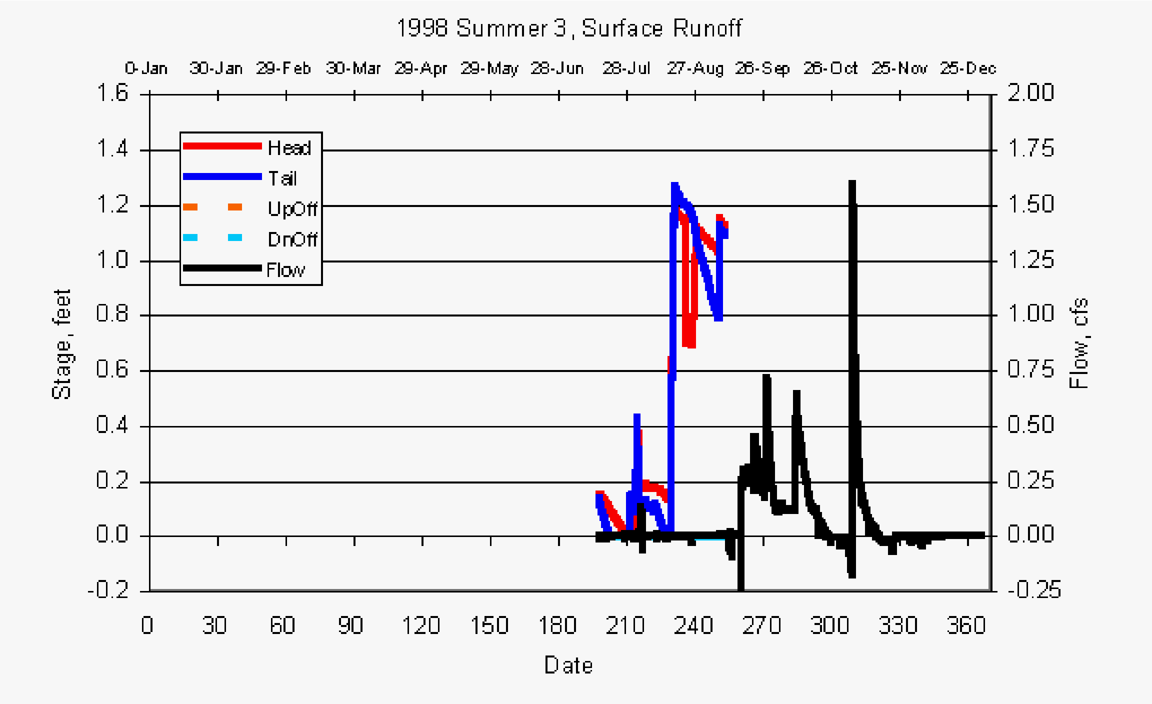


Figure 5.2.11.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 3 in 1998.

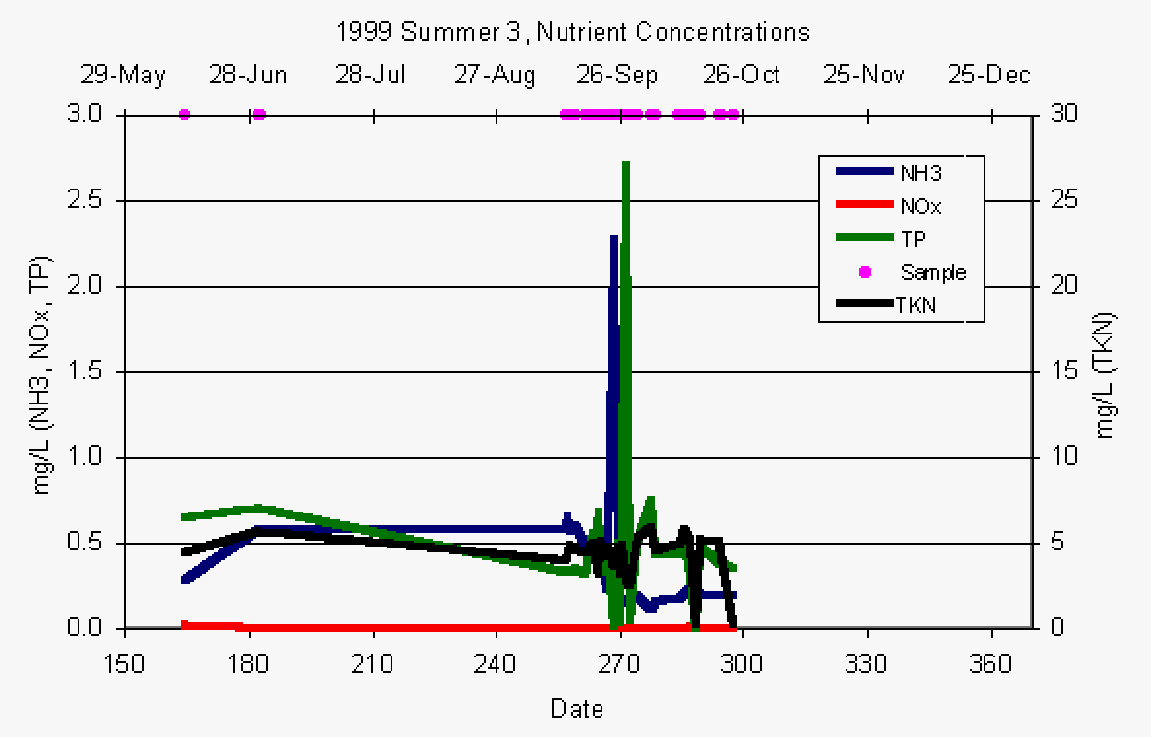


Figure 5.2.11.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 3 in 1998.

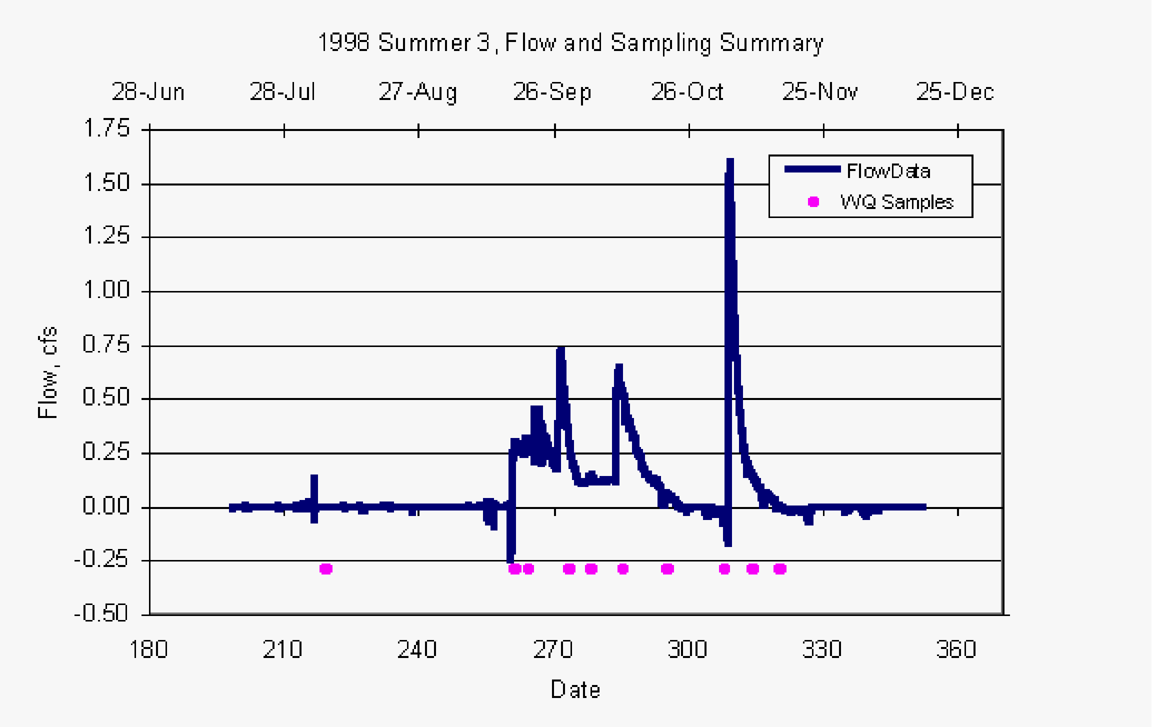


Figure 5.2.11.3. Collection dates and calculated runoff flow values for summer pasture 3 in 1998.

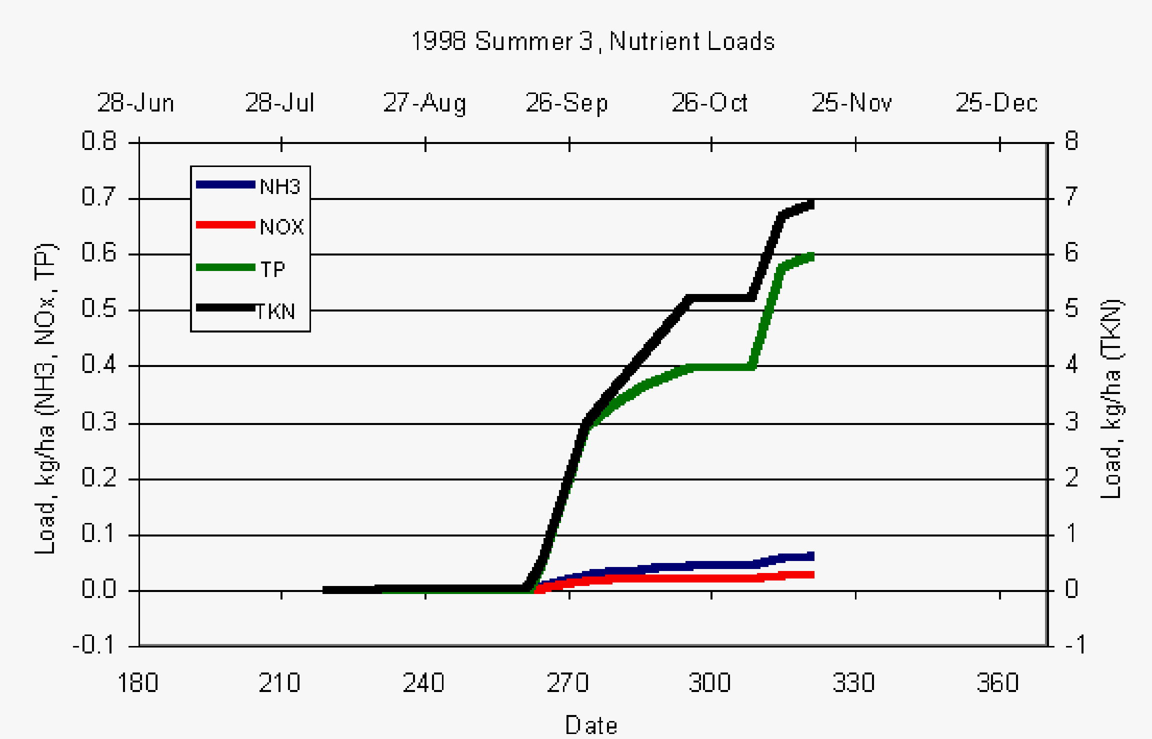


Figure 5.2.11.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 3 in 1998.

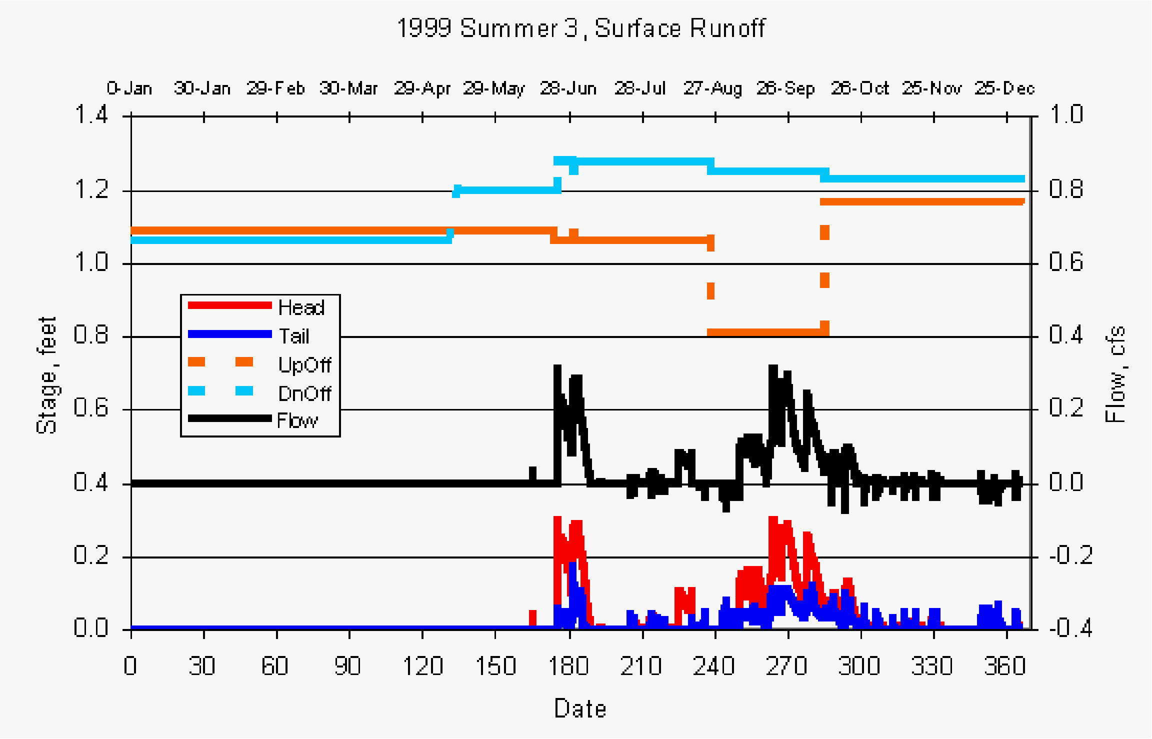


Figure 5.2.11.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 3 in 1999.

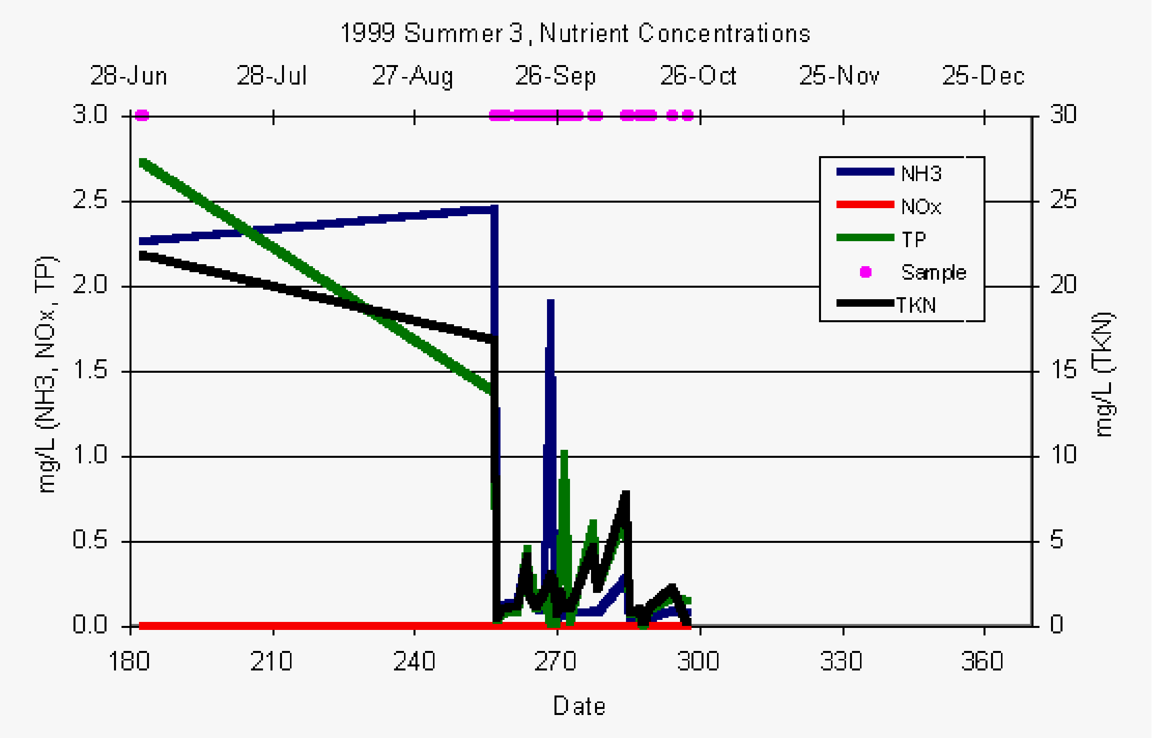


Figure 5.2.11.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 3 in 1999.

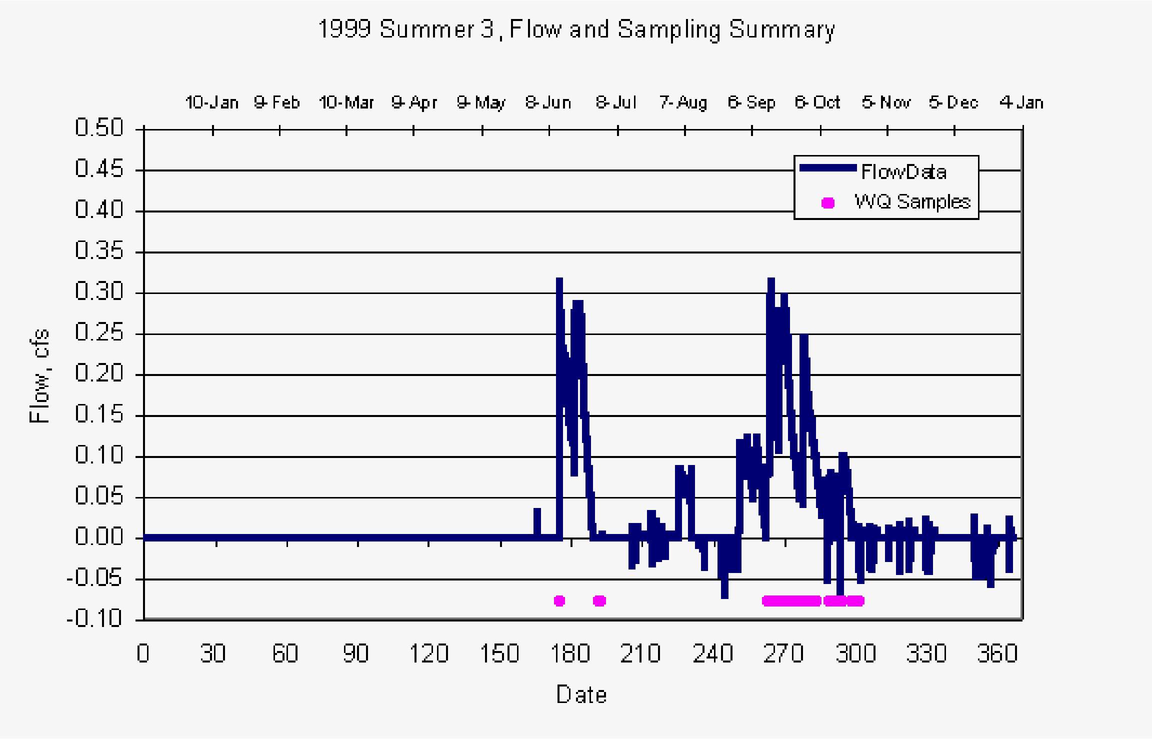


Figure 5.2.11.7. Collection dates and calculated runoff flow values for summer pasture 3 in 1999.

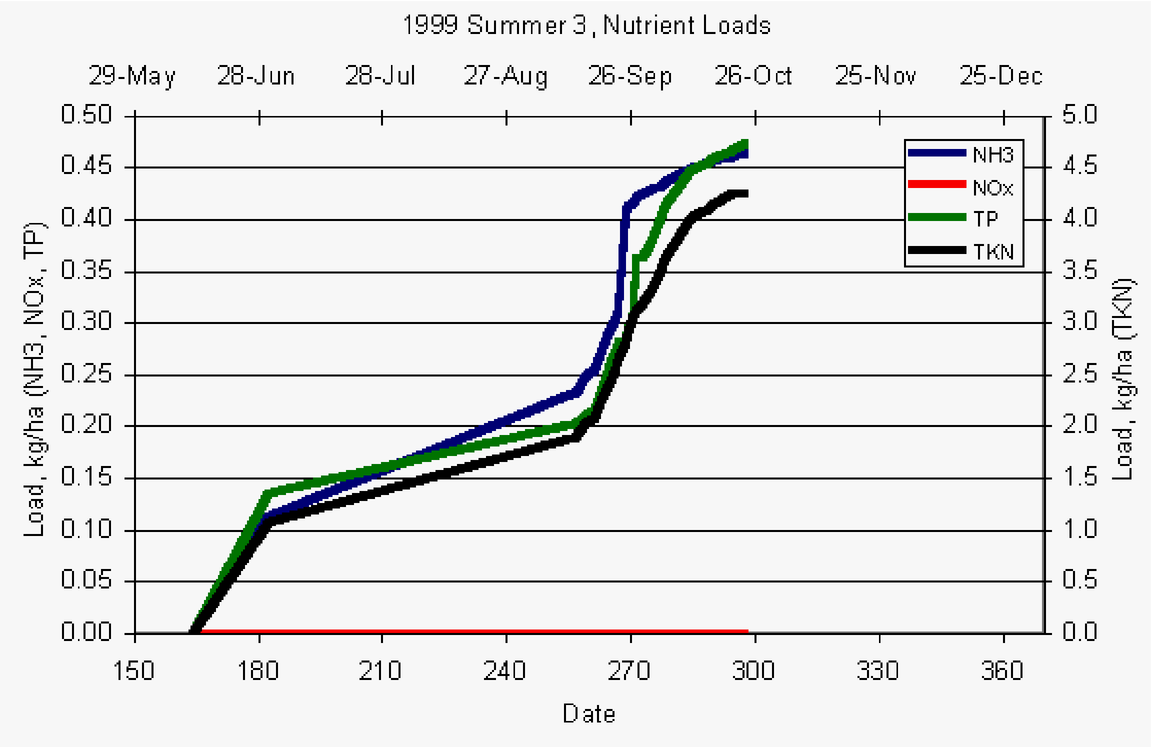


Figure 5.2.11.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 3 in 1999.

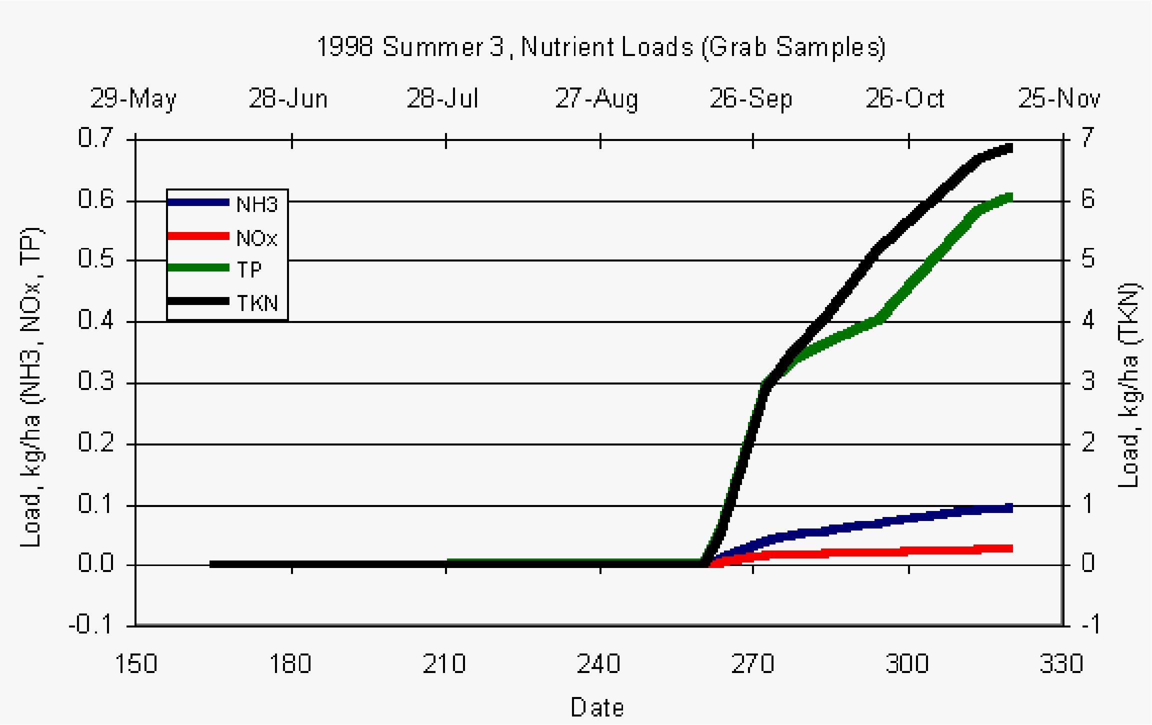


Figure 5.2.11.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 3 in 1998.

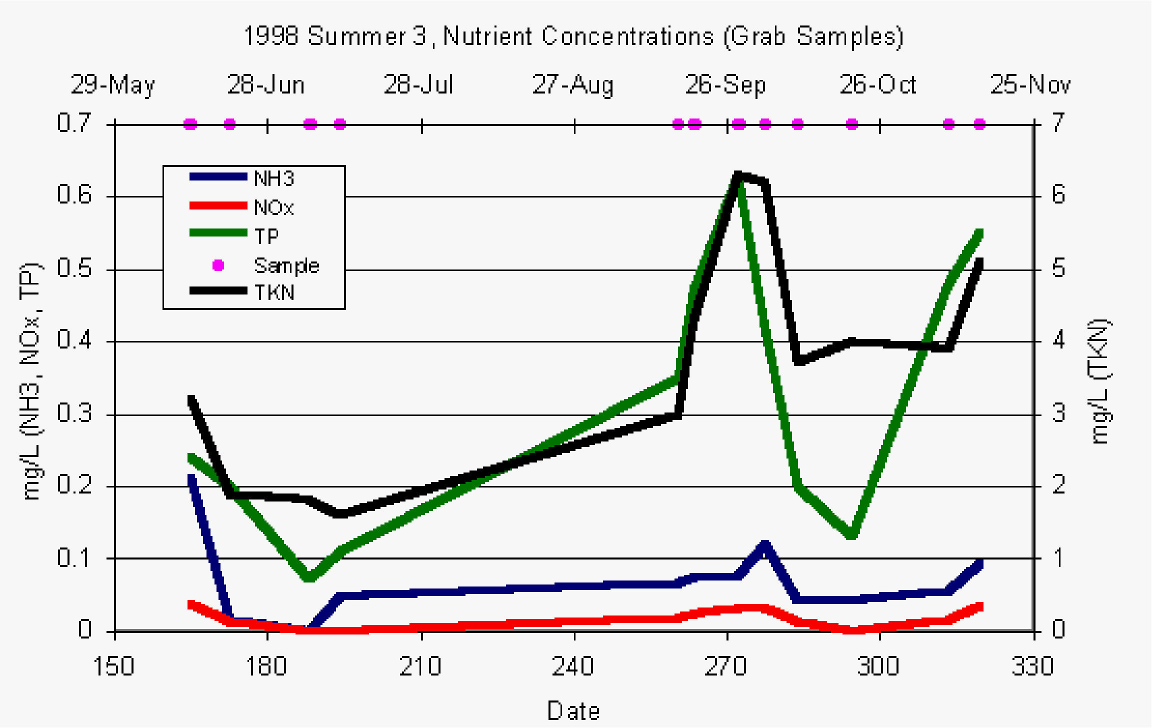


Figure 5.2.11.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 3 in 1998.

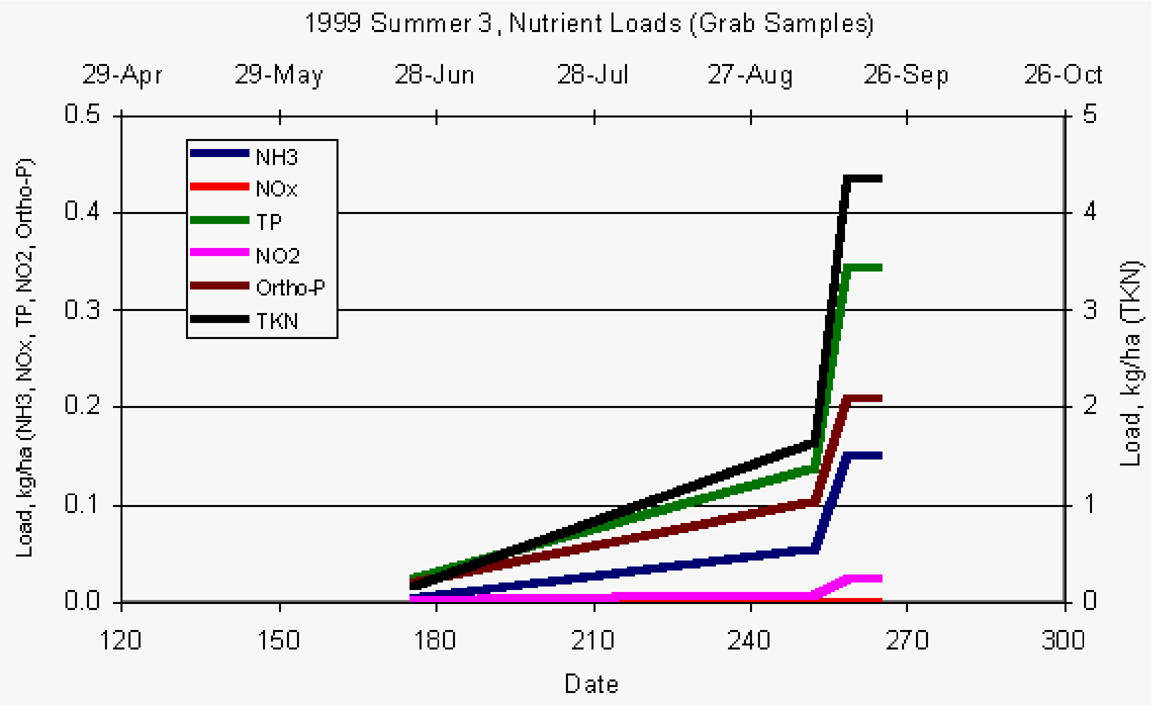


Figure 5.2.11.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 3 in 1999.

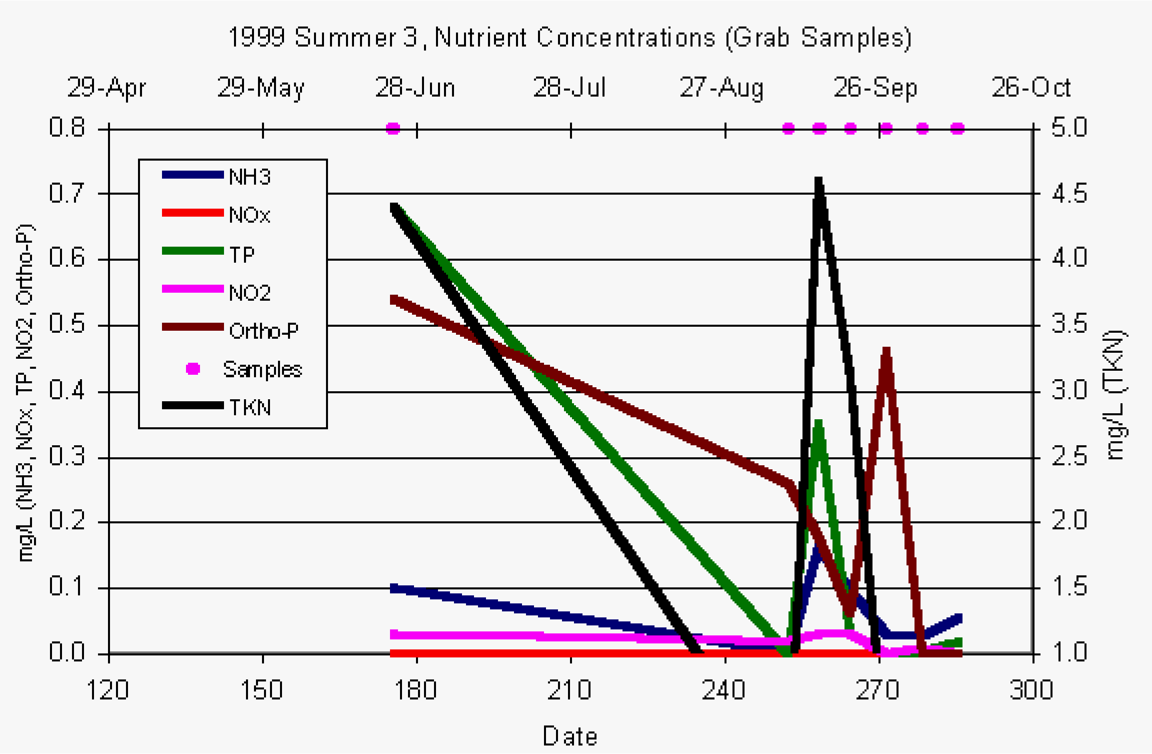


Figure 5.2.11.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 3 in 1999.

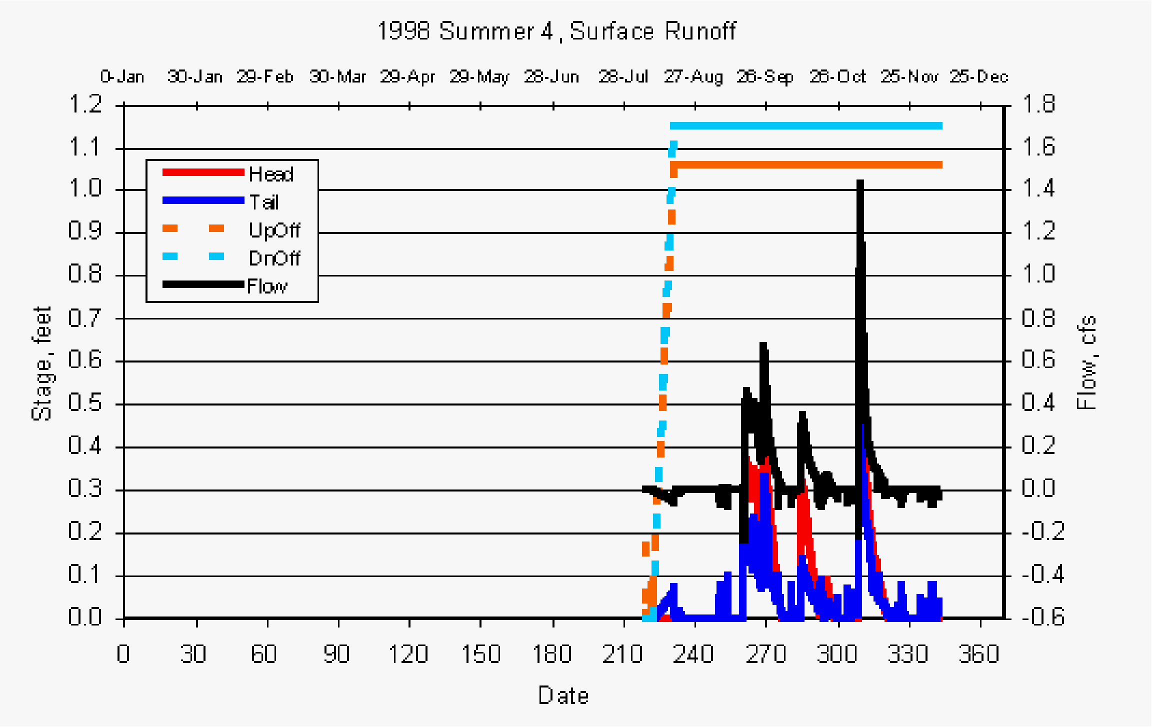


Figure 5.2.12.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 4 in 1998.

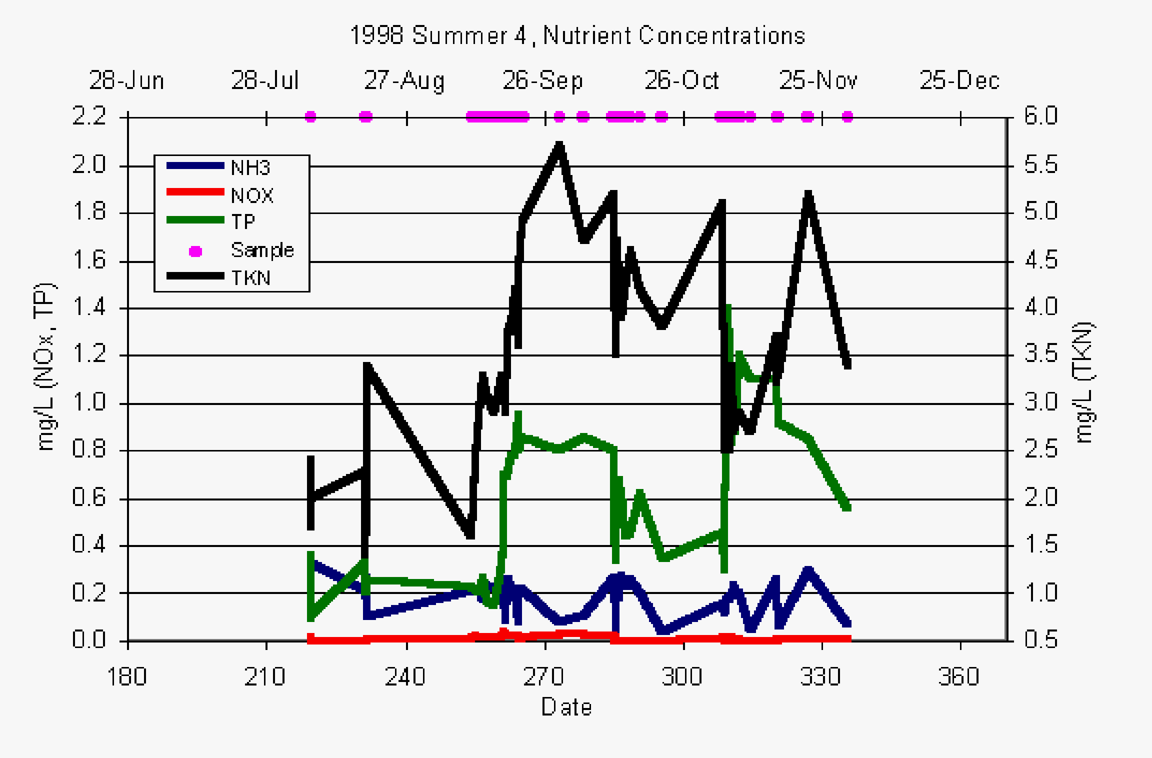


Figure 5.2.12.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 4 in 1998.

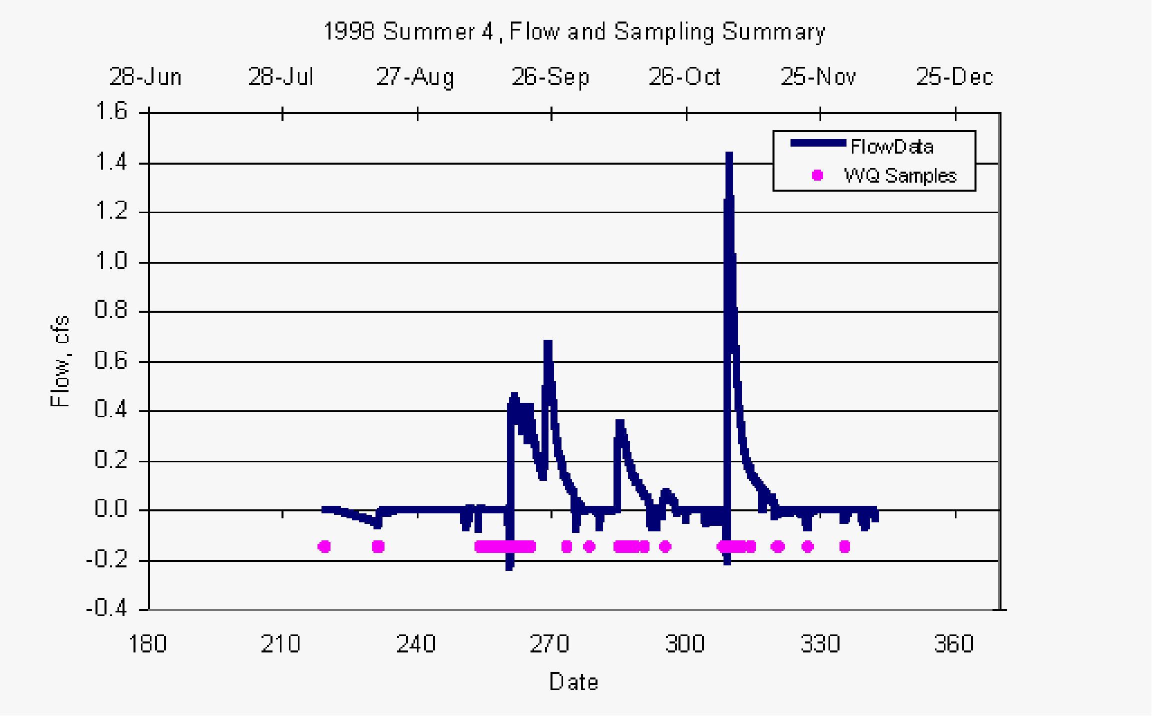


Figure 5.2.12.3. Collection dates and calculated runoff flow values for summer pasture 4 in 1998.

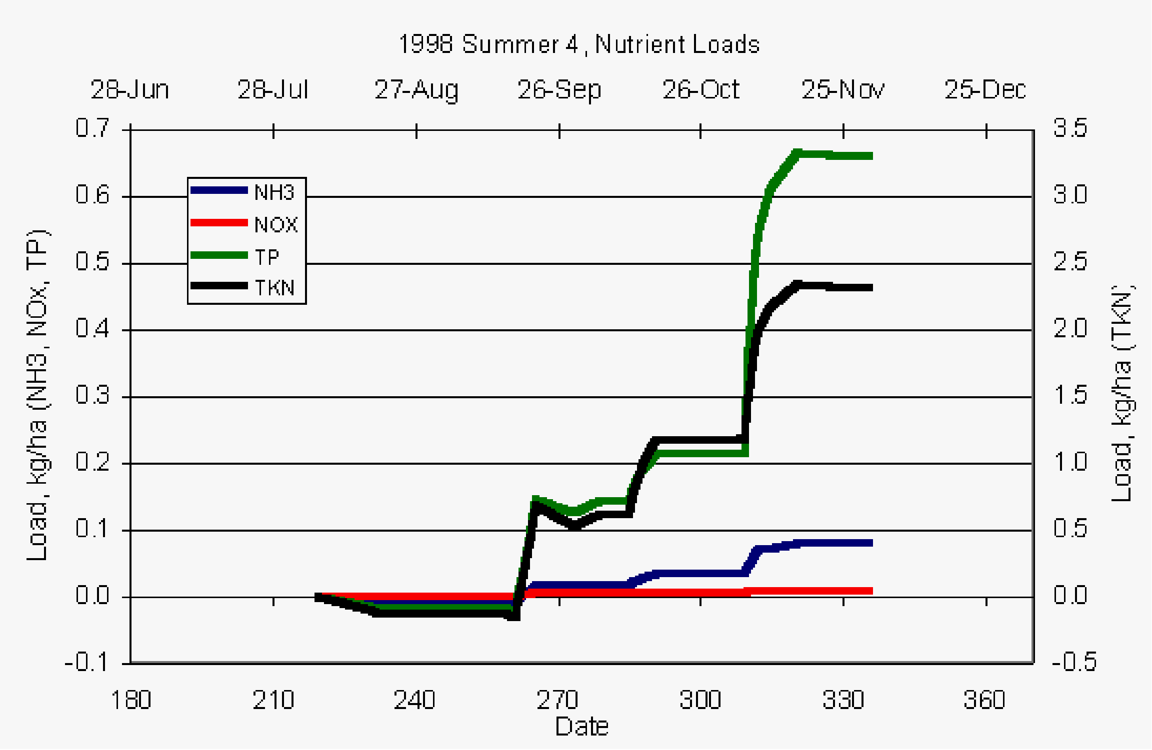


Figure 5.2.12.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 4 in 1998.

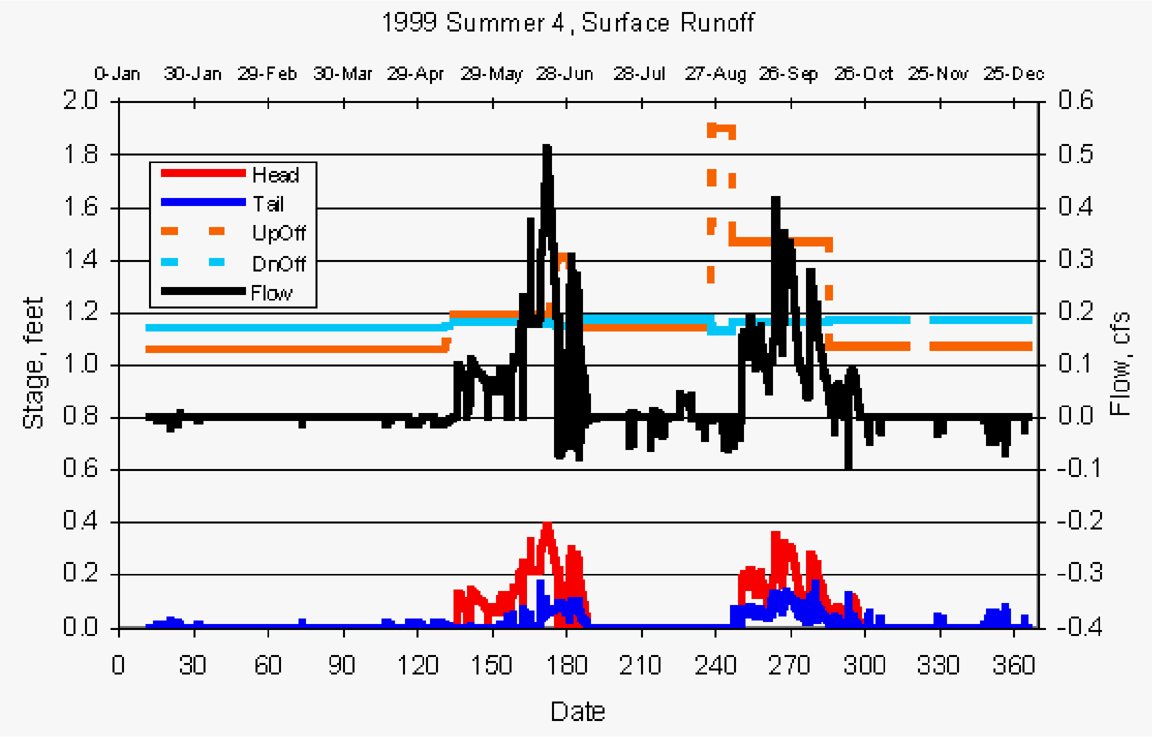


Figure 5.2.12.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 4 in 1999.

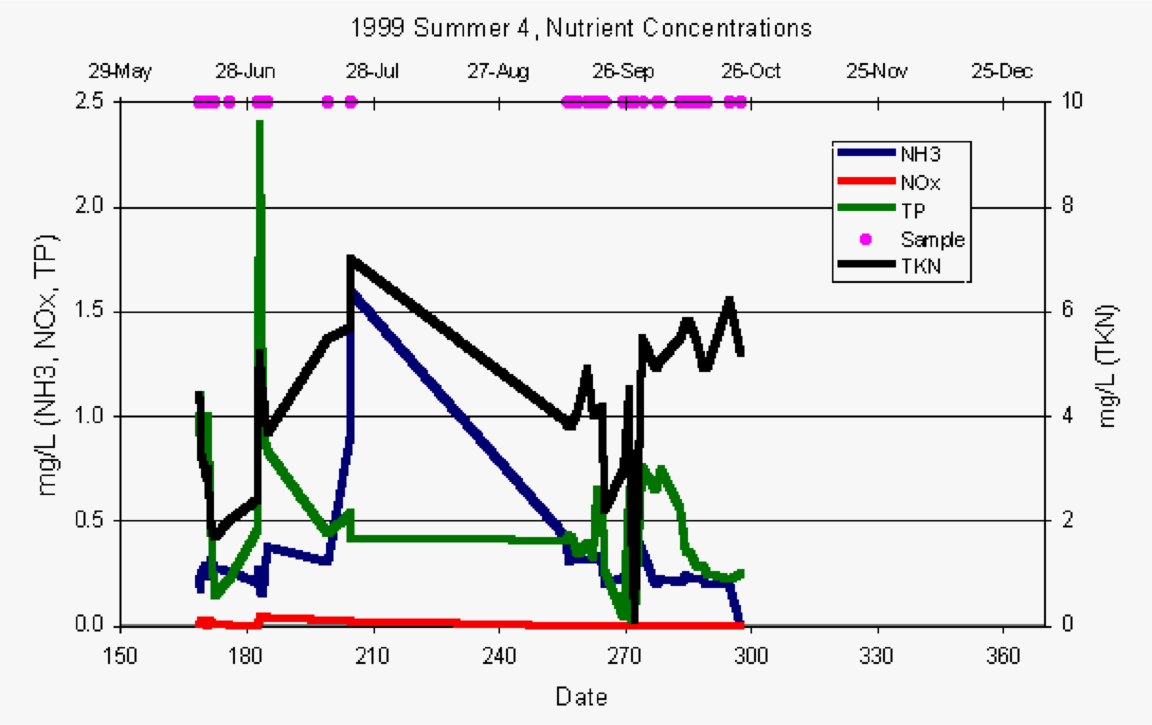


Figure 5.2.12.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 4 in 1999.

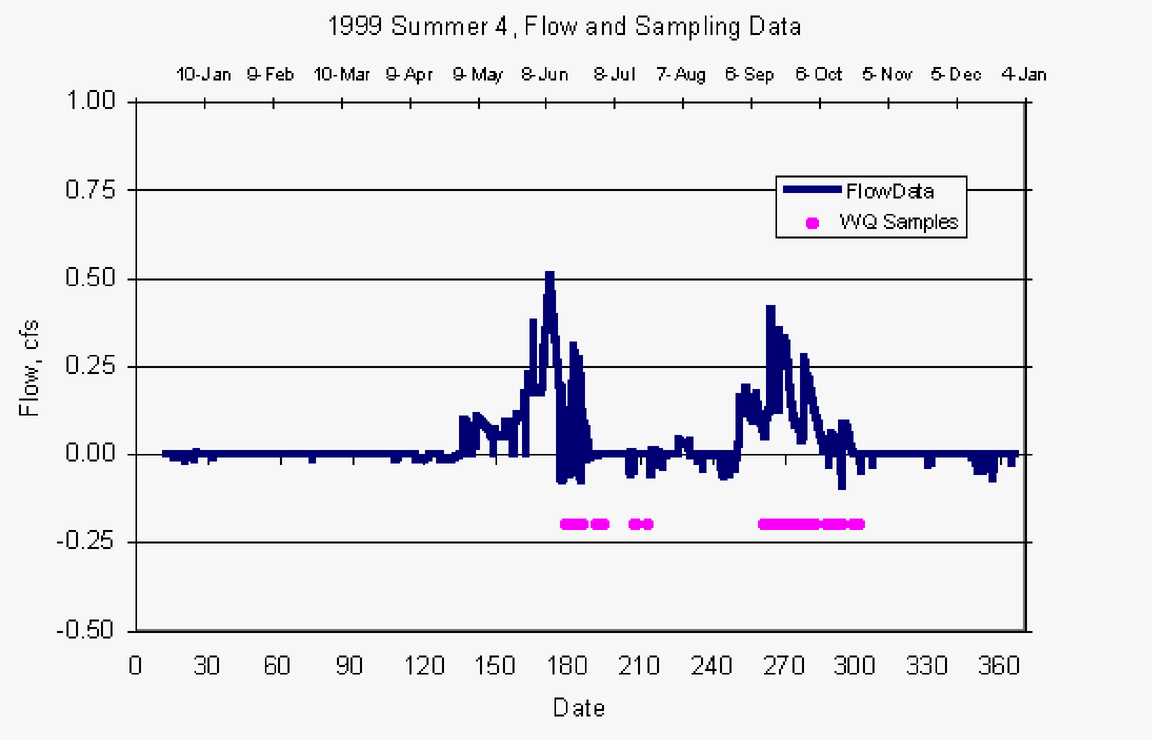


Figure 5.2.12.7. Collection dates and calculated runoff flow values for summer pasture 4 in 1999.

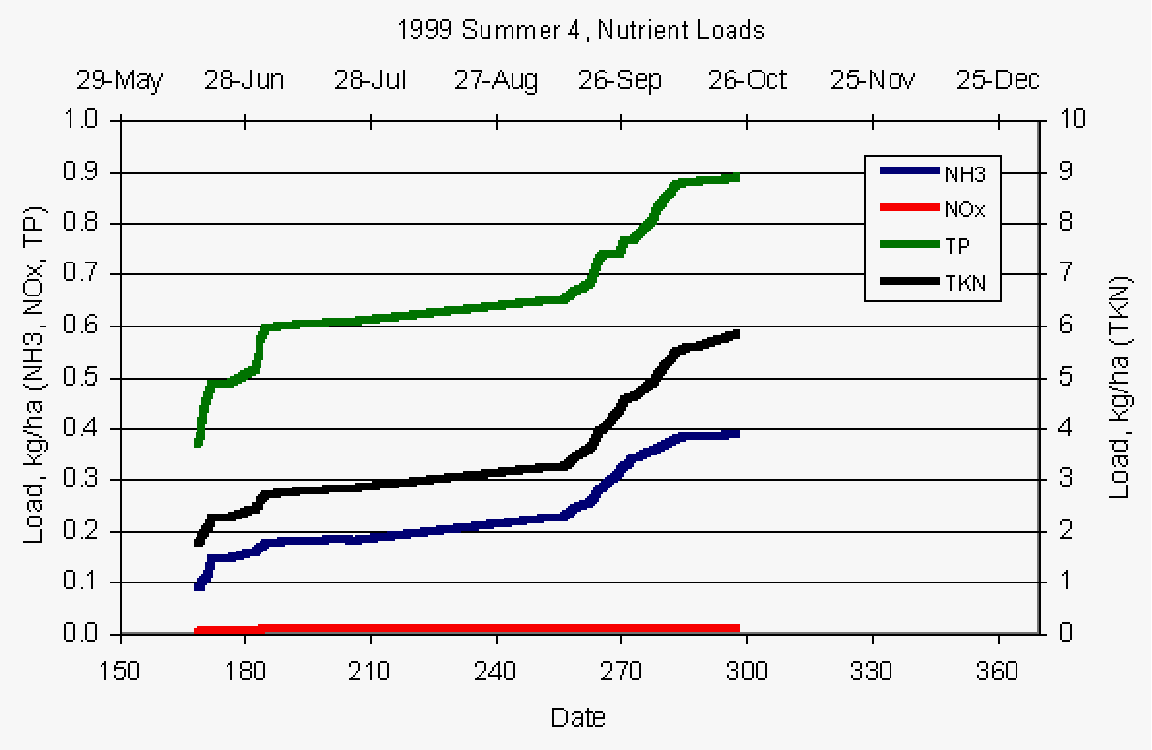


Figure 5.2.12.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 4 in 1999.

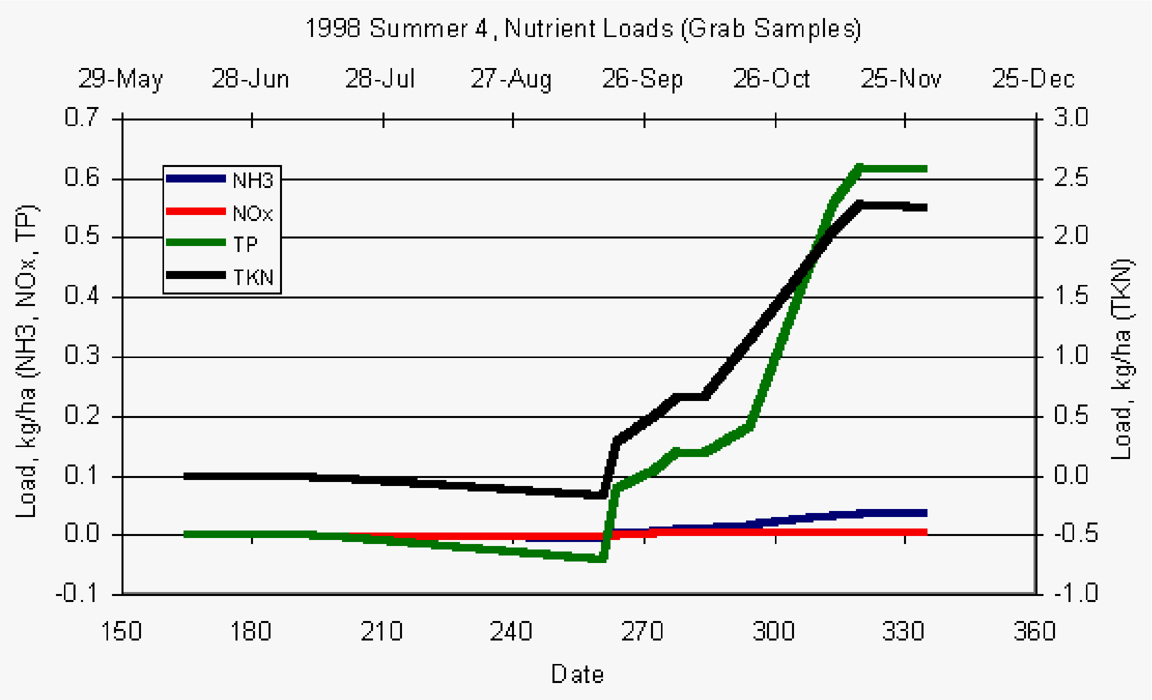


Figure 5.2.12.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 4 in 1998.

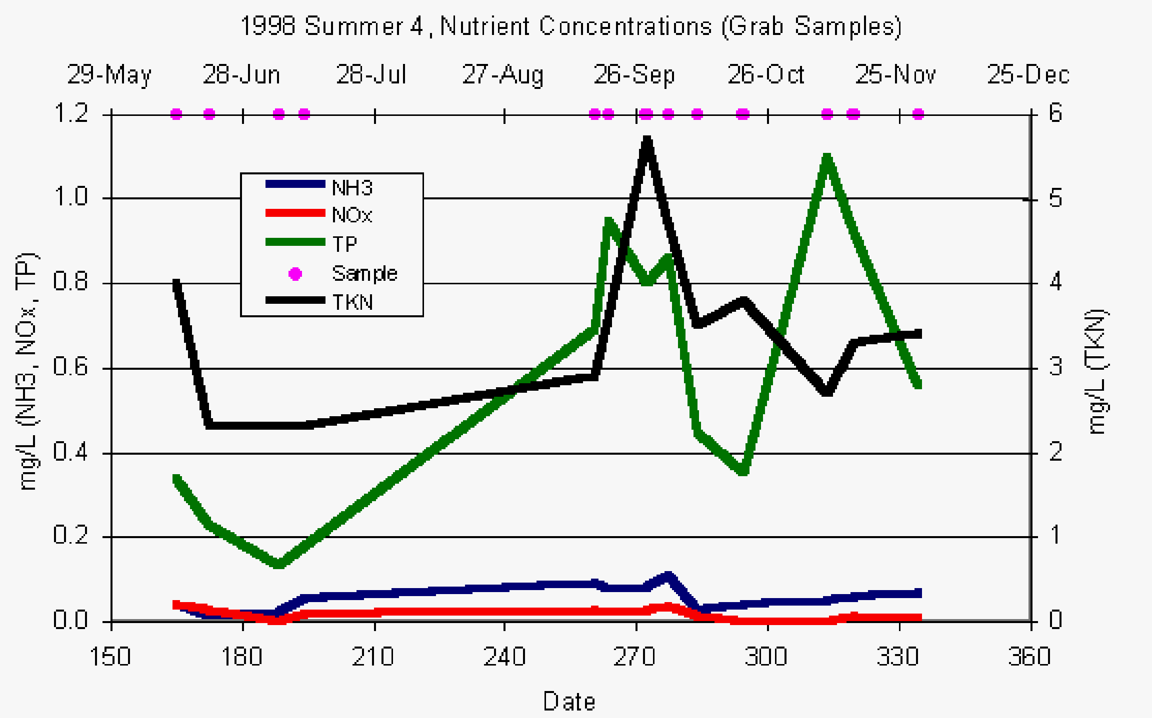


Figure 5.2.12.11. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 4 in 1998.

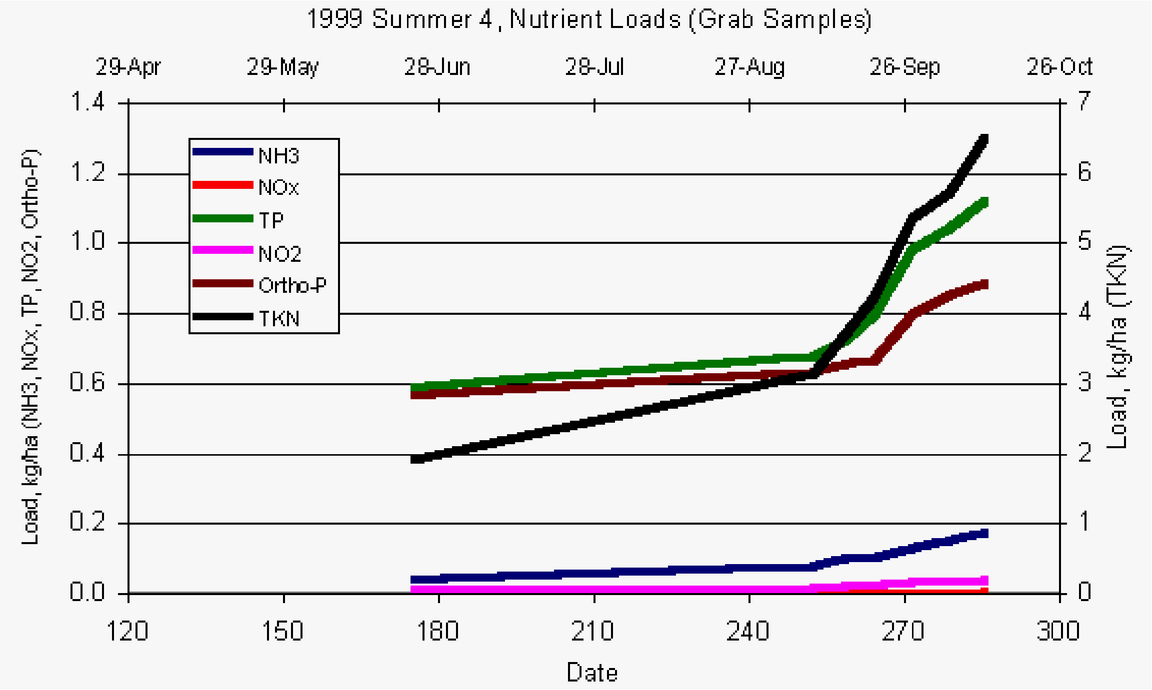


Figure 5.2.12.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 4 in 1999.

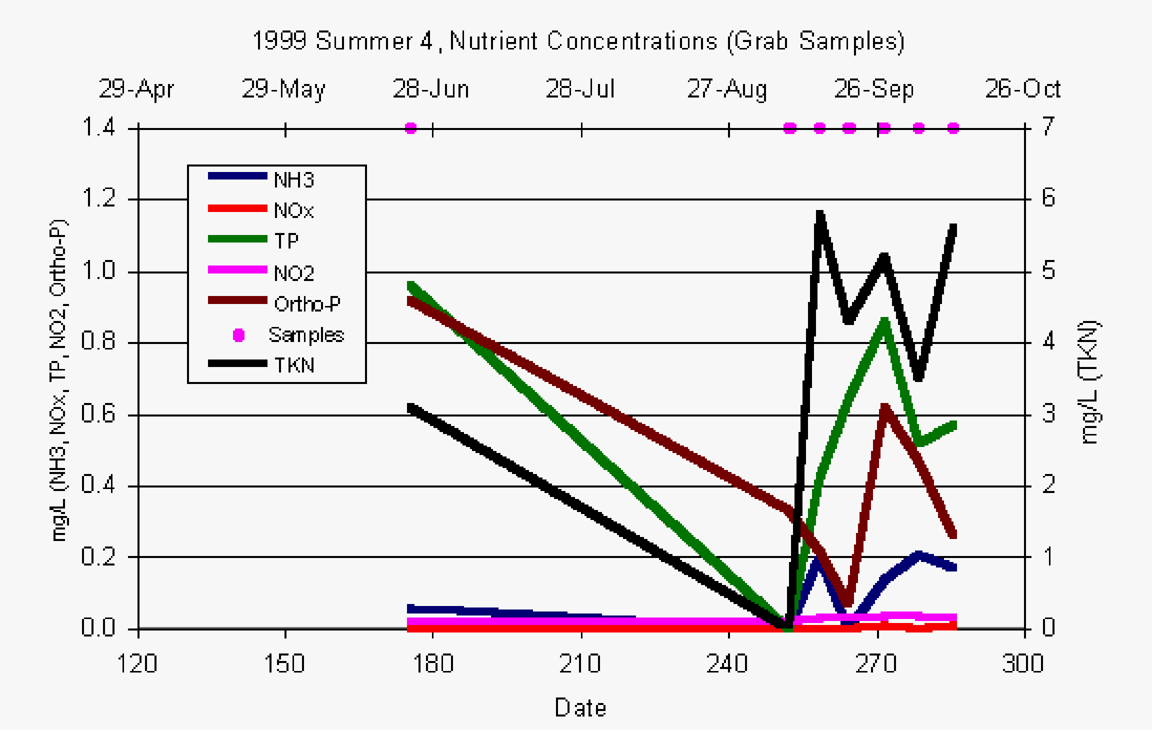


Figure 5.2.12.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 4 in 1999.

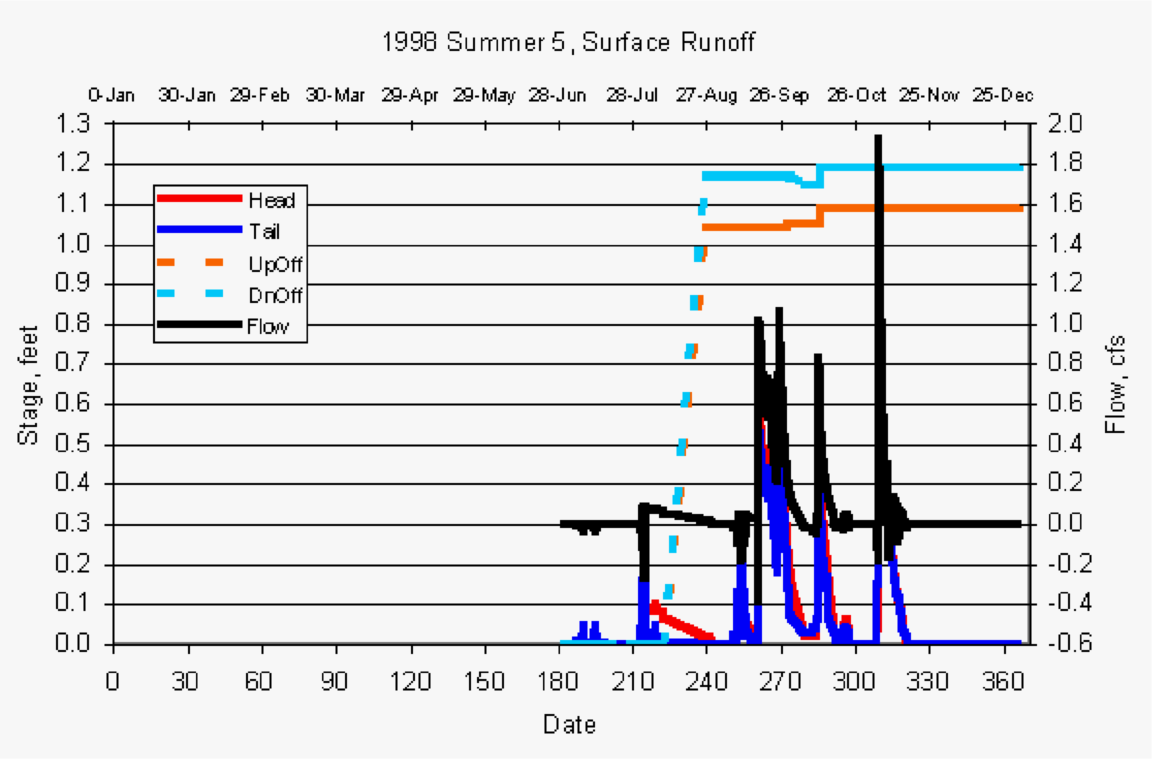


Figure 5.2.13.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 5 in 1998.

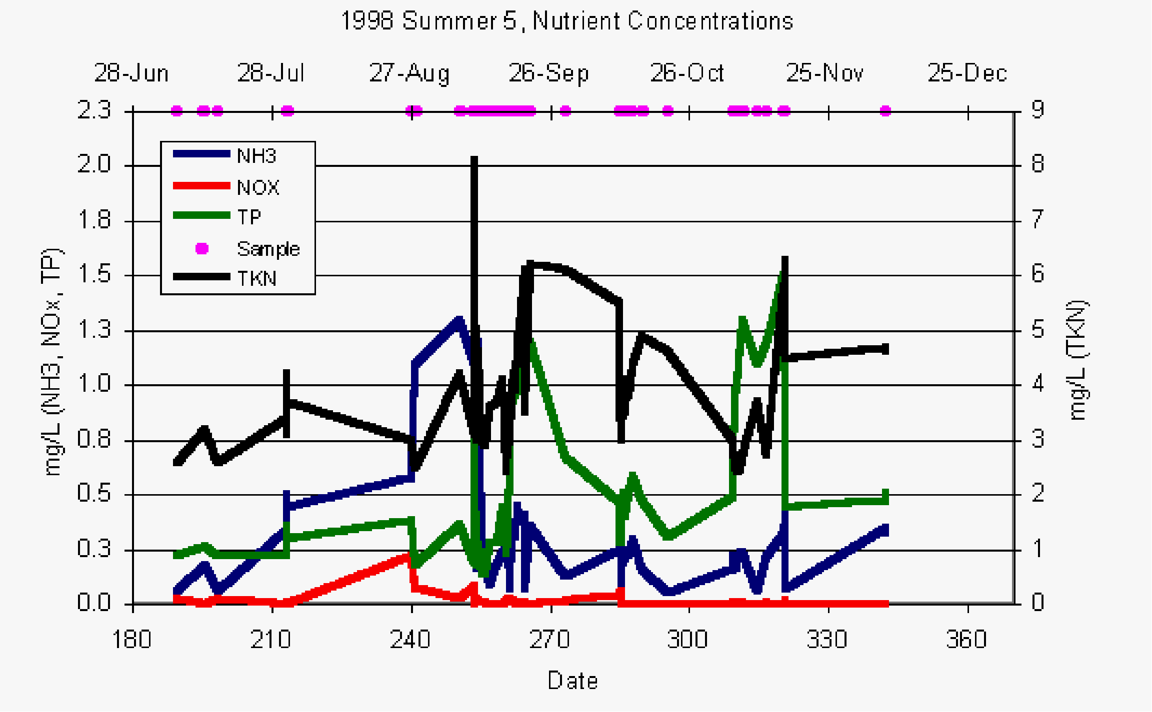


Figure 5.2.13.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 5 in 1998.

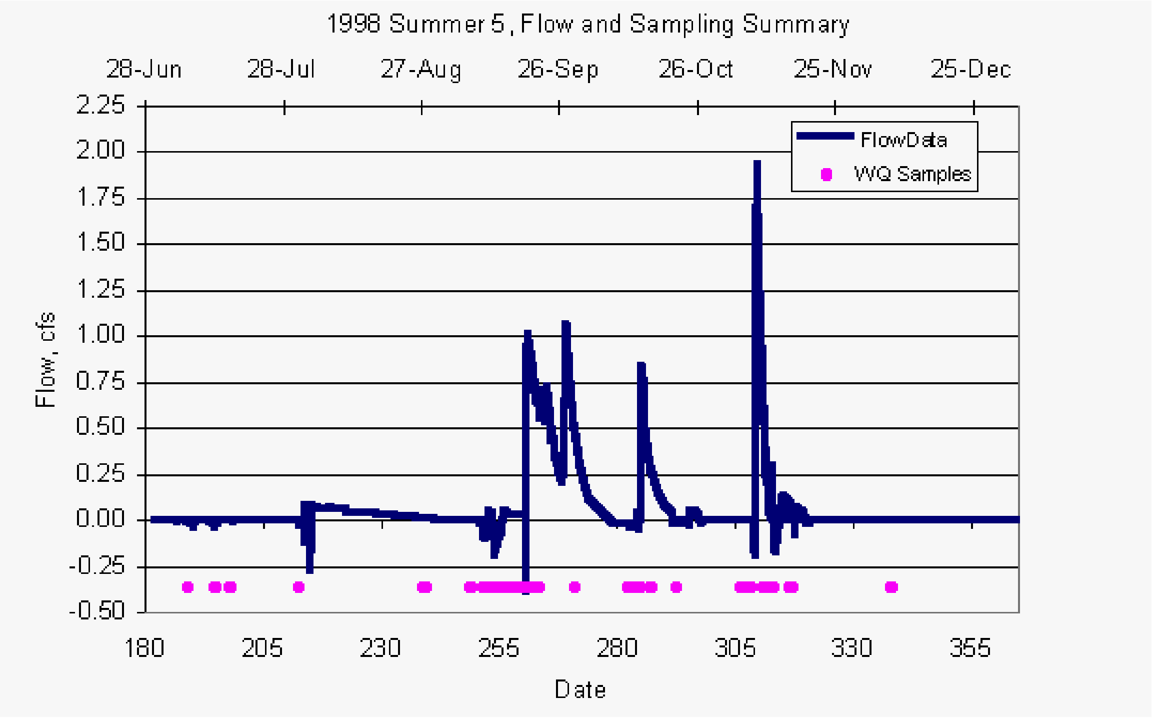


Figure 5.2.13.3. Collection dates and calculated runoff flow values for summer pasture 5 in 1998.

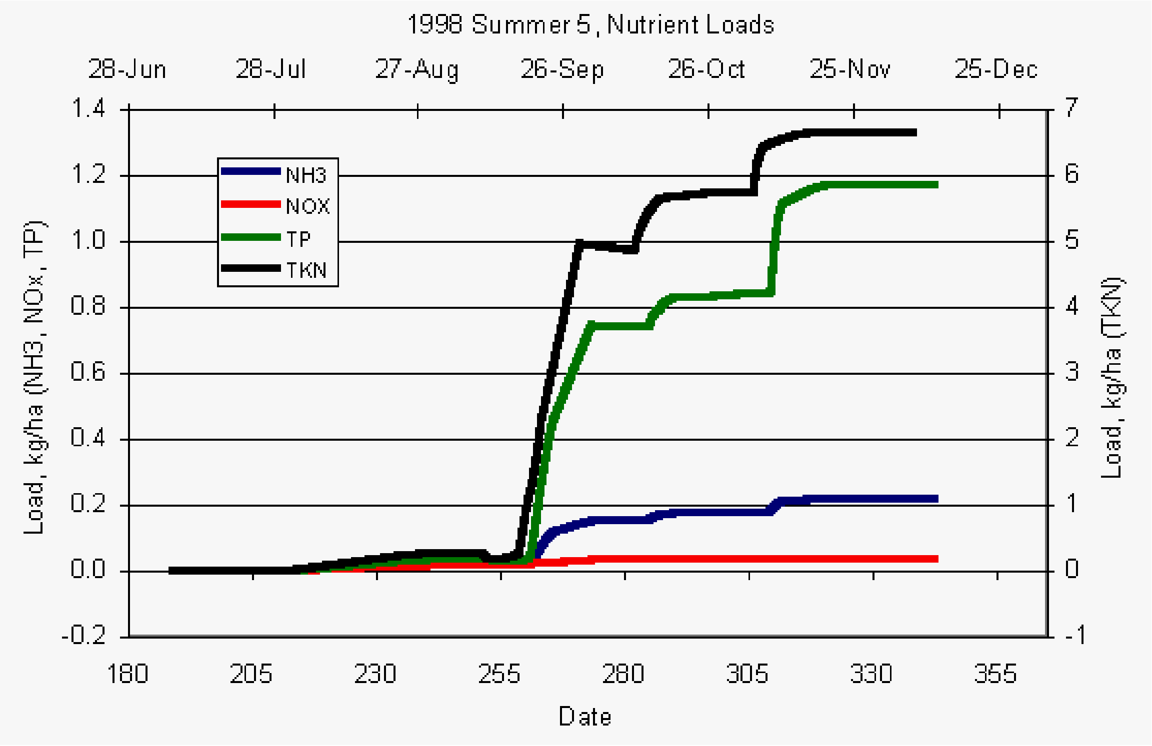


Figure 5.2.13.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 5 in 1998.

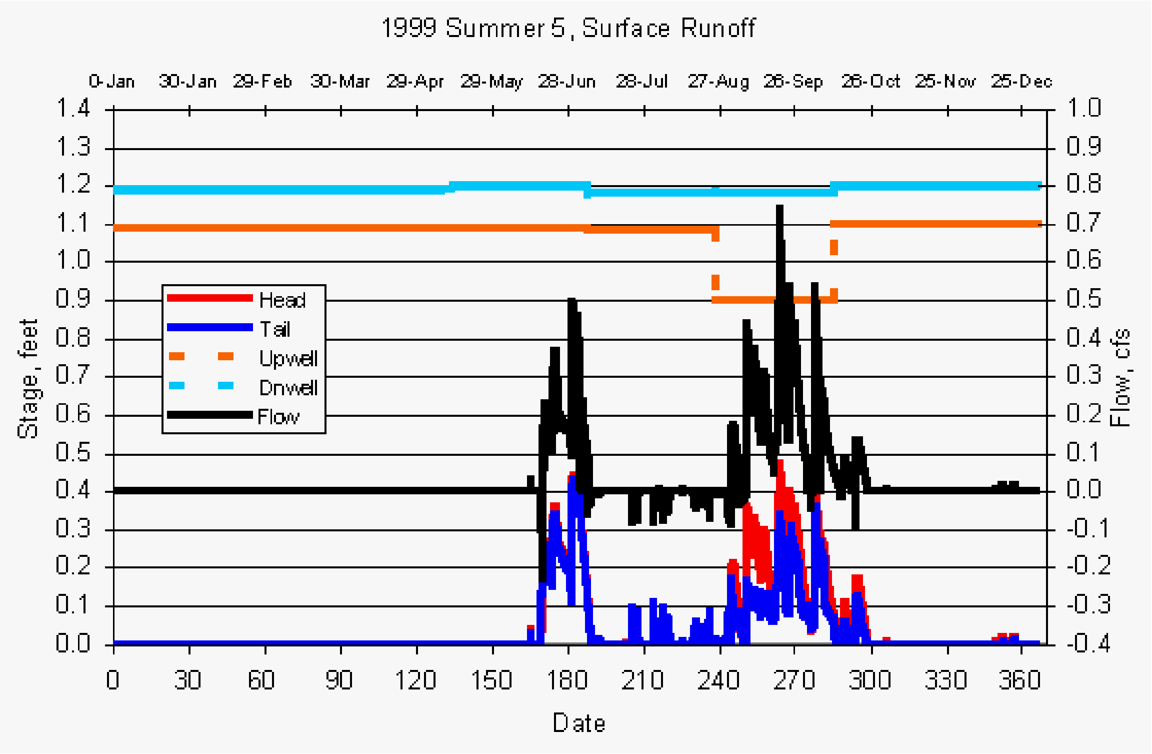


Figure 5.2.13.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 5 in 1999.

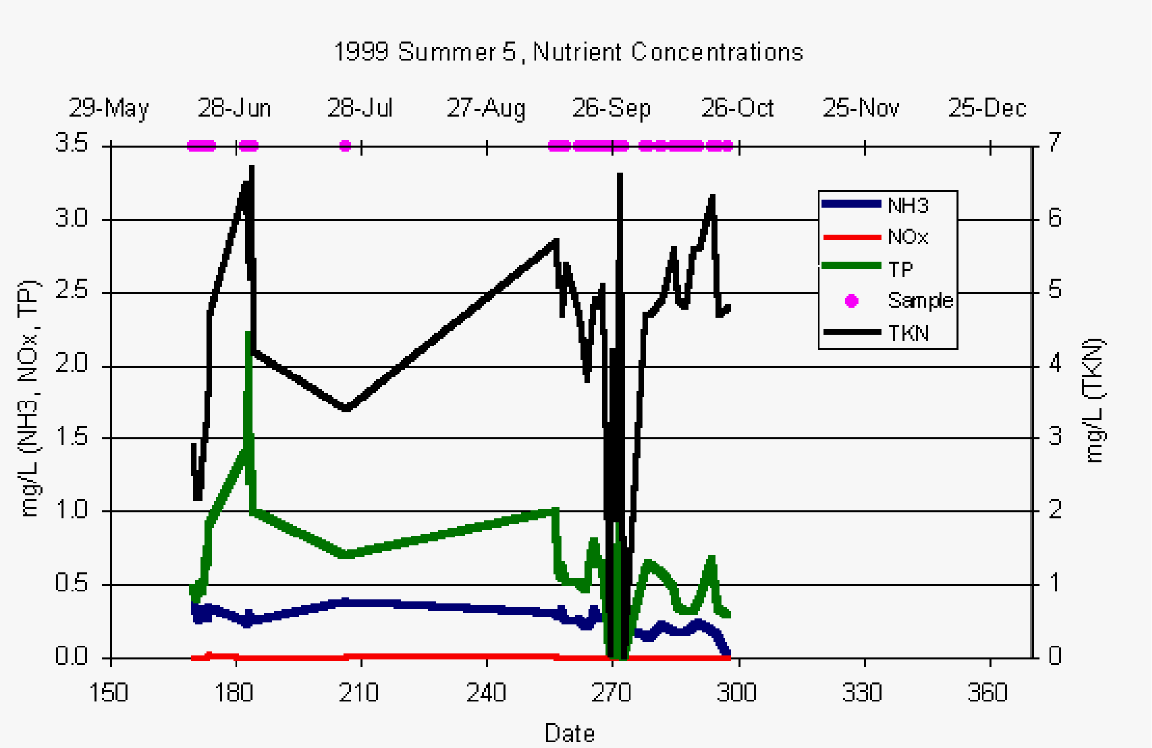


Figure 5.2.13.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 5 in 1999.

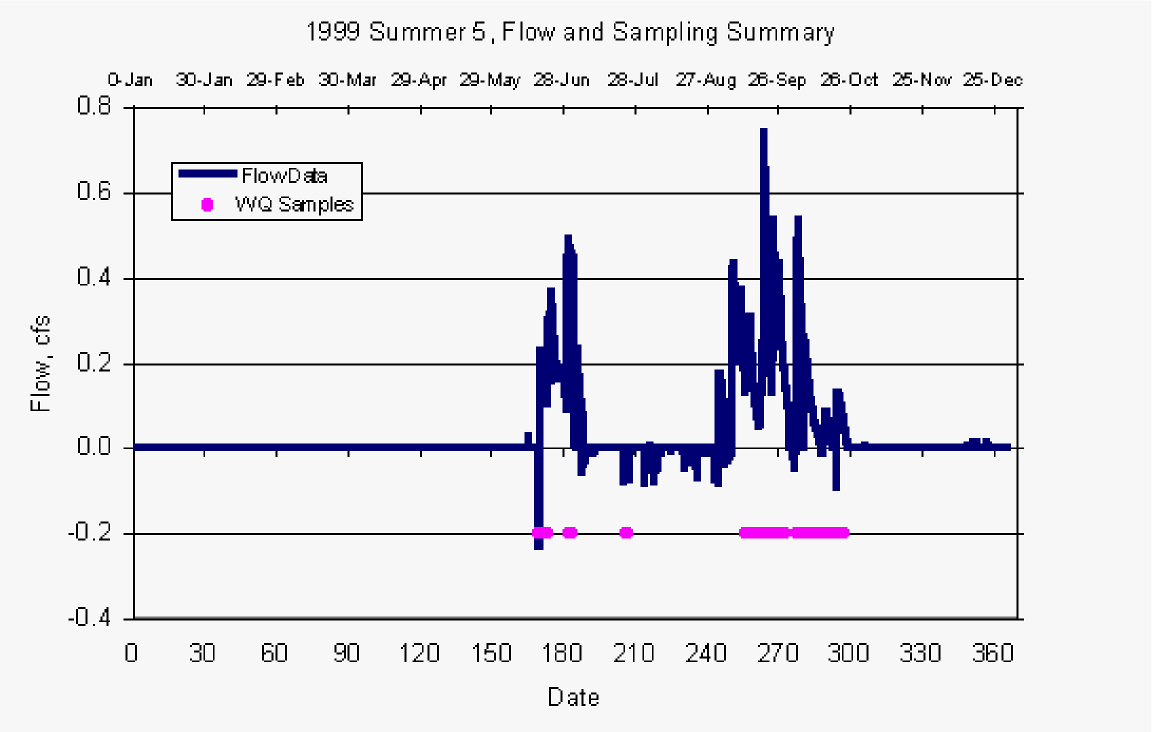


Figure 5.2.13.7. Collection dates and calculated runoff flow values for summer pasture 5 in 1999.

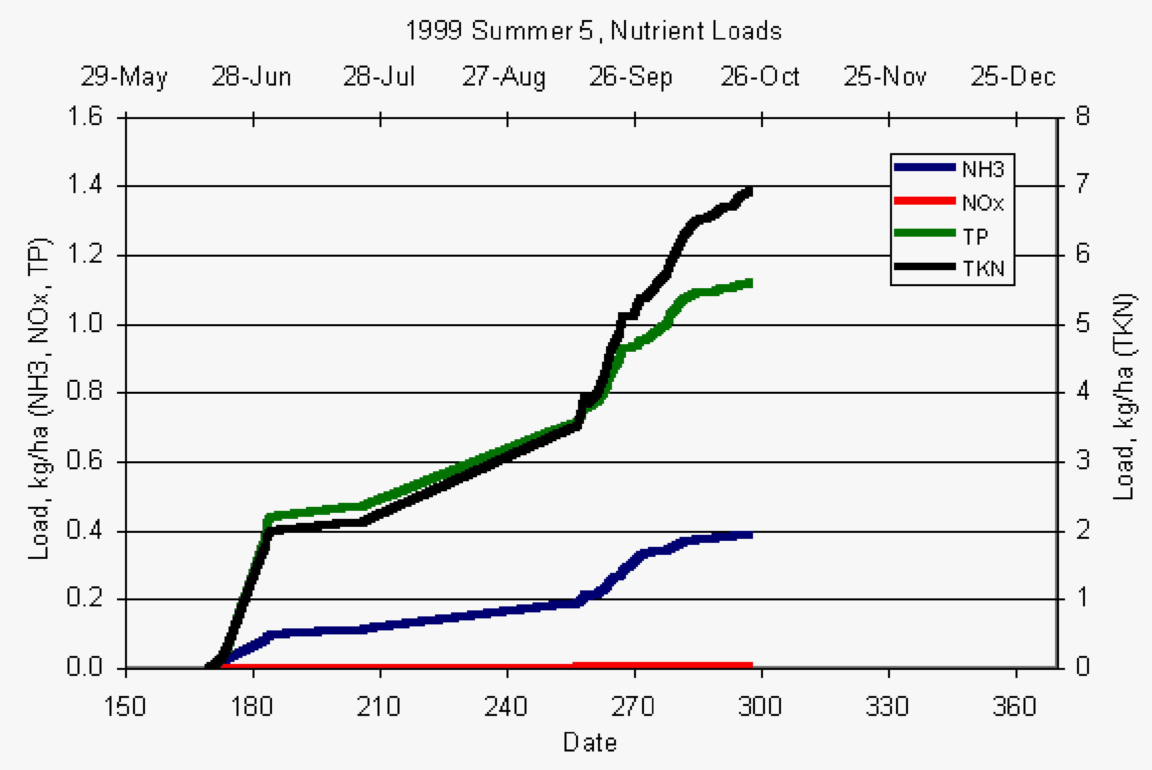


Figure 5.2.13.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 5 in 1999.

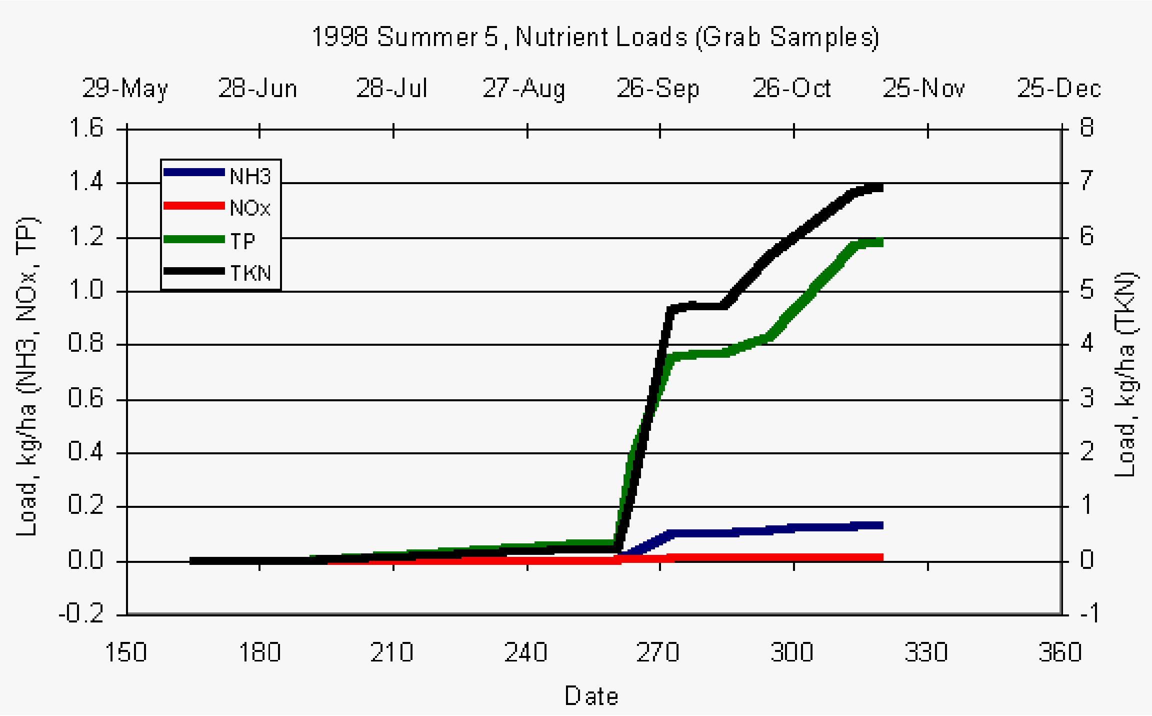


Figure 5.2.13.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 5 in 1998.

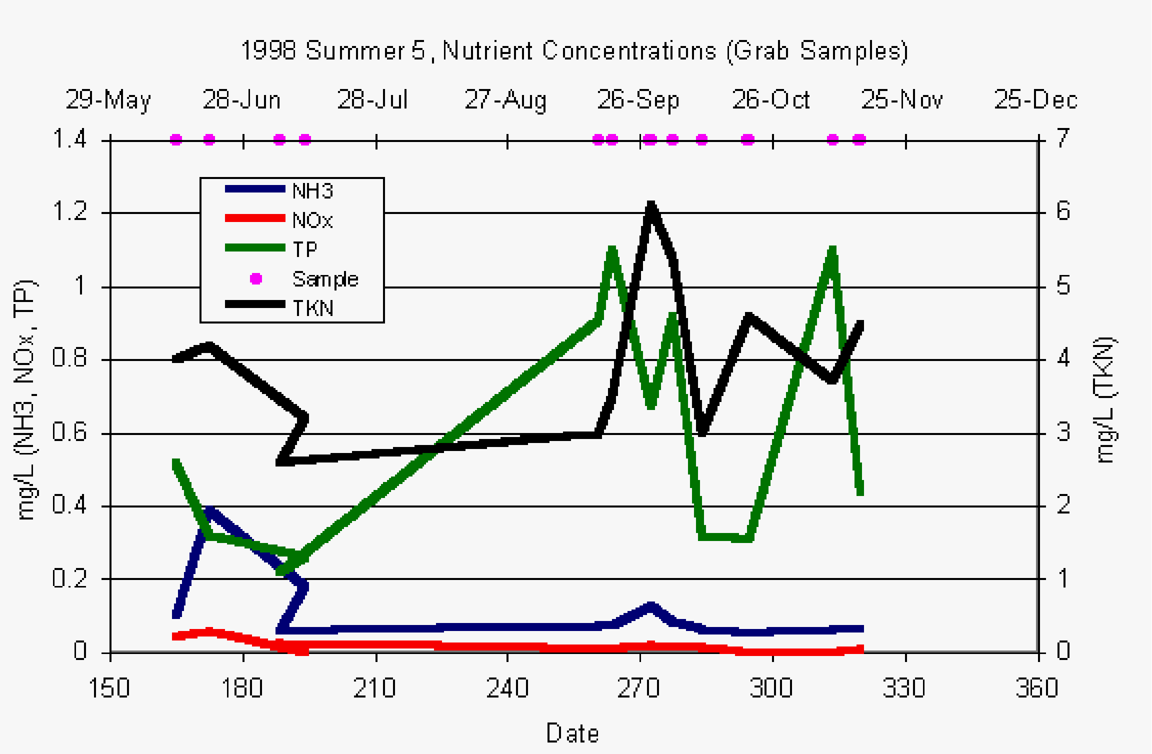


Figure 5.2.13.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 5 in 1998.

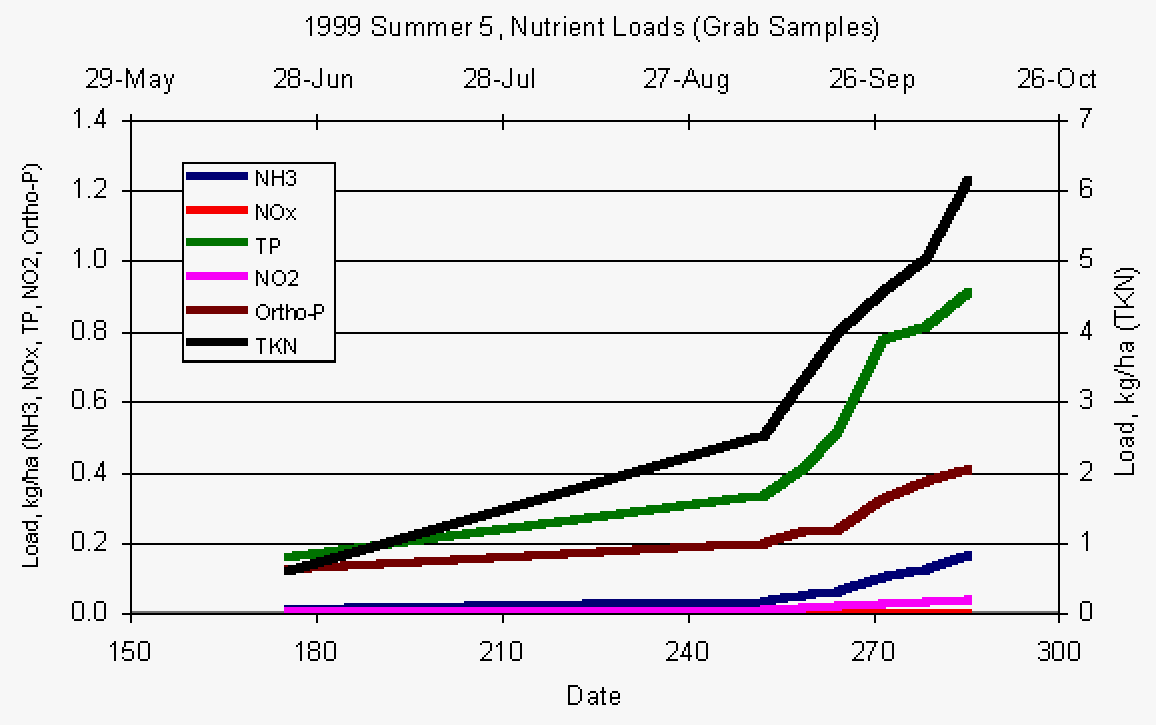
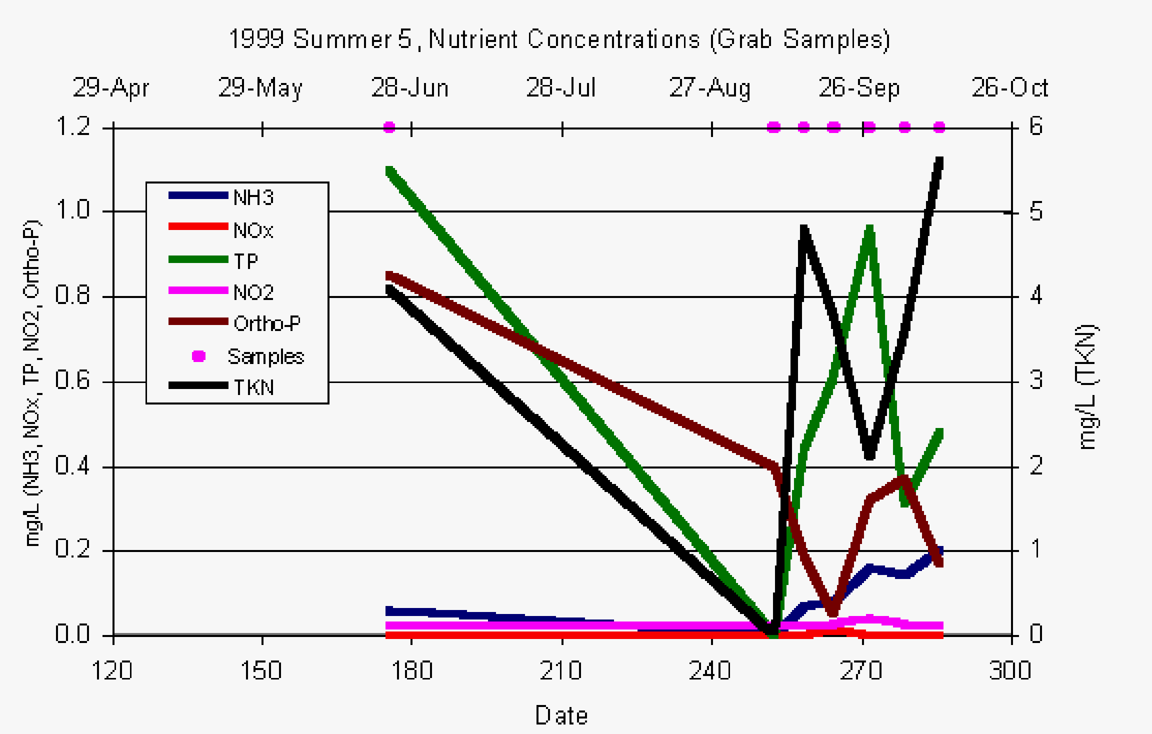


Figure 5.2.13.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 5 in 1999.



5.2.13.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 5 in 1999.

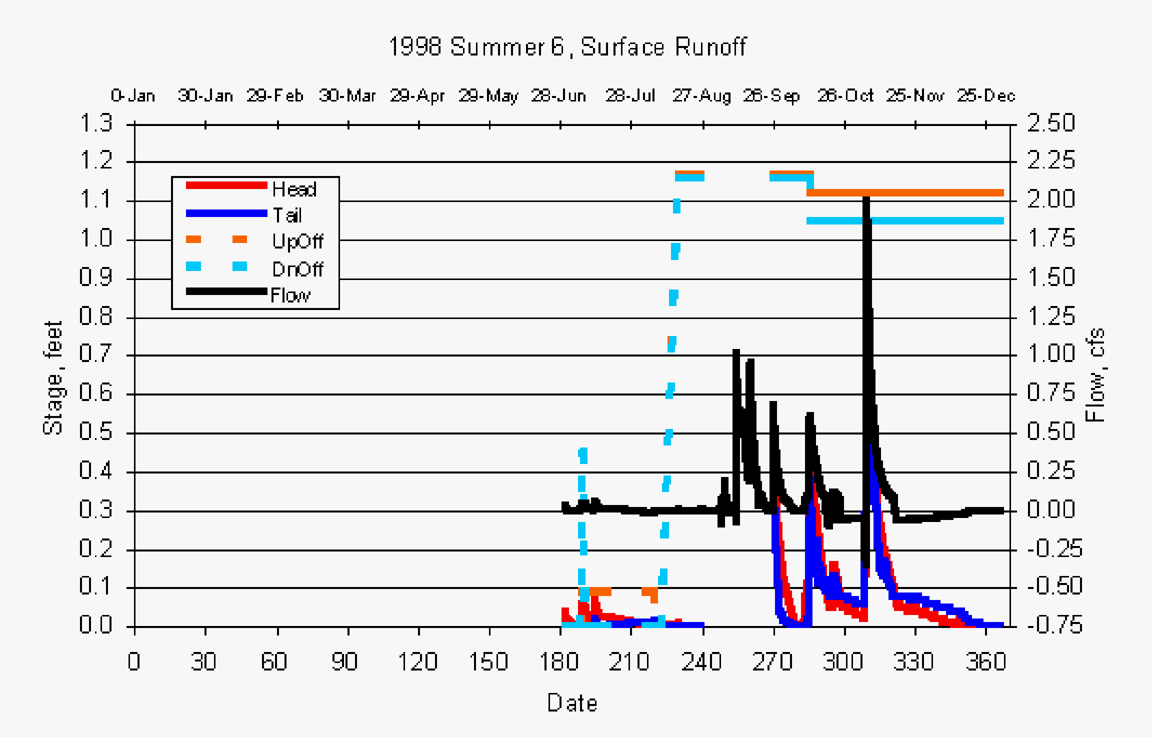


Figure 5.2.14.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 6 in 1998.

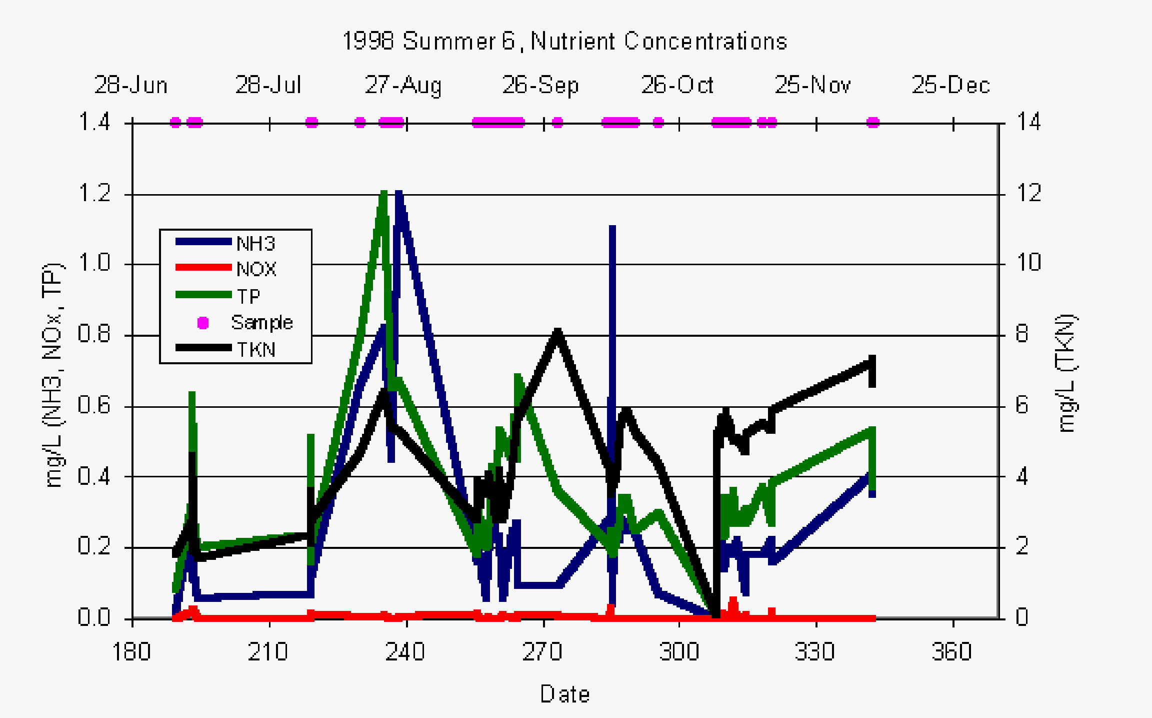


Figure 5.2.14.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 6 in 1998.

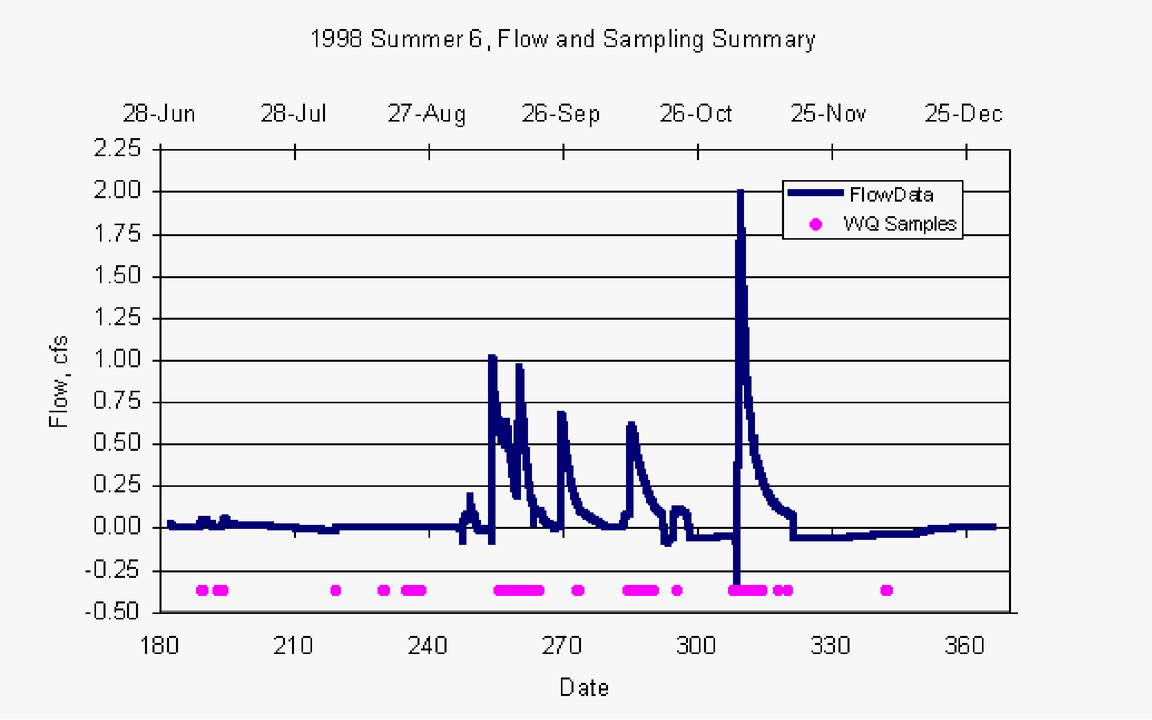


Figure 5.2.14.3. Collection dates and calculated runoff flow values for summer pasture 6 in 1998.

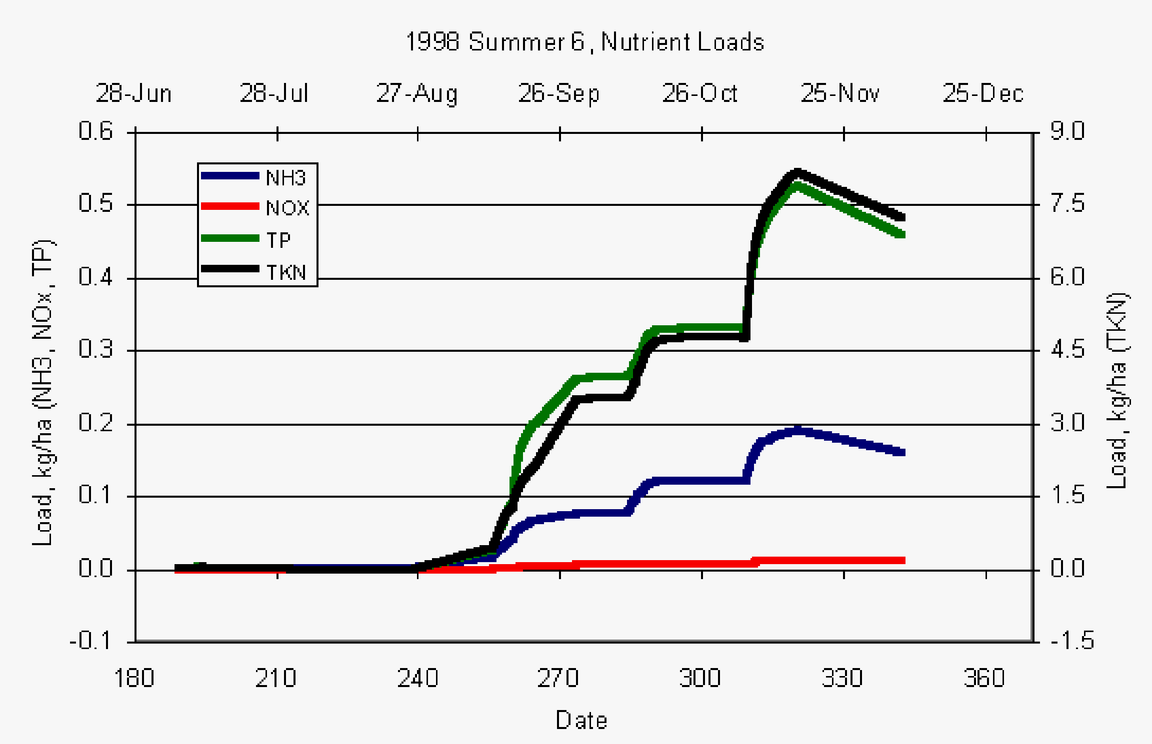


Figure 5.2.14.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 6 in 1998.

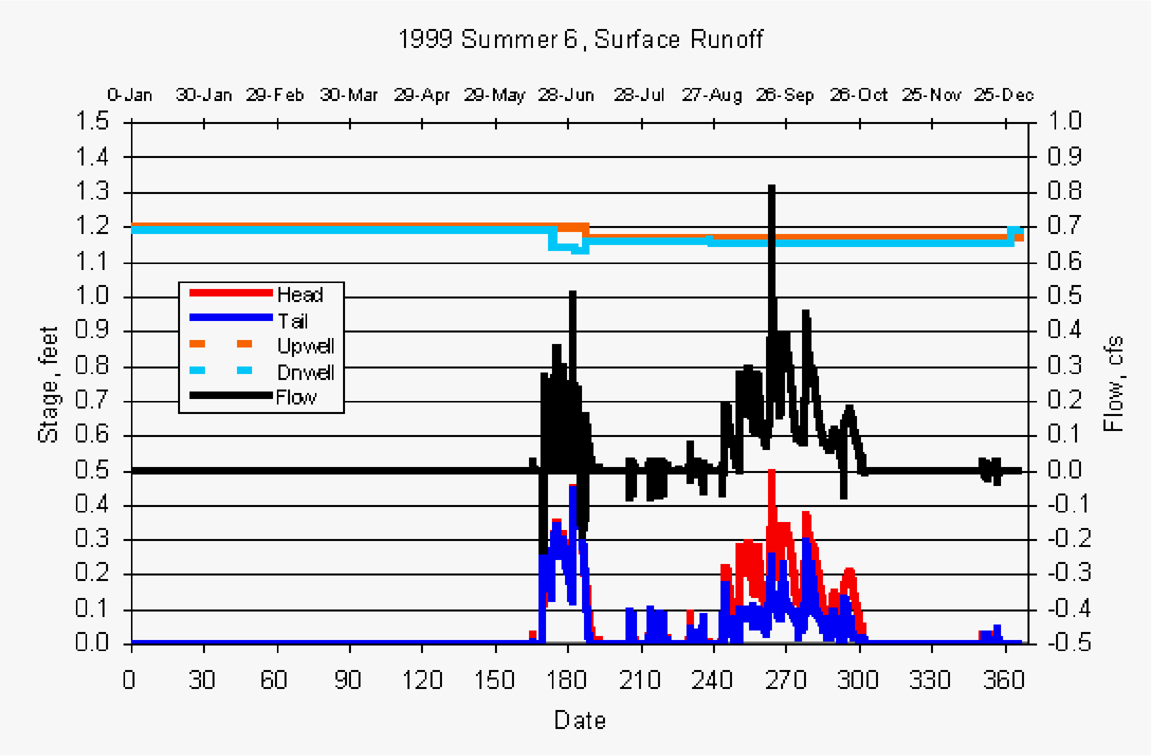


Figure 5.2.14.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 6 in 1999.

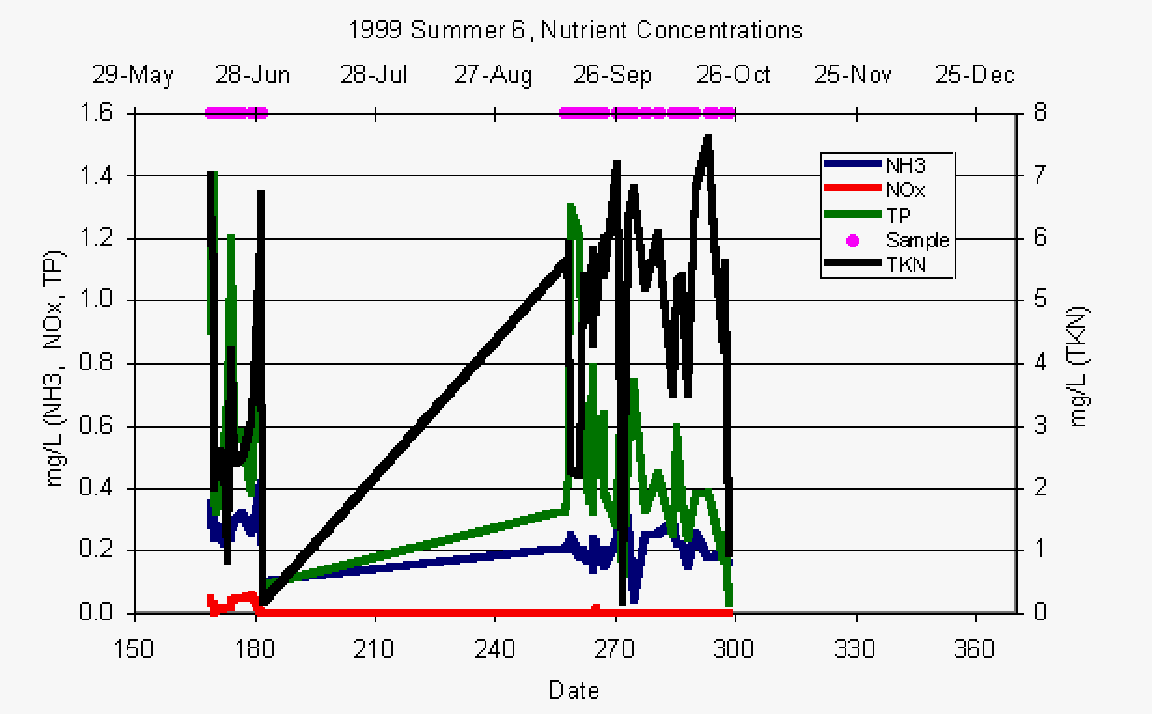


Figure 5.2.14.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 6 in 1999.

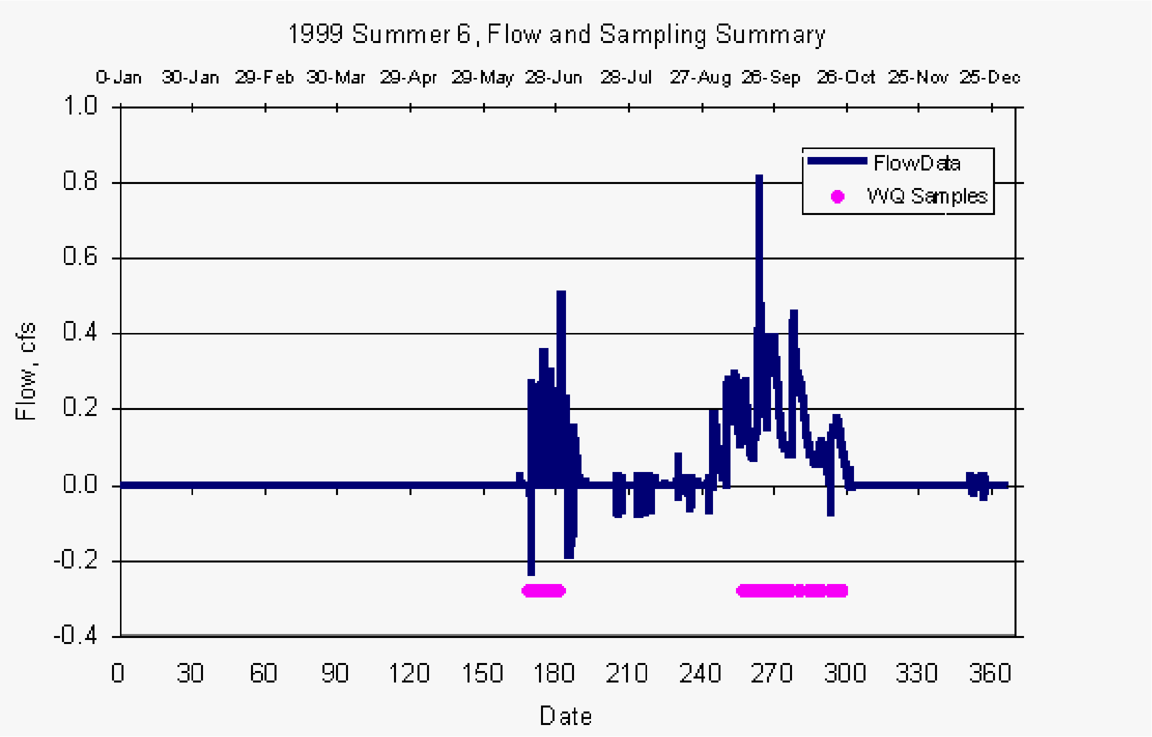


Figure 5.2.14.7. Collection dates and calculated runoff flow values for summer pasture 6 in 1999.

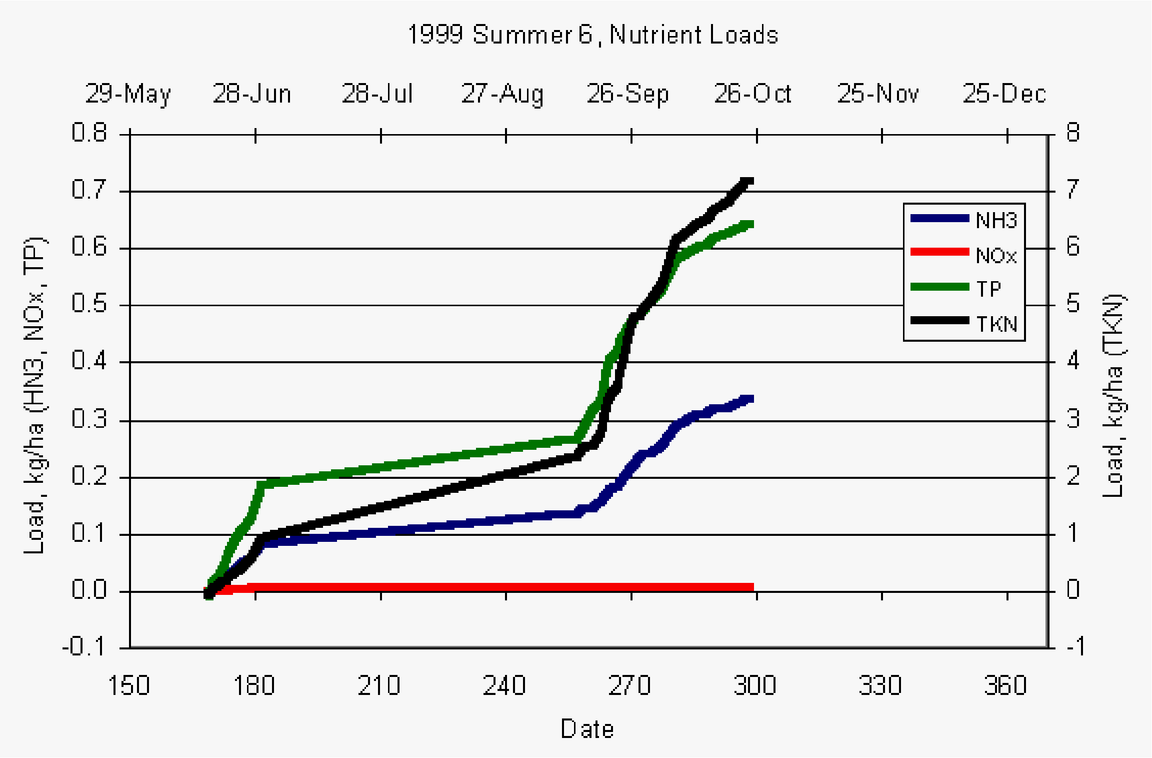


Figure 5.2.14.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 6 in 1999.

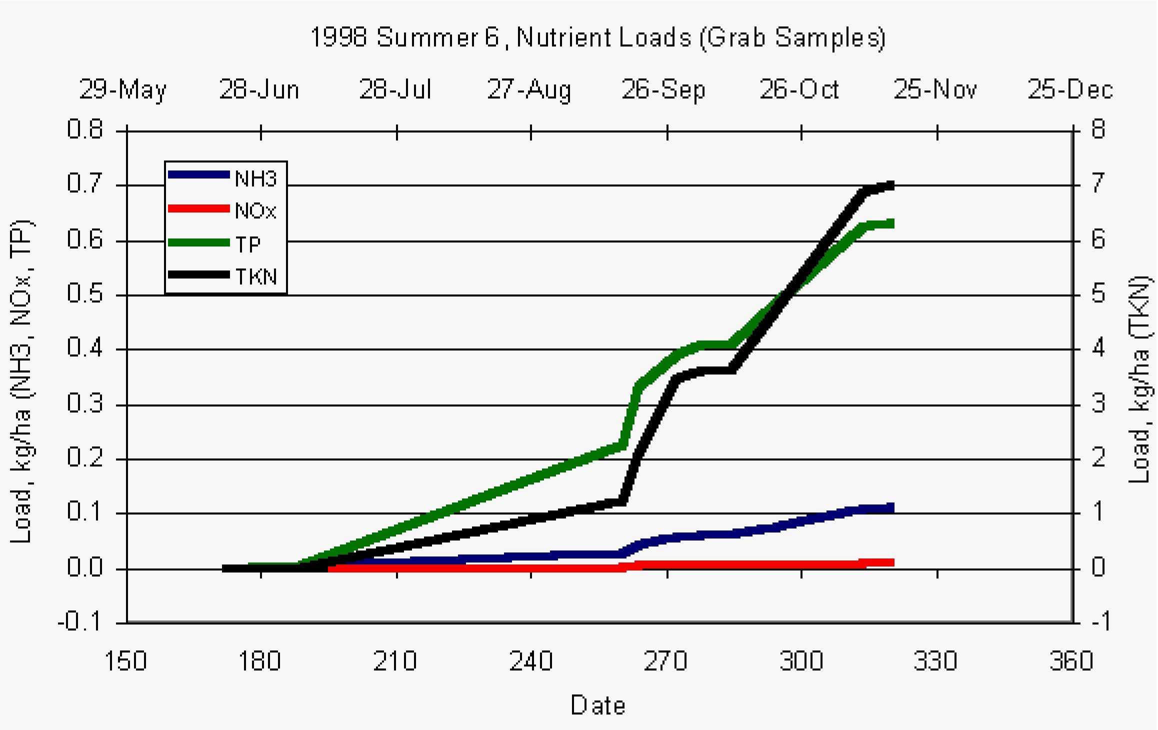


Figure 5.2.14.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 6 in 1998.

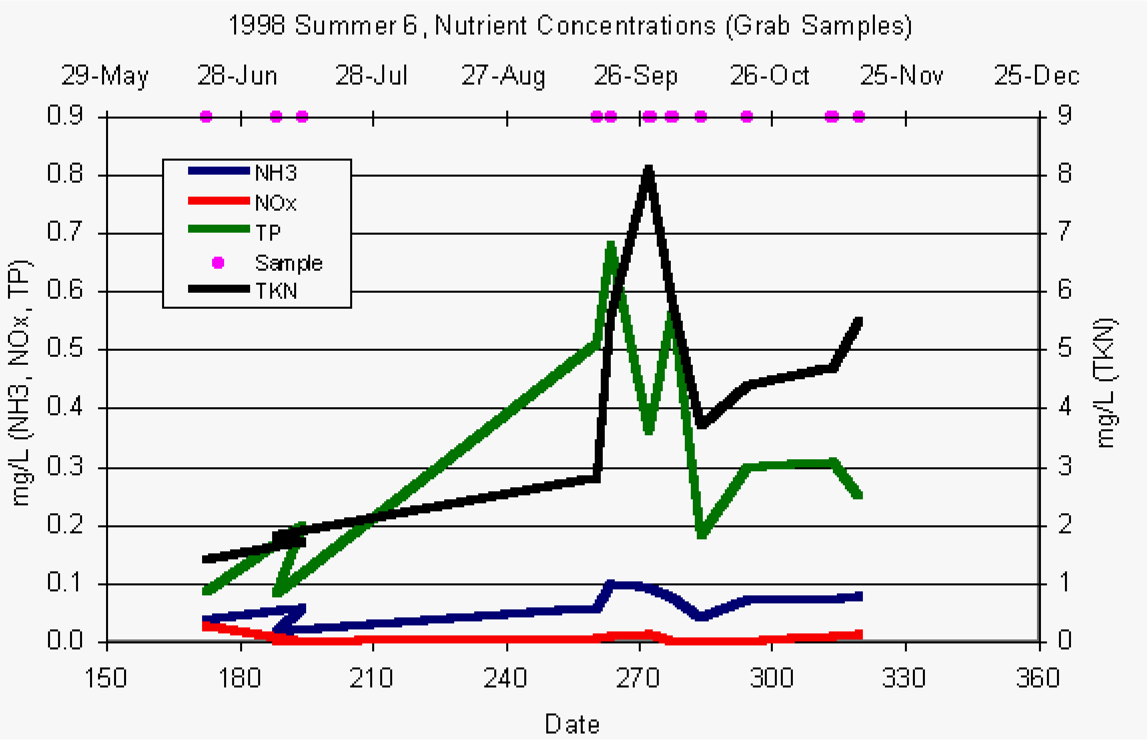


Figure 5.2.14.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 6 in 1998.

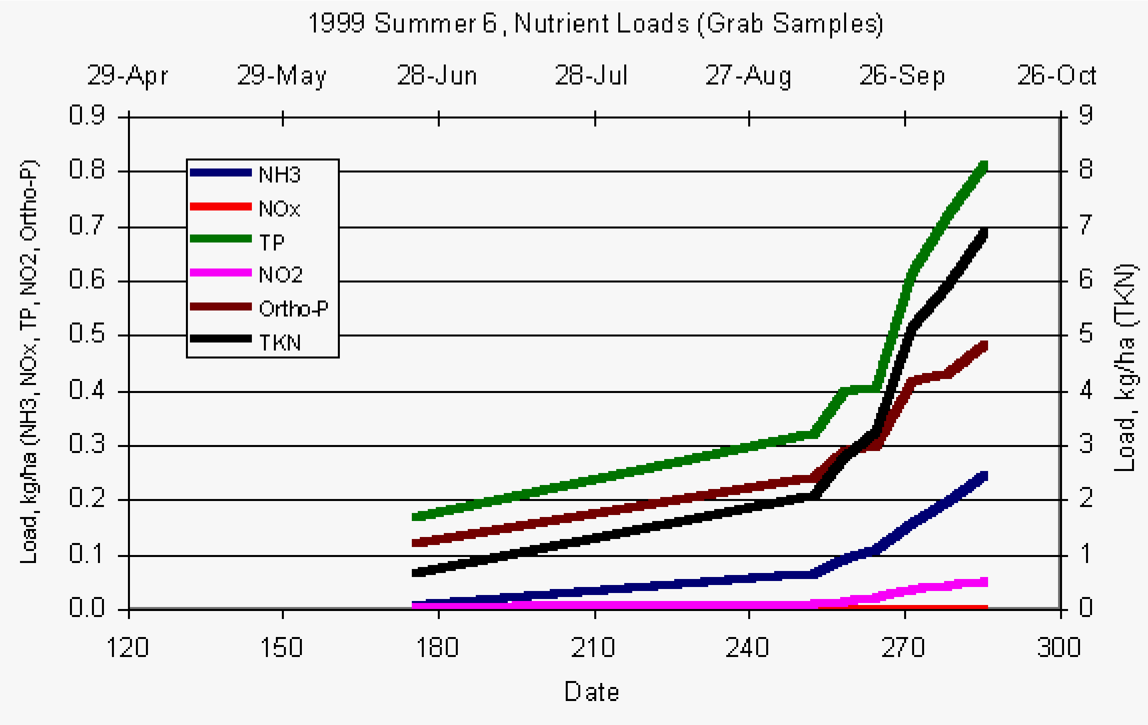


Figure 5.2.14.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 6 in 1999.

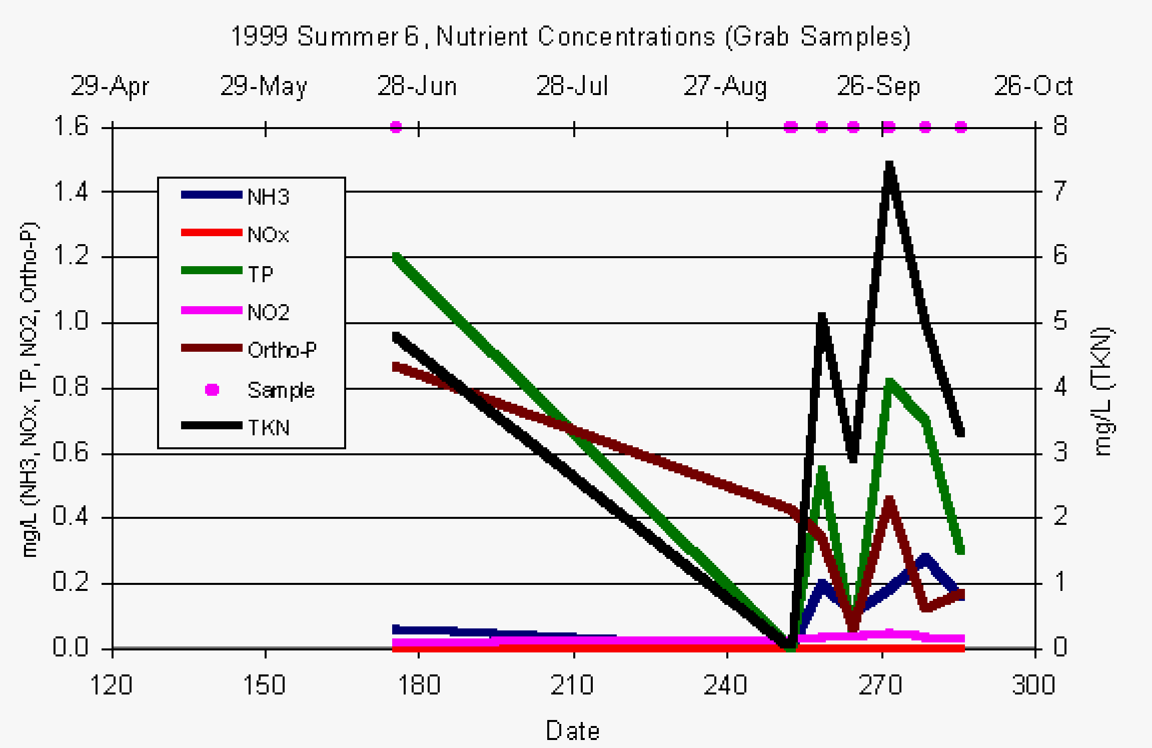


Figure 5.2.14.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 6 in 1999.

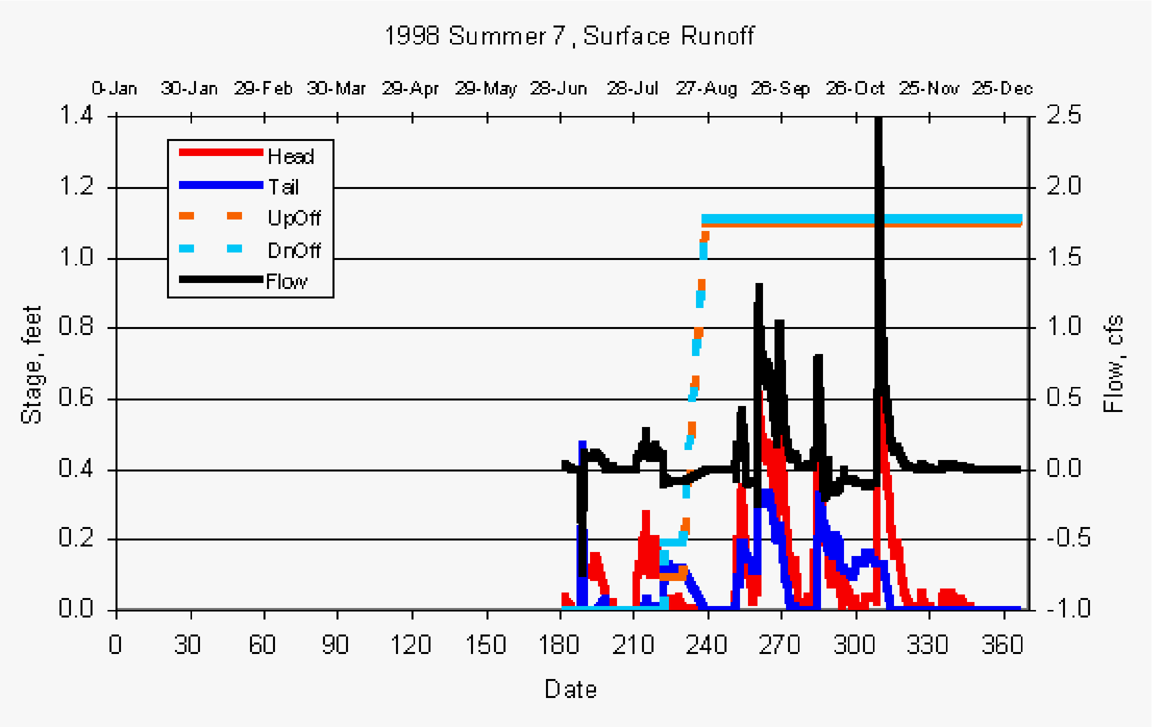


Figure 5.2.15.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 7 in 1998.

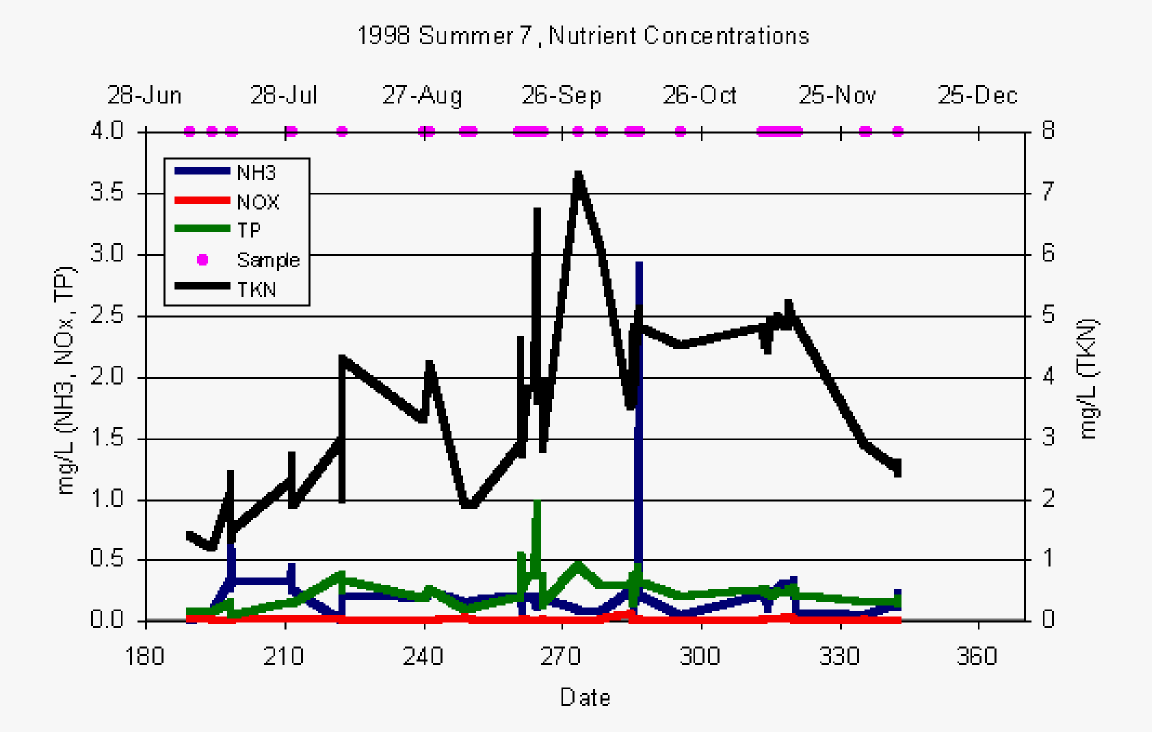


Figure 5.2.15.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 7 in 1998.

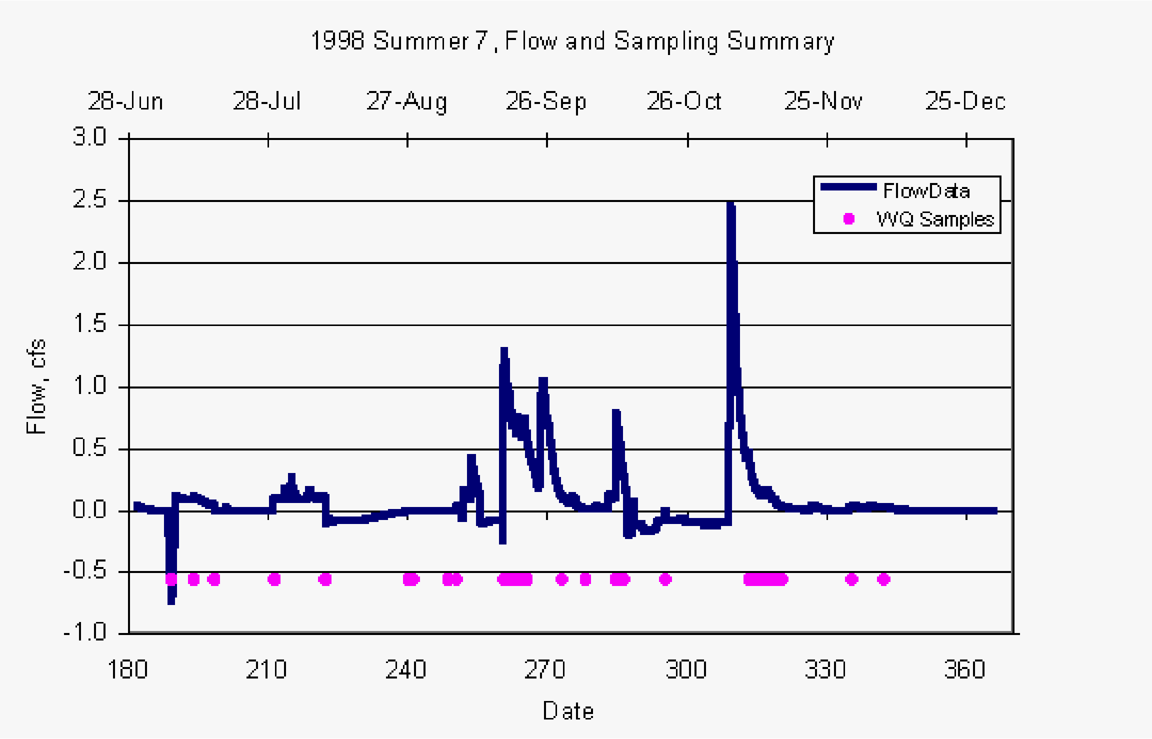


Figure 5.2.15.3. Collection dates and calculated runoff flow values for summer pasture 7 in 1998.

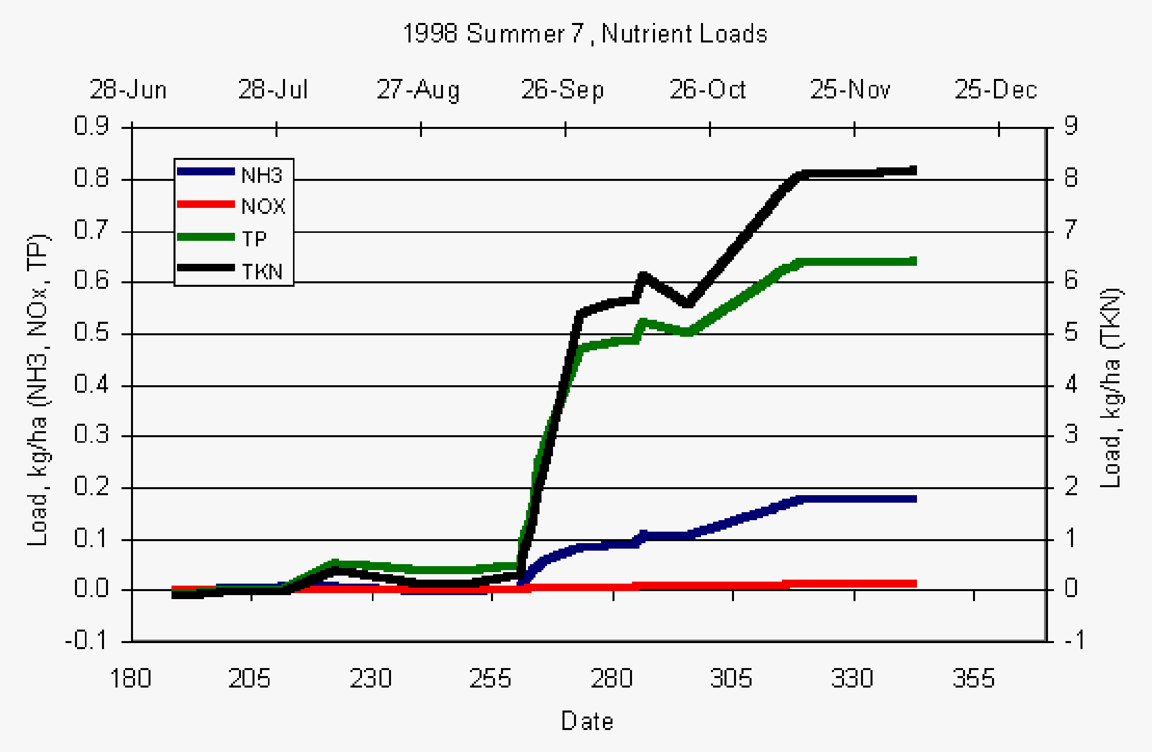


Figure 5.2.15.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 7 in 1998.

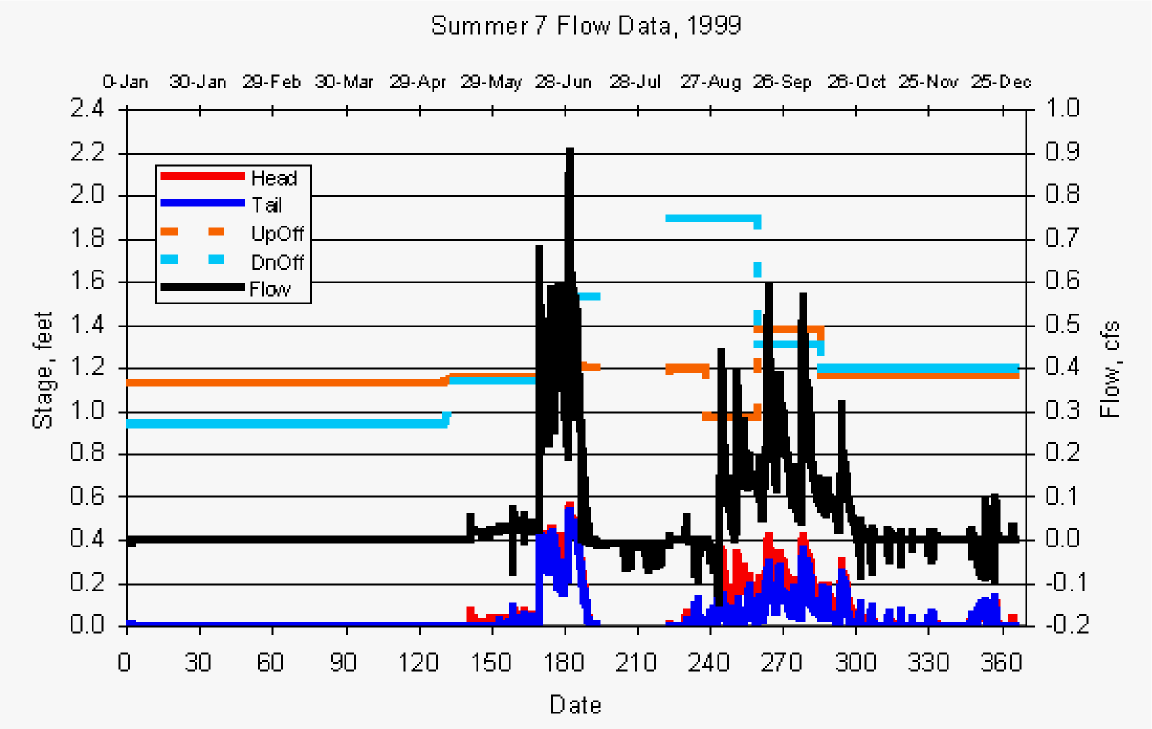


Figure 5.2.15.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 7 in 1999.

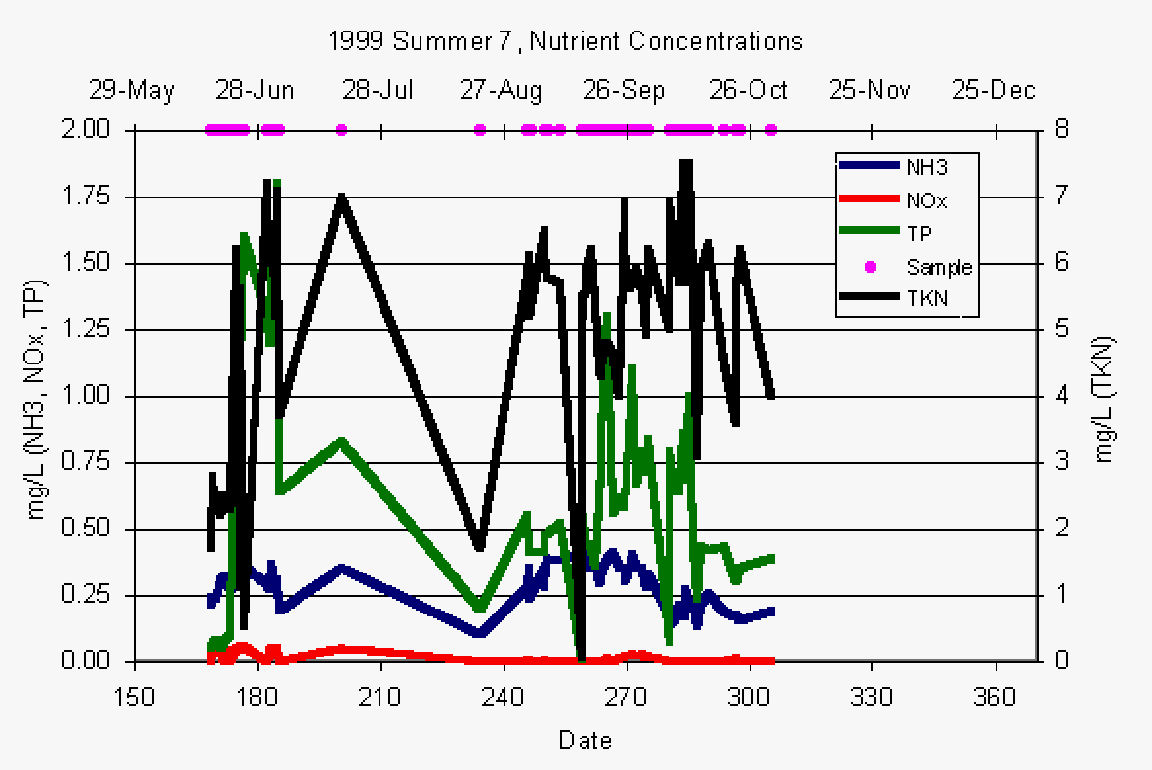


Figure 5.2.15.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 7 in 1999.

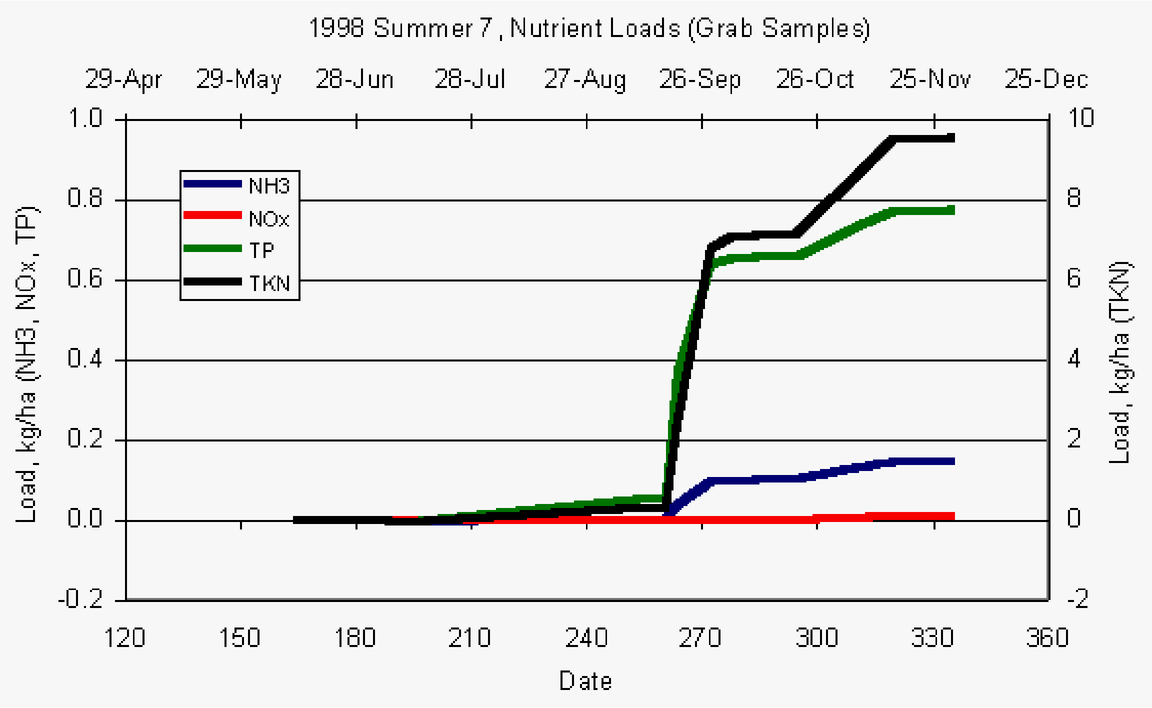


Figure 5.2.15.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 7 in 1998.

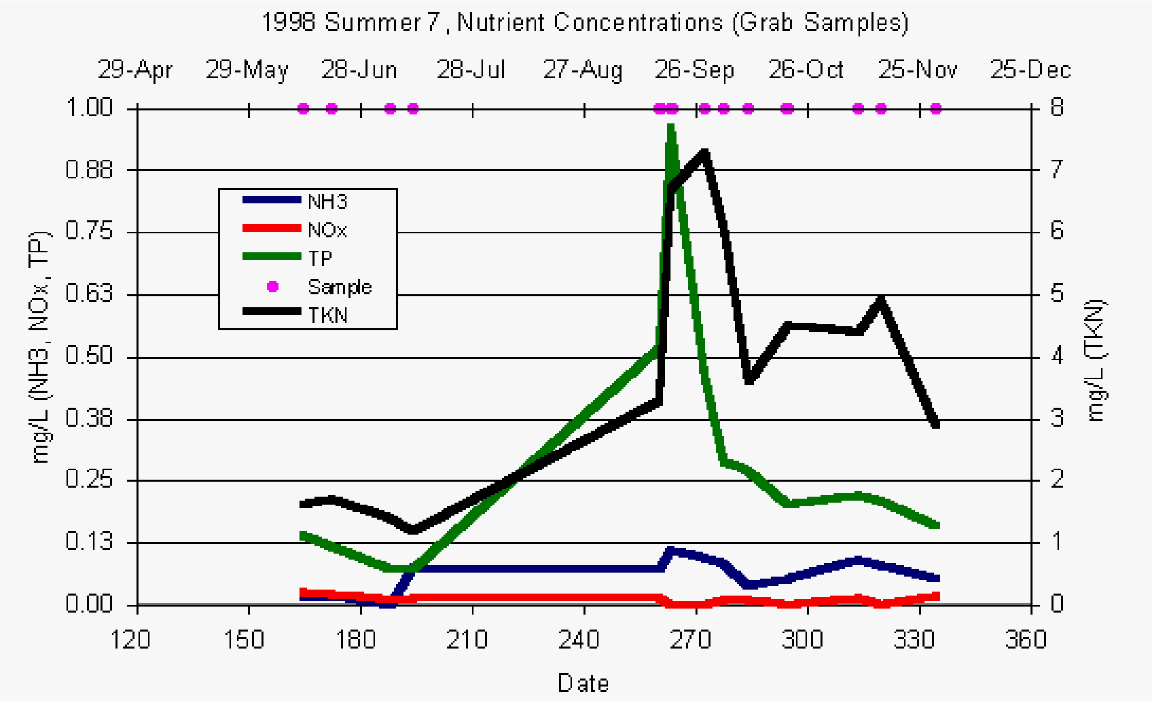


Figure 5.2.15.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 7 in 1998.

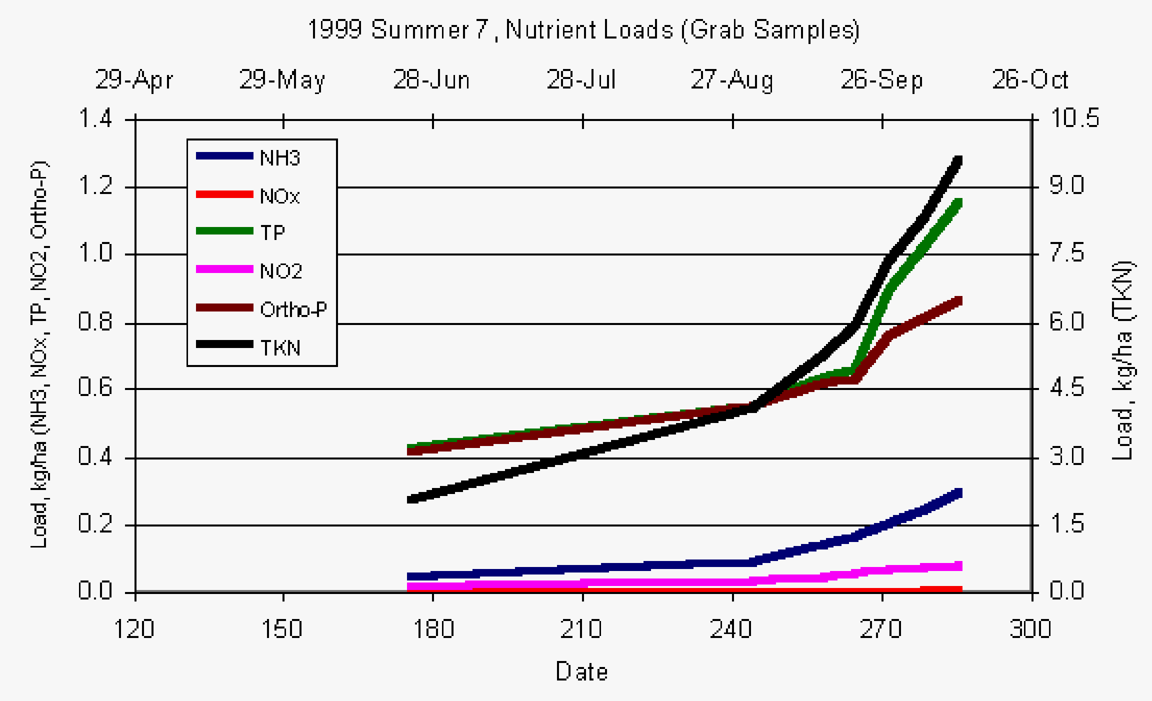


Figure 5.2.15.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 7 in 1999.

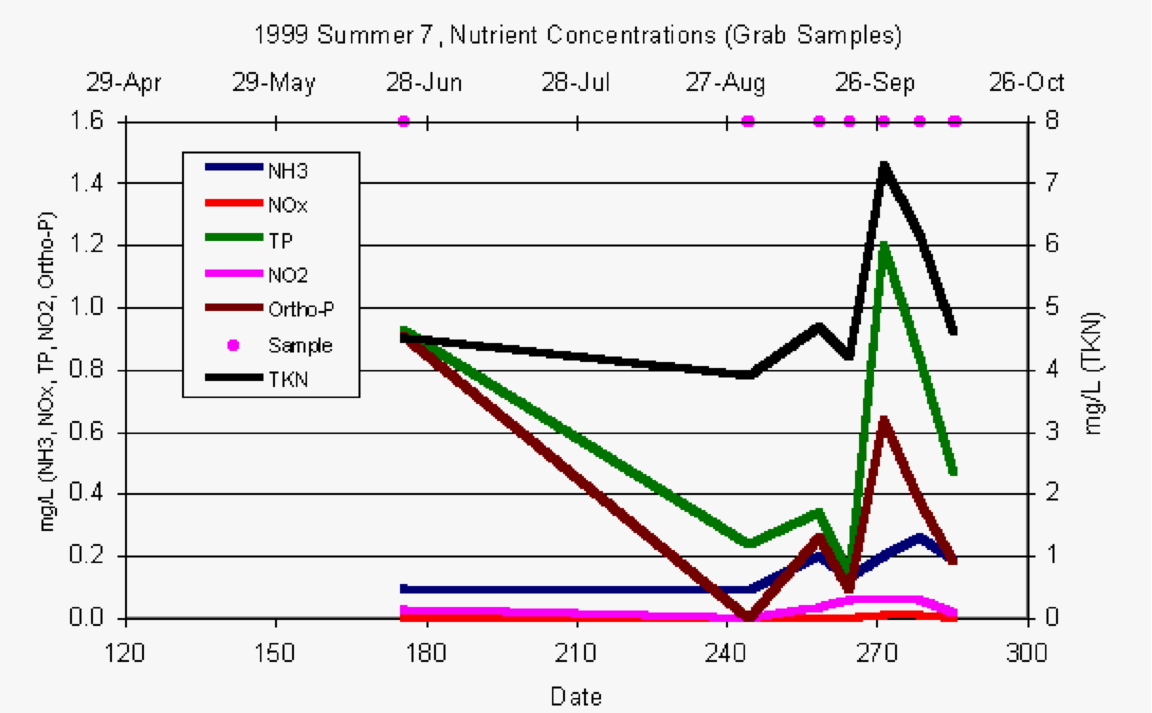


Figure 5.2.15.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 7 in 1999.

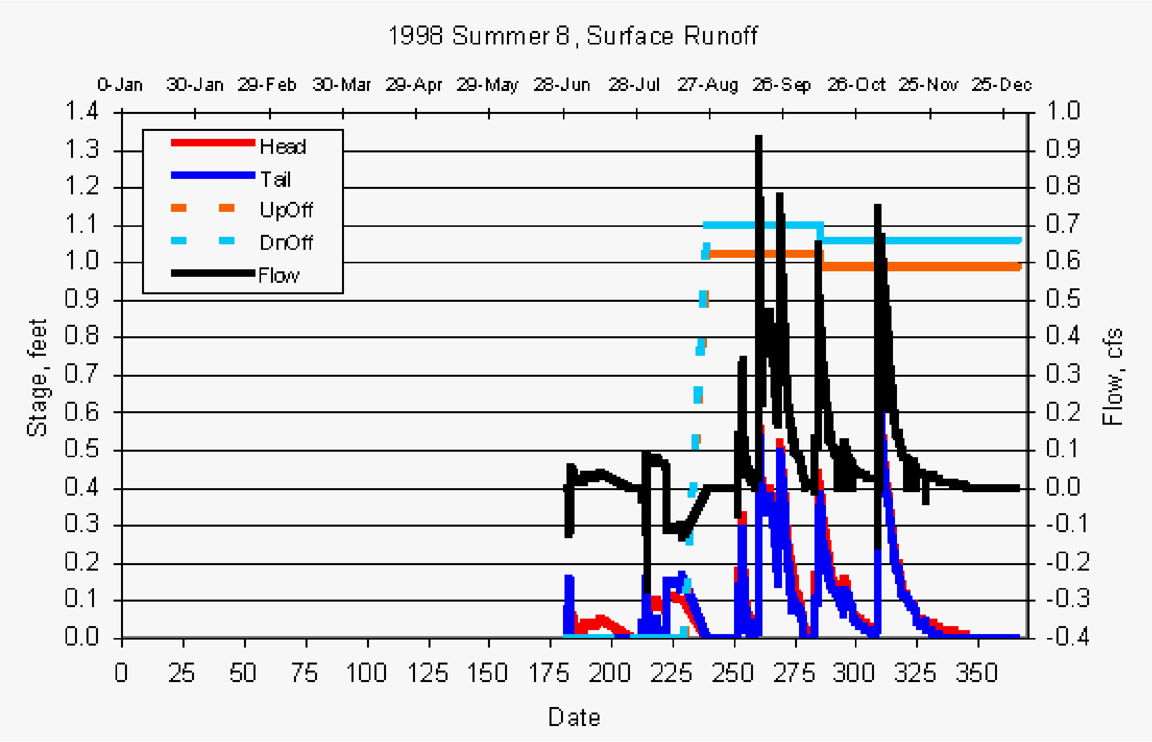


Figure 5.2.16.1. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 8 in 1998.

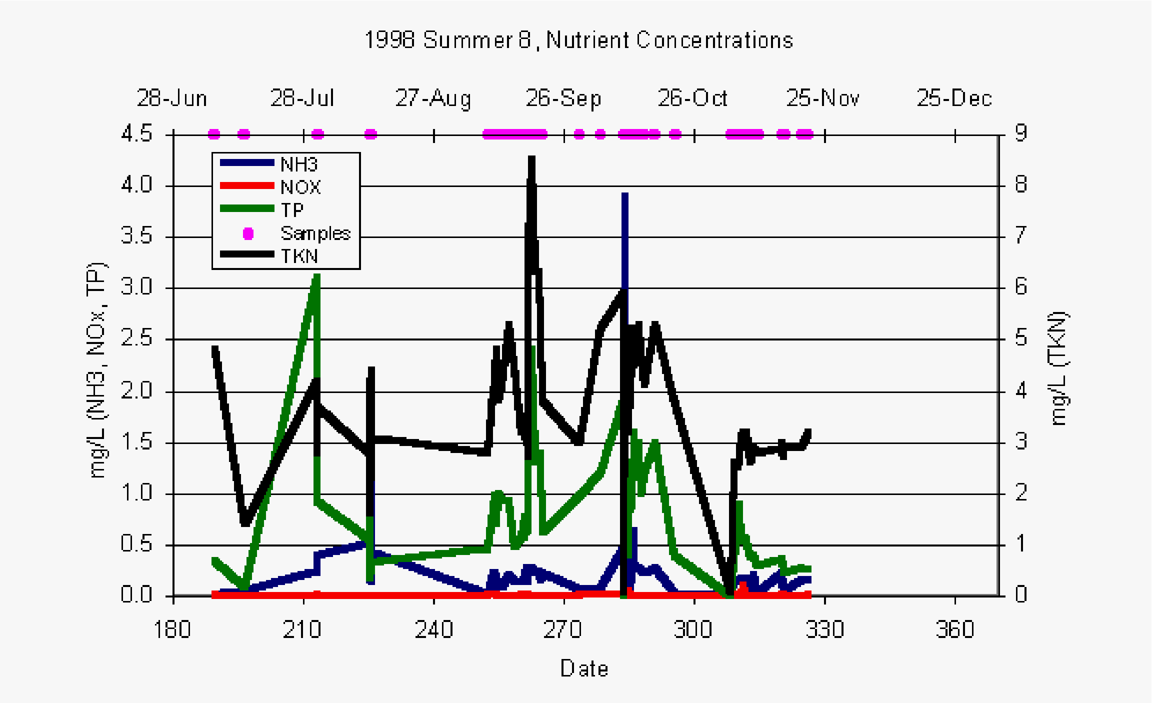


Figure 5.2.16.2. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 8 in 1998.

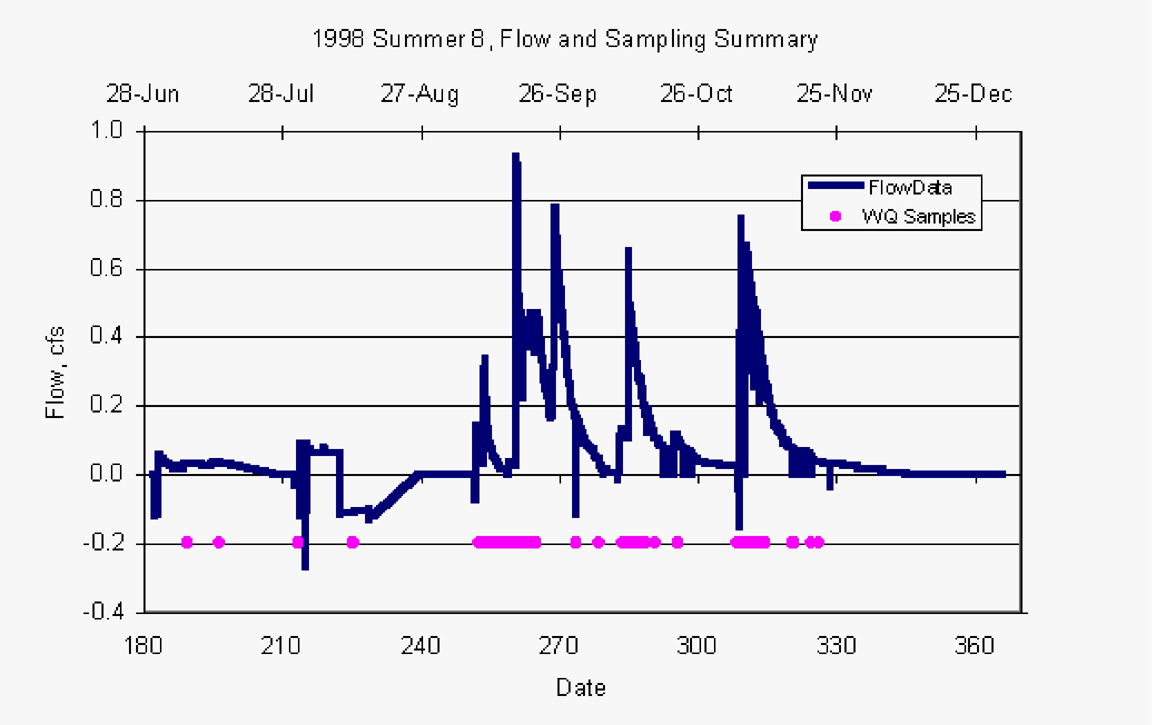


Figure 5.2.16.3. Collection dates and calculated runoff flow values for summer pasture 7 in 1998.

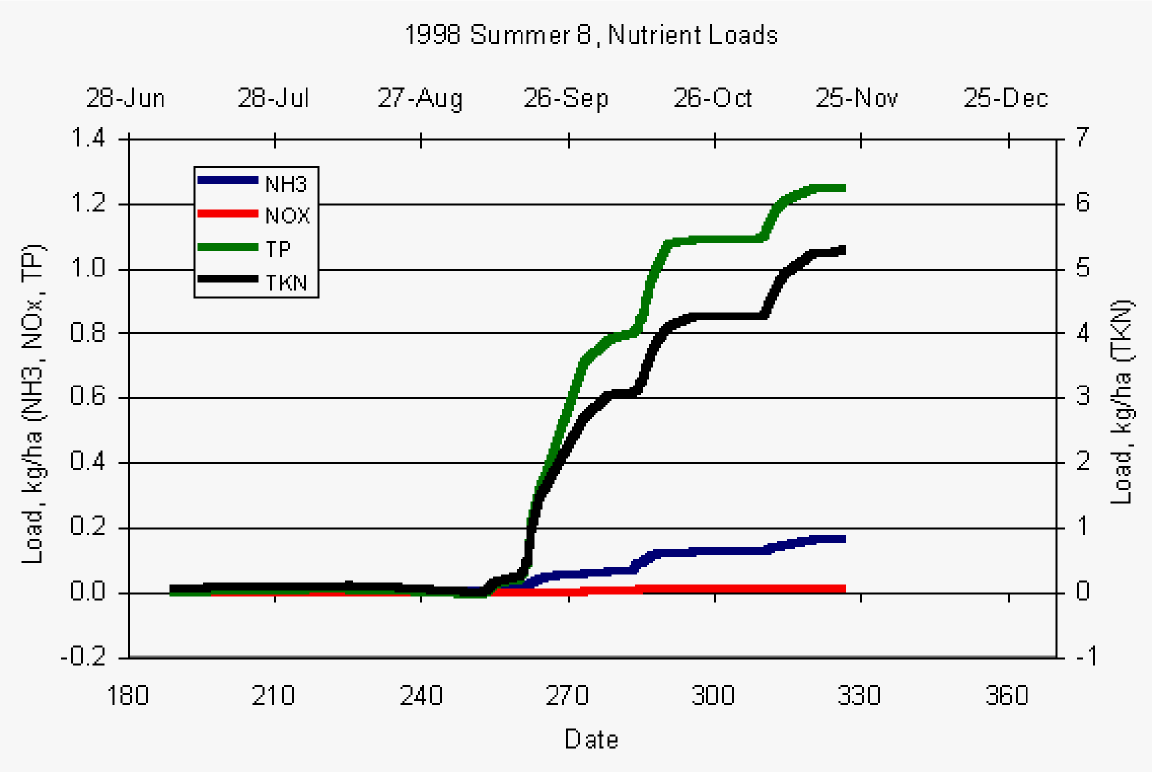


Figure 5.2.16.4. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 8 in 1998.

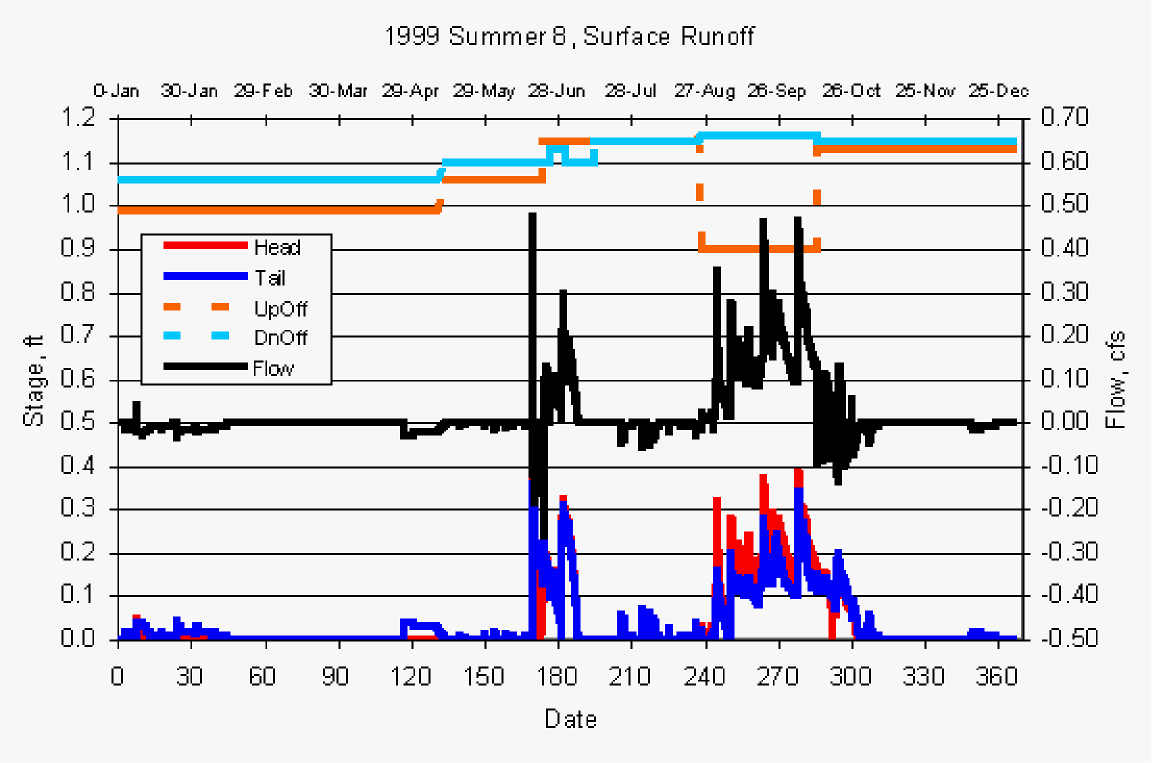


Figure 5.2.16.5. Stage measurements (upstream and downstream), sensor offset levels, and calculated flow values for flume at summer pasture 8 in 1999.

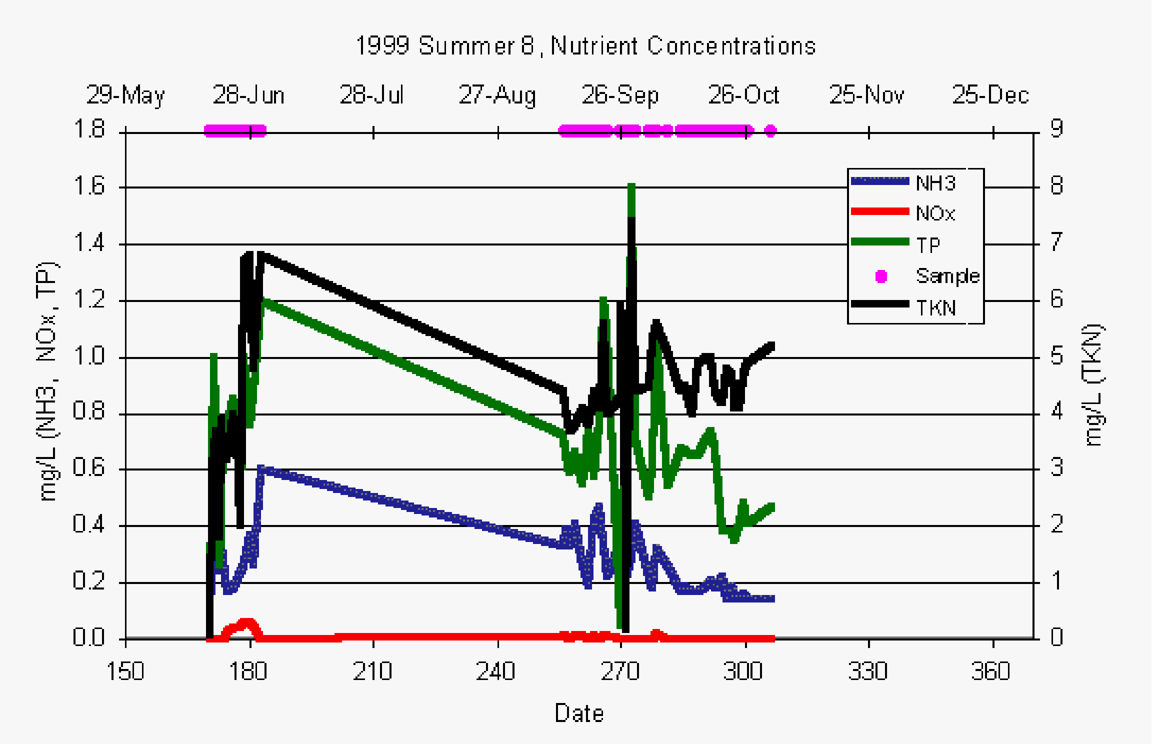


Figure 5.2.16.6. Collection dates and nutrient concentration results as elemental N and P of autosamples from summer pasture 8 in 1999.

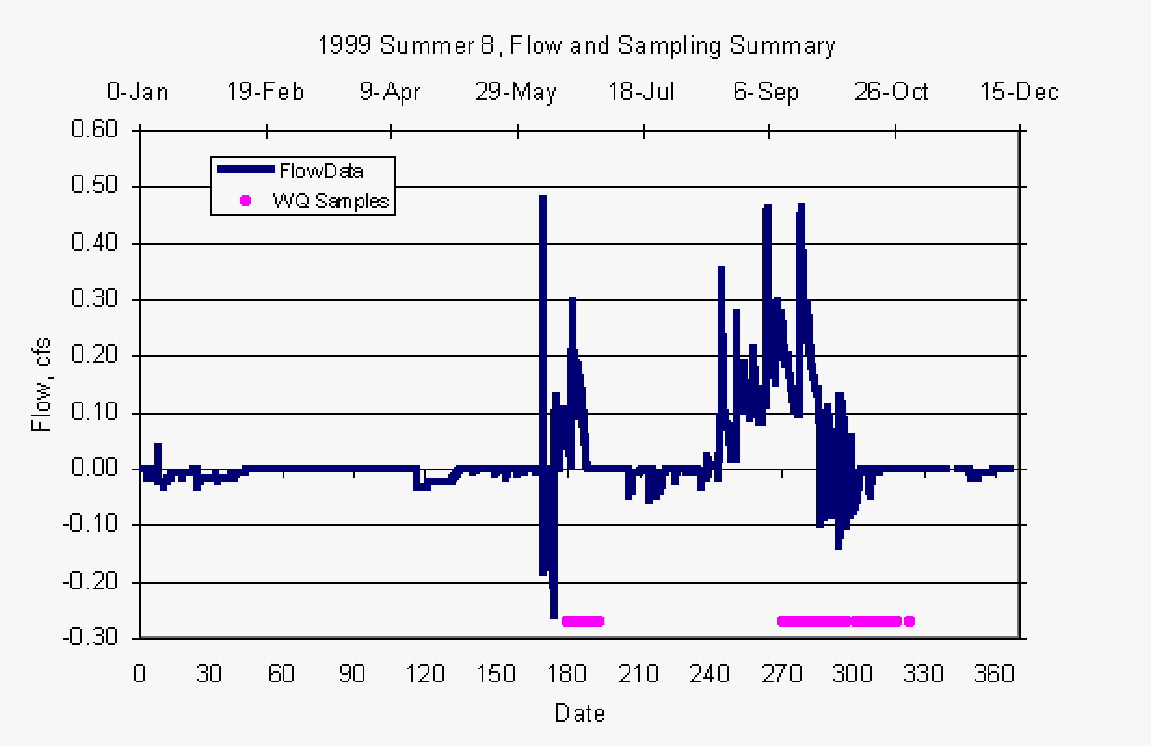


Figure 5.2.16.7. Collection dates and calculated runoff flow values for summer pasture 8 in 1999.

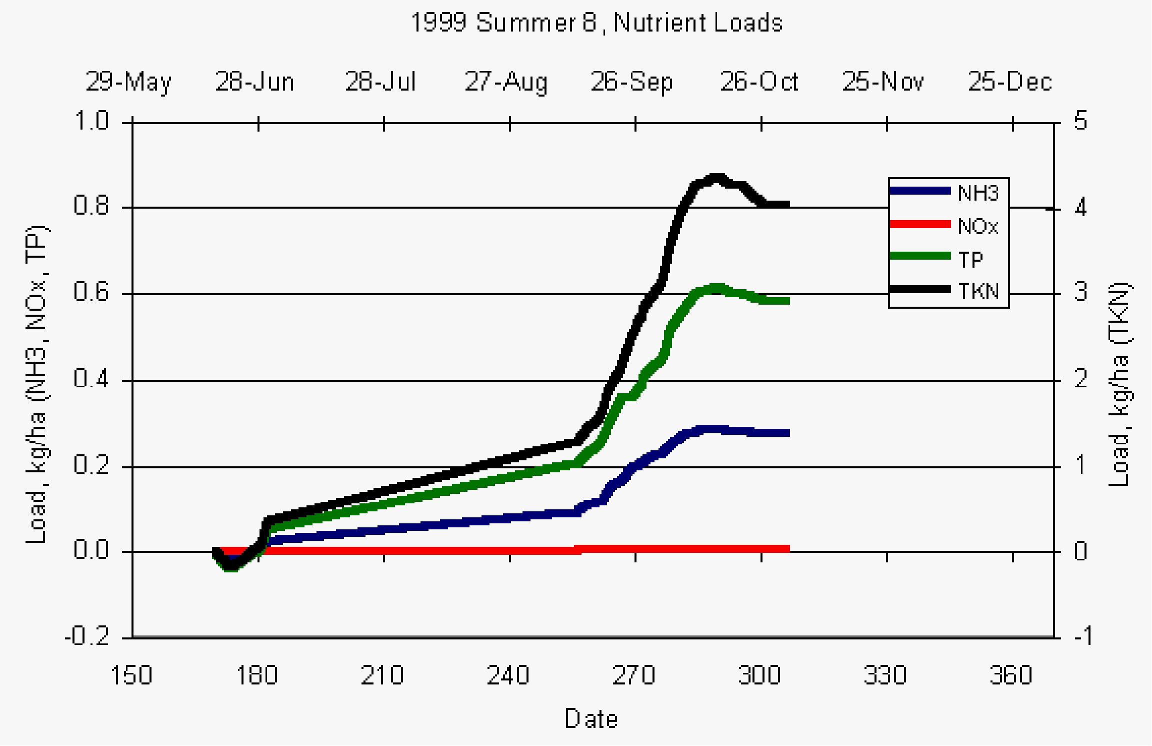


Figure 5.2.16.8. Nutrient loads in kg/ha of elemental N and P as calculated using autosamples at summer pasture 8 in 1999.

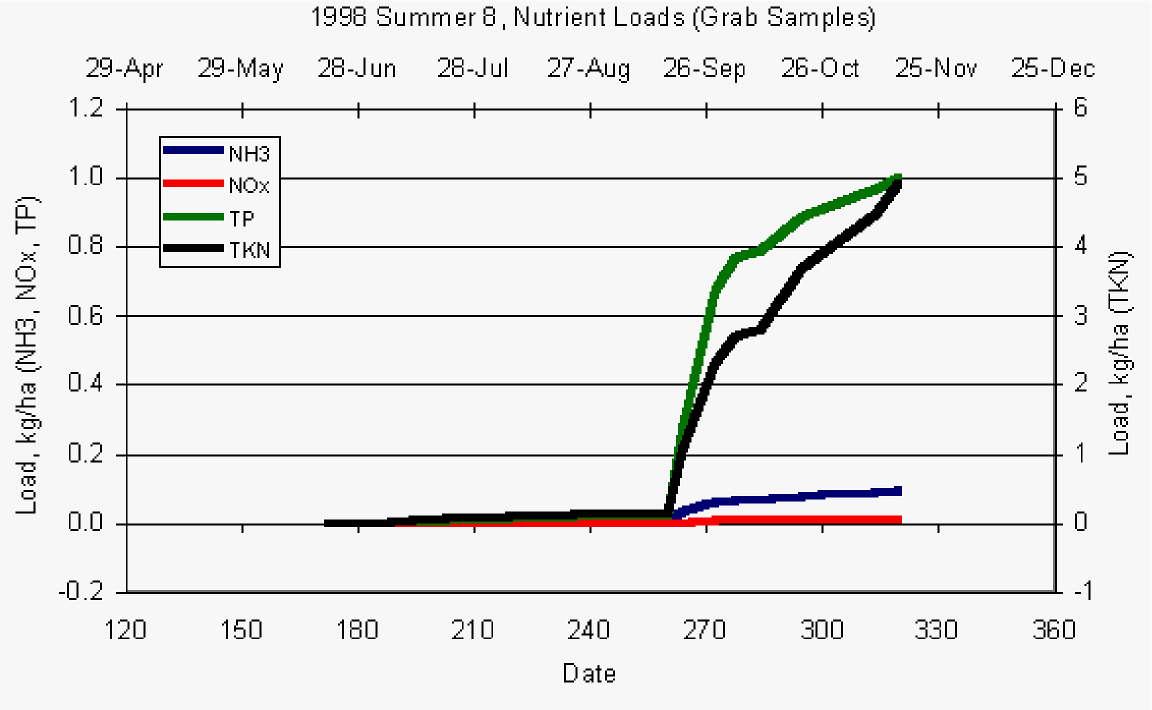


Figure 5.2.16.9. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 8 in 1998.

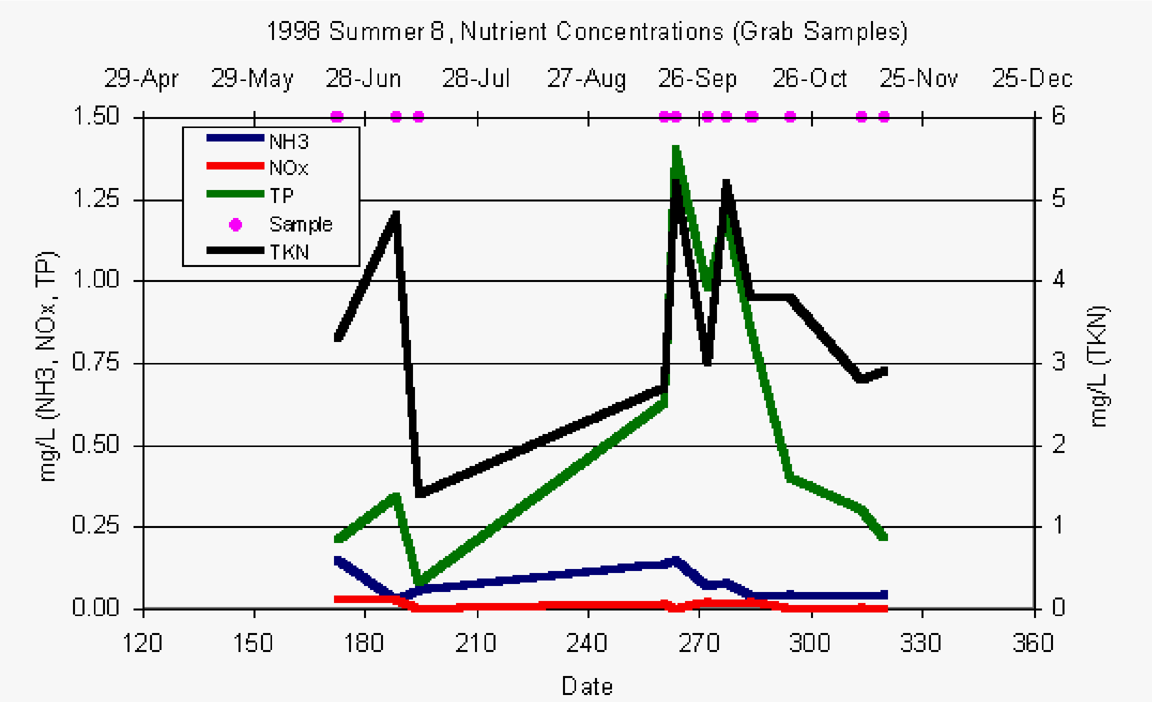


Figure 5.2.16.10. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 8 in 1998.

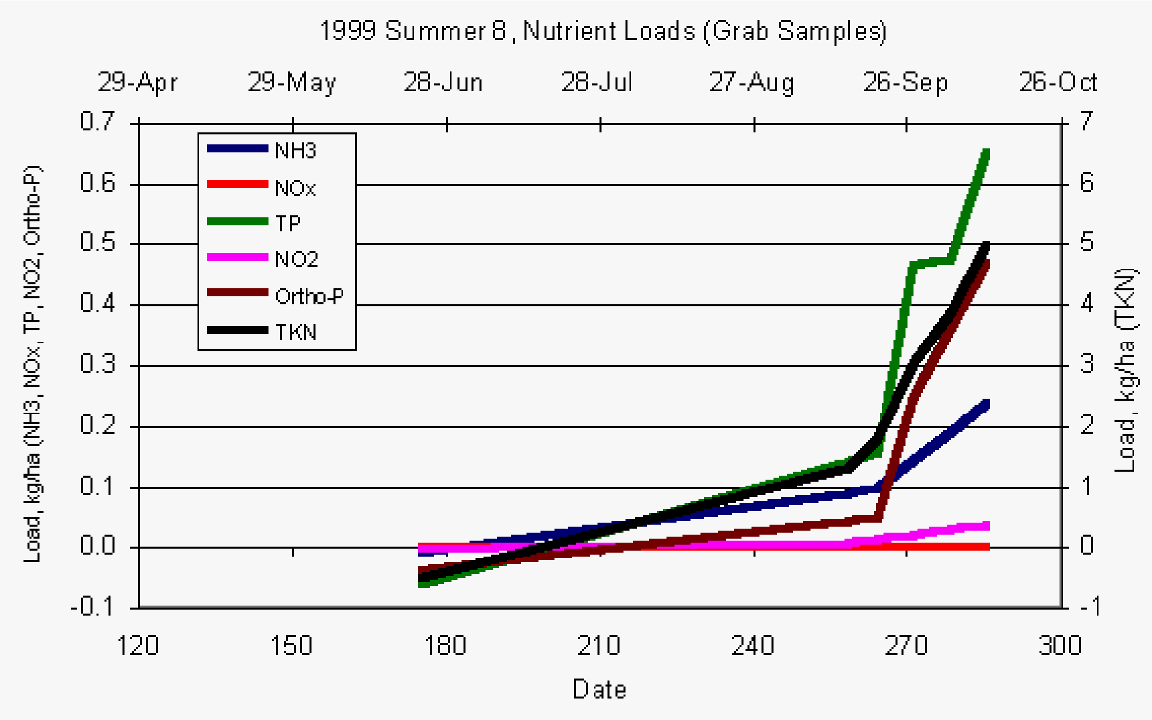


Figure 5.2.16.11. Nutrient loads in kg/ha of elemental N and P as calculated using grab samples at summer pasture 8 in 1999.

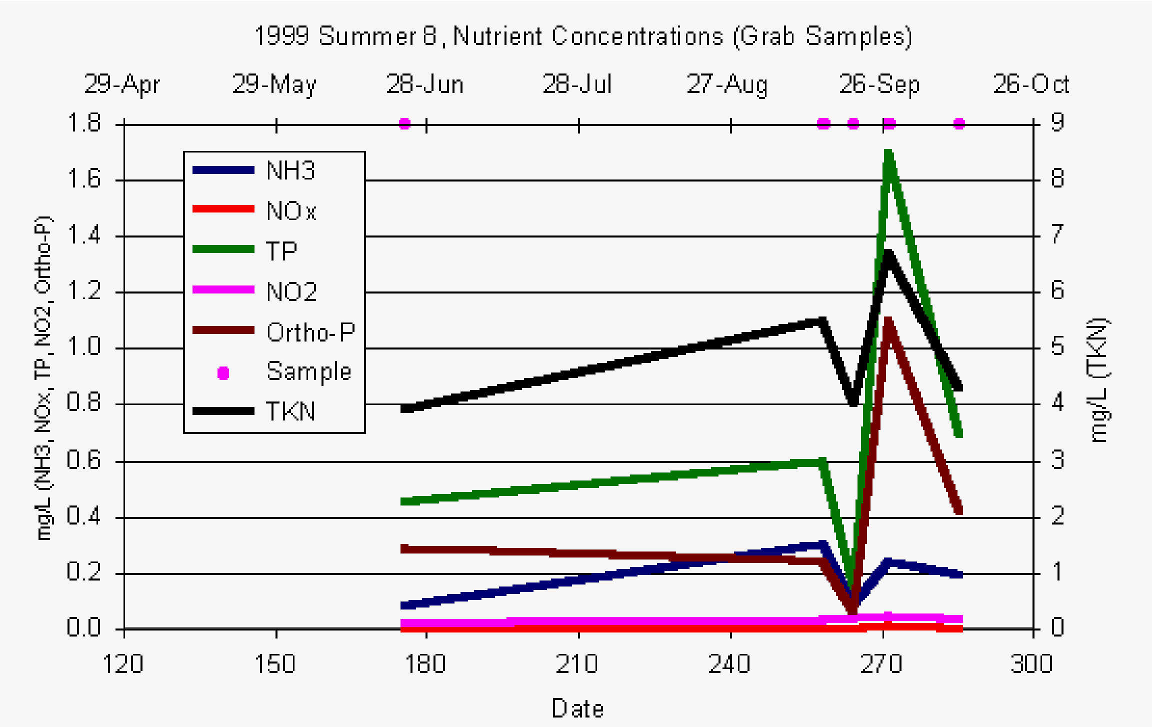


Figure 5.2.16.12. Collection dates and nutrient concentration results as elemental N and P of grab samples from summer pasture 8 in 1999.

6. Physical Parameters

6.1. Measurement Results

Beginnings in 1999 water quality physical parameters were measured at the time of grab sample collection in each flume. Methods employed for these field tests (conductivity, pH, temperature and dissolved oxygen) are described in the project SOP in Appendix B. Samples were collected at approximately 50% of the total water depth in the ditch adjacent to the flume.

Table 6.1.1 and Figure 6.1.1 provide the most condensed summary of these measurements in the form of site averages of all measurements. Tables 6.1.2 to 6.1.5 present the data for each individual test. Tables 6.1.6 to 6.1.11 and Figures 6.1.2 to 6.1.7 present the data for each sampling date. Tables 6.1.12 and 6.1.13 organize the values by summer and winter plots, respectively. Figures 6.1.8 to 6.1.23 show results for each pasture plot individually.

The general observations drawn from the results are that the water quality physical parameters appear degraded on the summer plots as compared to the winter plots. Electrical conductivity for the winter plots averaged 1600 uS/cm while the summer plots were 3500 uS/cm. Dissolved oxygen on both plots were low with winter averaging 2.1 mg/L and summer averaging 0.7 mg/L. The pH average on the winter plots (5.1) was slightly lower than the summer plots (6.0).

6.2. QA/QC Results

Tables 6.2.1 to 6.2.5 and Figures 6.2.1 to 6.2.5 present results of field duplicate and equipment blank measurements. Results from both field duplicates and equipment blanks were generally good.

Table 6.1.1. Average of all physical parameter measurements by site and array (control plots highlighted).

Site	Depth (feet)	SD	Temp (deg C)	SD	Conductivity (x100 µS/cm)	SD	pH	SD	DO (mg/L)	SD
S1	1.3	0.6	26	1.0	2.6	0.8	5.4	0.3	0.6	0.3
S2	1.2	0.4	26	1.0	2.8	1.1	5.7	0.2	0.6	0.1
S3	0.9	0.2	27	1.7	2.8	1.1	6.0	0.2	0.8	0.3
S4	1.3	0.4	26	1.1	2.9	1.2	5.8	0.3	0.9	0.6
S5	1.3	0.6	26	0.8	4.7	2.2	6.0	0.4	0.7	0.3
S6	0.9	0.2	27	0.8	3.6	1.9	6.3	0.3	0.6	0.2
S7	0.9	0.2	27	1.2	2.8	1.4	6.1	0.3	0.8	0.3
S8	1.0	0.4	28	1.0	3.2	0.7	6.2	0.5	0.8	0.3
S average	1.1	0.2	27	0.5	3.2	0.7	5.9	0.3	0.7	0.1
W1	1.0	0.0	25	1.9	1.9	0.2	5.7	0.5	1.2	0.5
W2	1.2	0.4	26	1.7	1.7	0.2	5.0	0.6	1.0	0.4
W3	0.9	0.2	26	3.4	1.5	0.4	5.5	0.2	3.0	1.5
W4	0.9	0.4	27	3.2	1.5	0.1	5.1	0.2	2.9	1.3
W5	0.8	0.3	26	2.3	1.4	0.2	4.8	0.1	2.2	0.4
W6	0.8	0.3	27	3.1	1.5	0.2	4.8	0.2	2.4	0.5
W7	1.1	0.4	27	2.7	1.8	0.3	4.9	0.2	1.8	0.5
W8	0.9	0.2	27	3.2	1.6	0.3	5.1	0.3	2.4	1.2
W average	0.9	0.1	26	0.6	1.6	0.2	5.1	0.3	2.1	0.7

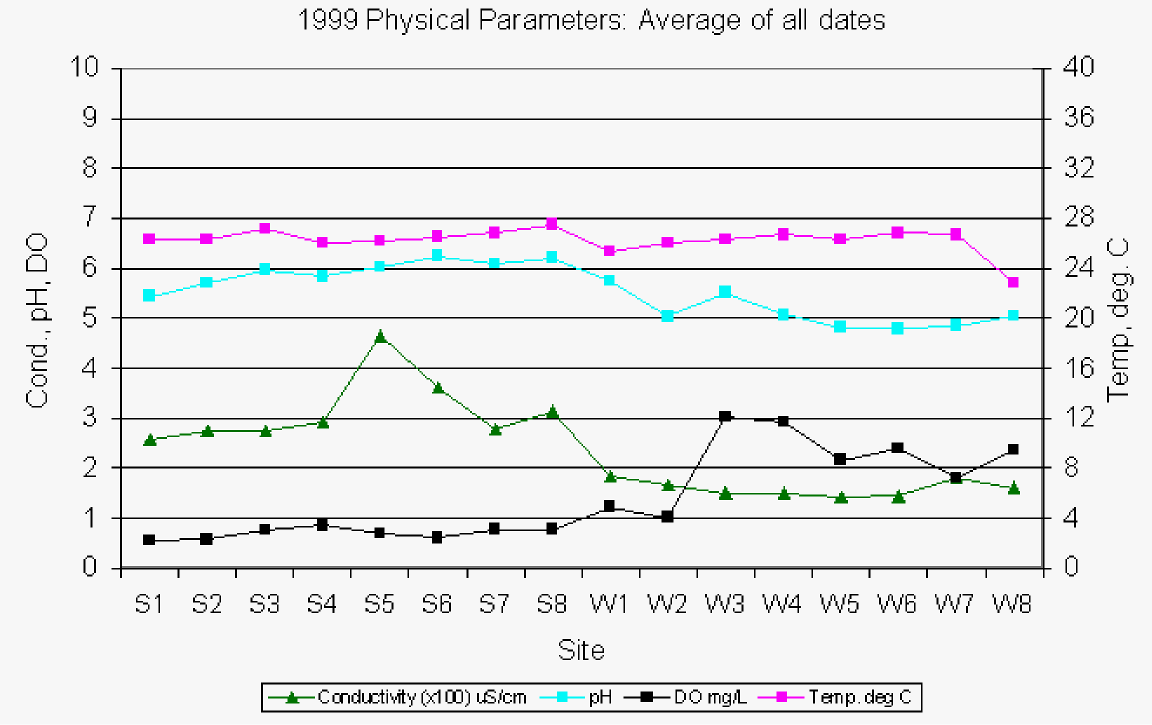


Figure 6.1.1. Mean values of water quality physical parameters for each pasture plot.

Table 6.1.2. Temperature (deg C) measurements by site and date (control plots highlighted).

Site	Date						Average
	10-Jun	25-Jun	17-Sep	22-Sep	29-Sep	13-Oct	
S1	26	28	27	27	26	25	26
S2	26	28	26	26	26	25	26
S3	26	30	27	27	27	25	27
S4	25	28	26	26	26	25	26
S5	26	27	26	26	26	25	26
S6	26	28	27	26	26	26	27
S7	26	27	29	26	26	26	27
S8	27	29	28	28	27	26	28
W1	25	29	24	25	25	24	25
W2	26	29	26	25	25	24	26
W3	26	33	25	24	24	24	26
W4	26	33	26	25	25	24	27
W5	25	31	26	25	25	25	26
W6	26	33	26	26	26	24	27
W7	25	32	27	25	25	25	27
W8		33	26	26	27	25	27

Table 6.1.3. Conductivity (x100 µS/cm) measurements by site and date (control plots highlighted).

Site	Date						Average
	10-Jun	25-Jun	17-Sep	22-Sep	29-Sep	13-Oct	
S1	3.1	2.6	1.1	2.9	2.8	3.2	2.6
S2	3.1	3.6	0.7	2.7	2.7	3.4	2.8
S3	3.3	3.3	0.6	2.9	2.9	3.3	2.8
S4	3.4	3.3	0.5	3.1	3.1	4.0	2.9
S5	4.9	6.5	0.5	4.5	4.5	6.0	4.7
S6	4.8	3.1	0.4	4.7	4.7	3.0	3.6
S7	3.4	3.0	0.4	3.2	3.2	2.3	2.8
S8	3.2	3.6	1.6	3.3	3.6	3.5	3.2
W1	2.0	1.8	1.7	1.5	2.0	2.2	1.9
W2	1.6	2.0	1.5	1.7	1.7	1.7	1.7
W3	1.3	1.2	2.4	1.4	1.4	1.5	1.5
W4	1.5	1.7	1.3	1.5	1.5	1.6	1.5
W5	1.3	1.6	1.6	1.3	1.3	1.5	1.4
W6	1.3	1.8	1.4	1.4	1.4	1.4	1.5
W7	1.7	1.9	1.9	2.2	2.2	1.4	1.8
W8	1.6	1.7	1.1	1.9	1.6	1.8	1.6

Table 6.1.4. pH measurements by site and date (control plots highlighted).

Site	Date						Average
	10-Jun	25-Jun	17-Sep	22-Sep	29-Sep	13-Oct	
S1	3.1	6.1	5.1	2.9	5.4	5.5	5.5
S2	3.1	6.1	5.8	2.7	5.5	5.7	5.7
S3	3.3	6.1	6.1	2.9	5.7	6.1	6.0
S4	3.4	6.0	5.4	3.1	5.6	6.3	5.8
S5	4.9	6.0	5.6	4.5	5.4	6.6	6.0
S6	4.8	5.9	6.0	4.7	6.3	6.7	6.3
S7	3.4	5.6	5.9	3.2	6.2	6.3	6.1
S8	3.2	5.6	6.0	3.3	6.7	6.7	6.2
W1	2.0	6.7	5.8	1.5	5.6	5.7	5.7
W2	1.6	5.7	4.7	1.7	4.6	5.7	5.0
W3	1.3	5.7	5.6	1.4	5.3	5.7	5.5
W4	1.5	5.1	5.4	1.5	5.0	5.0	5.1
W5	1.3	4.7	5.1	1.3	4.8	4.8	4.8
W6	1.3	4.7	5.1	1.4	4.7	4.8	4.8
W7	1.7	4.7	5.2	2.2	5.0	4.8	4.9
W8	1.6	4.9	5.0	1.9	5.0	5.0	5.1

Table 6.1.5. DO (mg/L) measurements by site and date (control plots highlighted).

Site	Date						Average
	10-Jun	25-Jun	17-Sep	22-Sep	29-Sep	13-Oct	
S1	1.0	0.3	0.7	1.0	0.5	0.6	0.6
S2	0.5	0.5	0.6	0.4	0.4	0.8	0.6
S3	1.0	0.6	0.8	1.0	1.0	1.0	0.8
S4	2.0	0.4	0.4	0.7	0.7	0.9	0.9
S5	1.0	0.4	0.6	0.5	0.5	1.2	0.7
S6	0.5	0.4	0.6	0.6	0.6	1.1	0.6
S7	0.9	0.4	1.0	0.9	0.9	1.0	0.8
S8	0.9	0.5	1.2	0.9	0.5	0.7	0.8
W1	1.7	0.9	0.8	2.0	1.0	0.9	1.2
W2	1.7	0.7	1.1	0.9	0.9	0.9	1.0
W3	3.9	5.6	1.5	2.2	2.2	2.8	3.0
W4	4.6	4.7	2.0	1.8	1.8	2.3	2.9
W5	2.3	2.9	1.8	2.2	2.2	1.8	2.2
W6	2.5	3.0	2.2	2.9	2.9	1.9	2.4
W7	2.7	1.9	1.0	1.7	1.7	1.8	1.8
W8	3.0	4.4	2.4	1.6	1.5	2.4	2.4

Table 6.1.6. Water quality physical parameters for all sites on June 10, 1999 (control plots highlighted).

Site	Temp (deg C)	Conductivity (x100 µS/cm)	pH	DO (mg/L)
S1	26	3.1	5.3	1.0
S2	26	3.1	5.6	0.5
S3	26	3.3	5.9	1.0
S4	25	3.4	5.9	2.0
S5	26	4.9	6.3	1.0
S6	26	4.8	6.3	0.5
S7	26	3.4	6.1	0.9
S8	27	3.2	6.5	0.9
S Average	25.9	3.7	5.9	1.0
W1	25	2.0	5.1	1.7
W2	26	1.6	4.4	1.7
W3	26	1.3	5.3	3.9
W4	26	1.5	4.8	4.6
W5	25	1.3	4.7	2.3
W6	26	1.3	4.7	2.5
W7	25	1.7	4.7	2.7
W8		1.6	4.9	3.0
W Average	25.6	1.5	4.8	2.8

Table 6.1.7. Water quality physical parameters for all sites on June 25, 1999 (control plots highlighted).

Site	Temp (deg C)	Conductivity (x100 µS/cm)	pH	DO (mg/L)
S1	28	2.6	6.1	0.3
S2	28	3.6	6.1	0.5
S3	30	3.3	6.1	0.6
S4	28	3.3	6.0	0.4
S5	27	6.5	6.0	0.4
S6	28	3.1	5.9	0.4
S7	27	3.0	5.6	0.4
S8	29	3.6	5.6	0.5
S Average	28.1	3.6	5.9	0.4
W1	29	1.8	6.7	0.9
W2	29	2.0	5.7	0.7
W3	33	1.2	5.7	5.6
W4	33	1.7	5.1	4.7
W5	31	1.6	4.7	2.9
W6	33	1.8	4.7	3.0
W7	32	1.9	4.7	1.9
W8	33	1.7	4.9	4.4
W Average	31.6	1.7	5.3	3.0

Table 6.1.8. Water quality physical parameters for all sites on September 17, 1999 (control plots highlighted).

Site	Temp (deg C)	Conductivity (x100 µS/cm)	pH	DO (mg/L)
S1	27	1.1	5.1	0.7
S2	26	0.7	5.8	0.6
S3	27	0.6	6.1	0.8
S4	26	0.5	5.4	0.4
S5	26	0.5	5.6	0.6
S6	27	0.4	6.0	0.6
S7	29	0.4	5.9	1.0
S8	28	1.6	6.0	1.2
S Average	27.0	0.7	5.7	0.7
W1	24	1.7	5.8	0.8
W2	26	1.5	4.7	1.1
W3	25	2.4	5.6	1.5
W4	26	1.3	5.4	2.0
W5	26	1.6	5.1	1.8
W6	26	1.4	5.1	2.2
W7	27	1.9	5.2	1.0
W8	25	1.1	5.0	2.4
W Average	25.6	1.6	5.2	1.6

Table 6.1.9. Water quality physical parameters for all sites on September 22, 1999 (control plots highlighted).

Site	Temp (deg C)	Conductivity (x100 µS/cm)	pH	DO (mg/L)
S1	27	2.9	5.7	1.0
S2	26	2.7	5.5	0.4
S3	27	2.9	5.7	1.0
S4	26	3.1	5.6	0.7
S5	26	4.5	5.4	0.5
S6	26	4.7	6.3	0.6
S7	26	3.2	6.2	0.9
S8	28	3.3	5.9	0.9
S Average	26.5	3.4	5.8	0.7
W1	25	1.5	5.4	2.0
W2	25	1.7	4.6	0.9
W3	24	1.4	5.3	2.2
W4	25	1.5	5.0	1.8
W5	25	1.3	4.8	2.2
W6	26	1.4	4.7	2.9
W7	25	2.2	5.0	1.7
W8	26	1.9	5.0	1.6
W Average	25.1	1.6	5.0	1.9

Table 6.1.10. Water quality physical parameters for all sites on September 29, 1999 (control plots highlighted).

Site	Temp (deg C)	Conductivity (x100 µS/cm)	pH	DO (mg/L)
S1	26	2.8	5.4	0.5
S2	26	2.7	5.5	0.4
S3	27	2.9	5.7	1.0
S4	26	3.1	5.6	0.7
S5	26	4.5	5.4	0.5
S6	26	4.7	6.3	0.6
S7	26	3.2	6.2	0.9
S8	27	3.6	6.7	0.5
S Average	26.3	3.4	5.9	0.6
W1	25	2.0	5.6	1.0
W2	25	1.7	4.6	0.9
W3	24	1.4	5.3	2.2
W4	25	1.5	5.0	1.8
W5	25	1.3	4.8	2.2
W6	26	1.4	4.7	2.9
W7	25	2.2	5.0	1.7
W8	27	1.6	5.0	1.5
W Average	25.3	1.6	5.0	1.8

Table 6.1.11. Water quality physical parameters for all sites on October 13, 1999 (control plots highlighted).

Site	Temp (deg C)	Conductivity (x100 µS/cm)	pH	DO (mg/L)
S1	25	3.2	5.5	0.6
S2	25	3.4	5.7	0.8
S3	25	3.3	6.1	1.0
S4	25	4.0	6.3	0.9
S5	25	6.0	6.6	1.2
S6	26	3.0	6.7	1.1
S7	26	2.3	6.3	1.0
S8	26	3.5	6.7	0.7
S Average	25.4	3.6	6.2	0.9
W1	24	2.2	5.7	0.9
W2	24	1.7	5.7	0.9
W3	24	1.5	5.7	2.8
W4	24	1.6	5.0	2.3
W5	25	1.5	4.8	1.8
W6	24	1.4	4.8	1.9
W7	25	1.4	4.8	1.8
W8	25	1.8	5.0	2.4
W Average	24.4	1.6	5.2	1.9

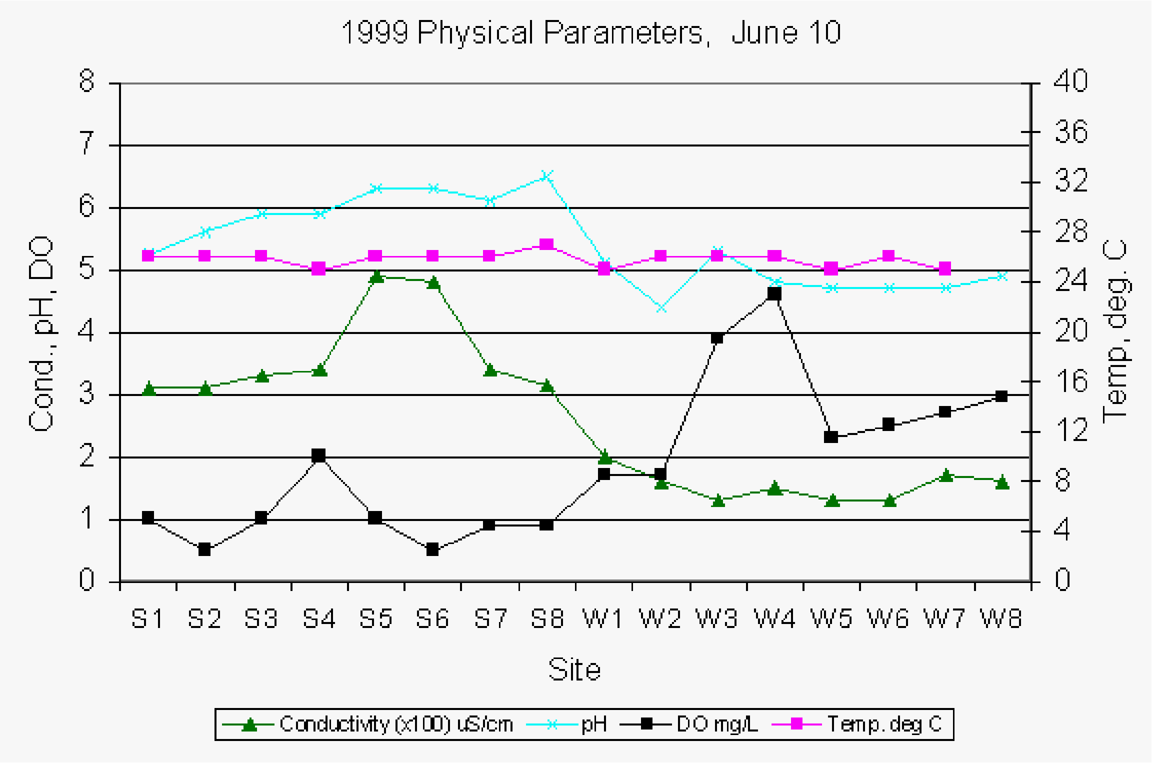


Figure 6.1.2. Summary of physical parameter measurements for each pasture plot on June 10, 1999.

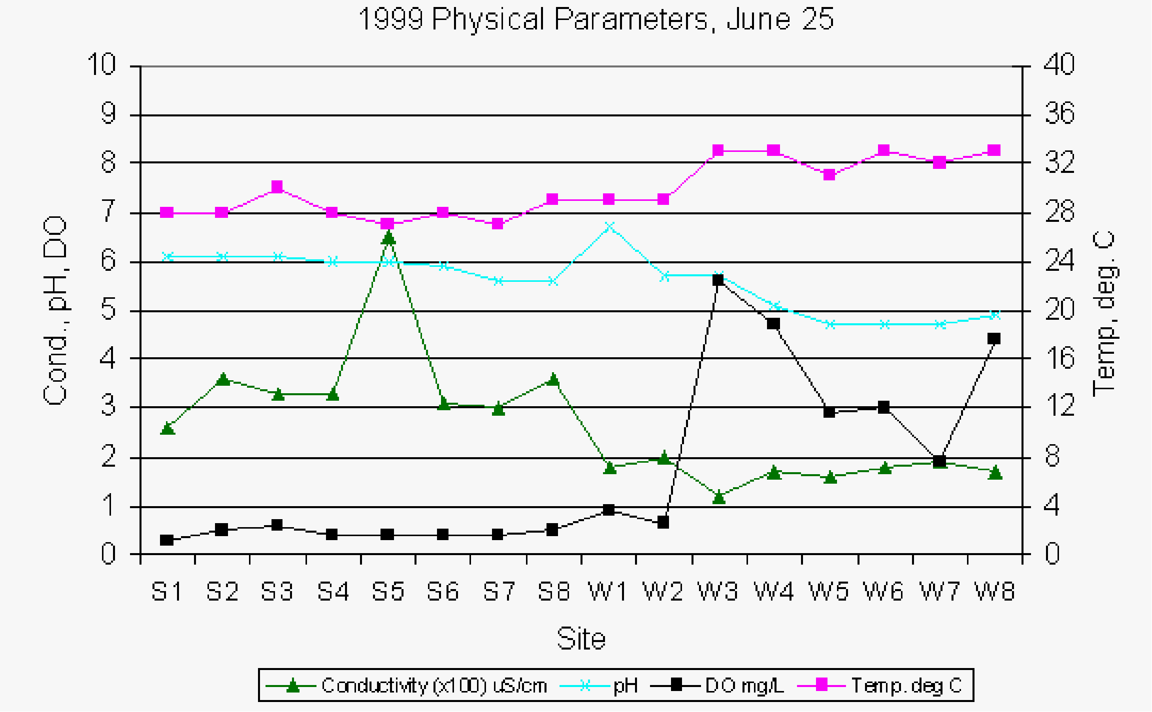


Figure 6.1.3. Summary of physical parameter measurements for each pasture plot on June 25, 1999.

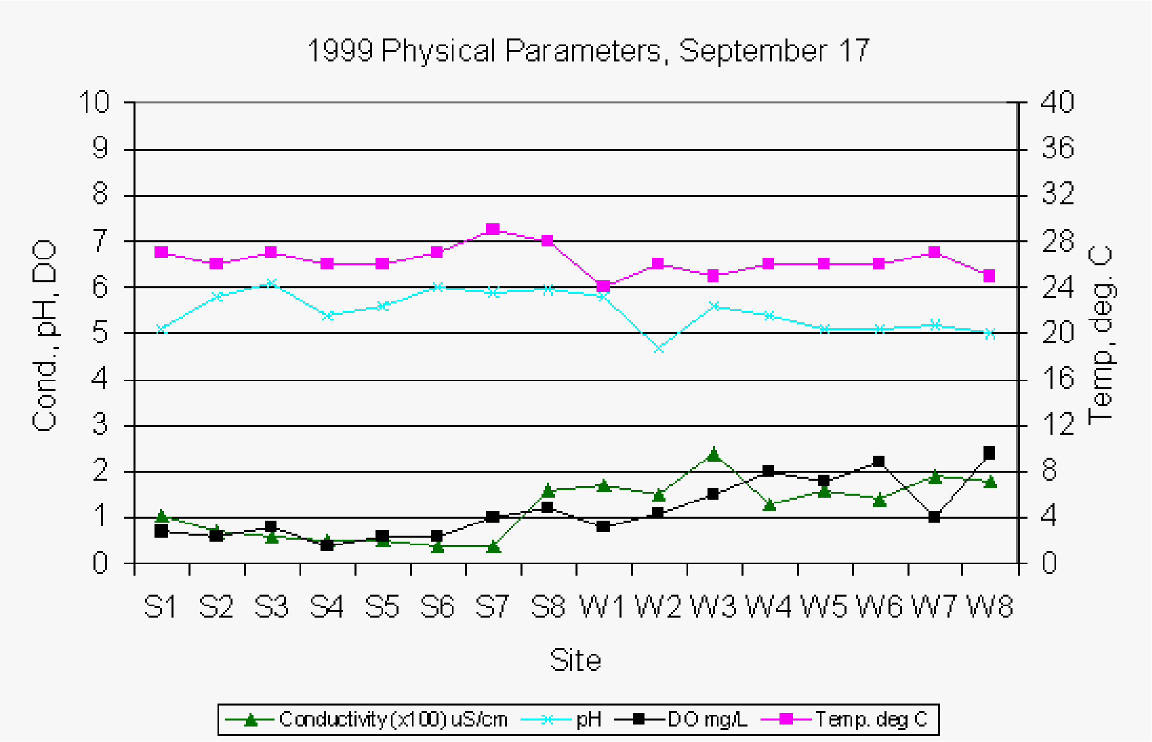


Figure 6.1.4. Summary of physical parameter measurements for each pasture plot on September 17, 1999.

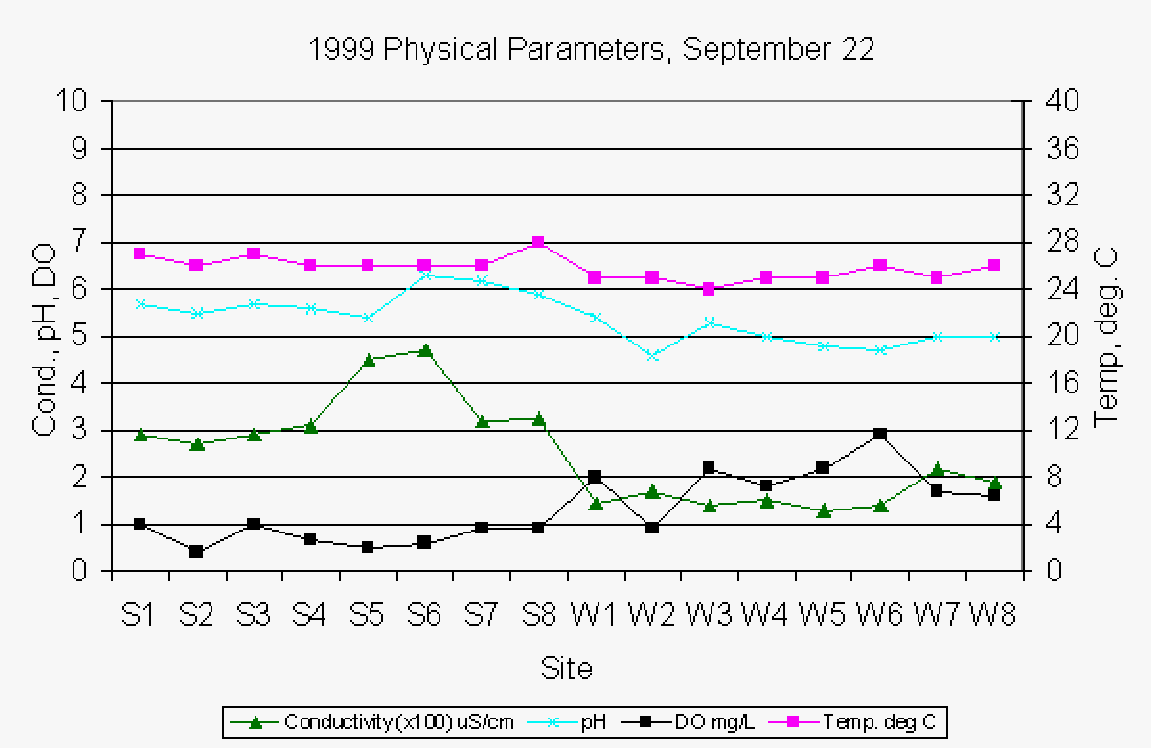


Figure 6.1.5. Summary of physical parameter measurements for each pasture plot on September 22, 1999.

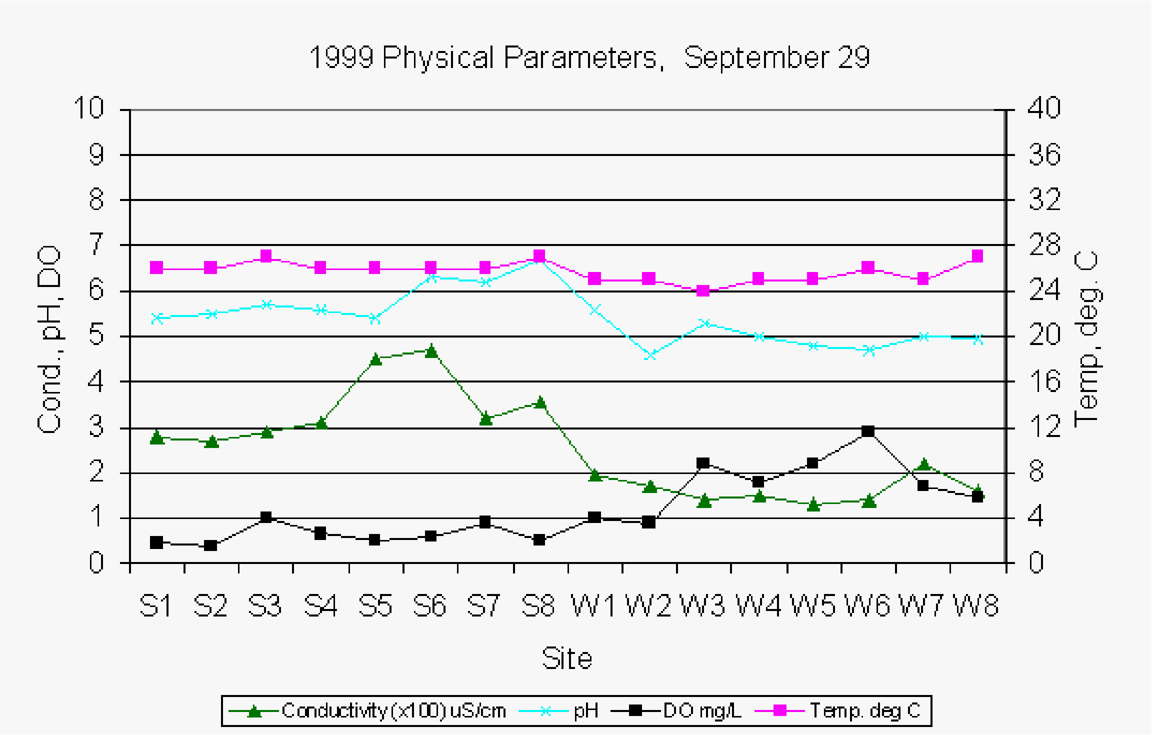


Figure 6.1.6. Summary of physical parameter measurements for each pasture plot on September 29, 1999.

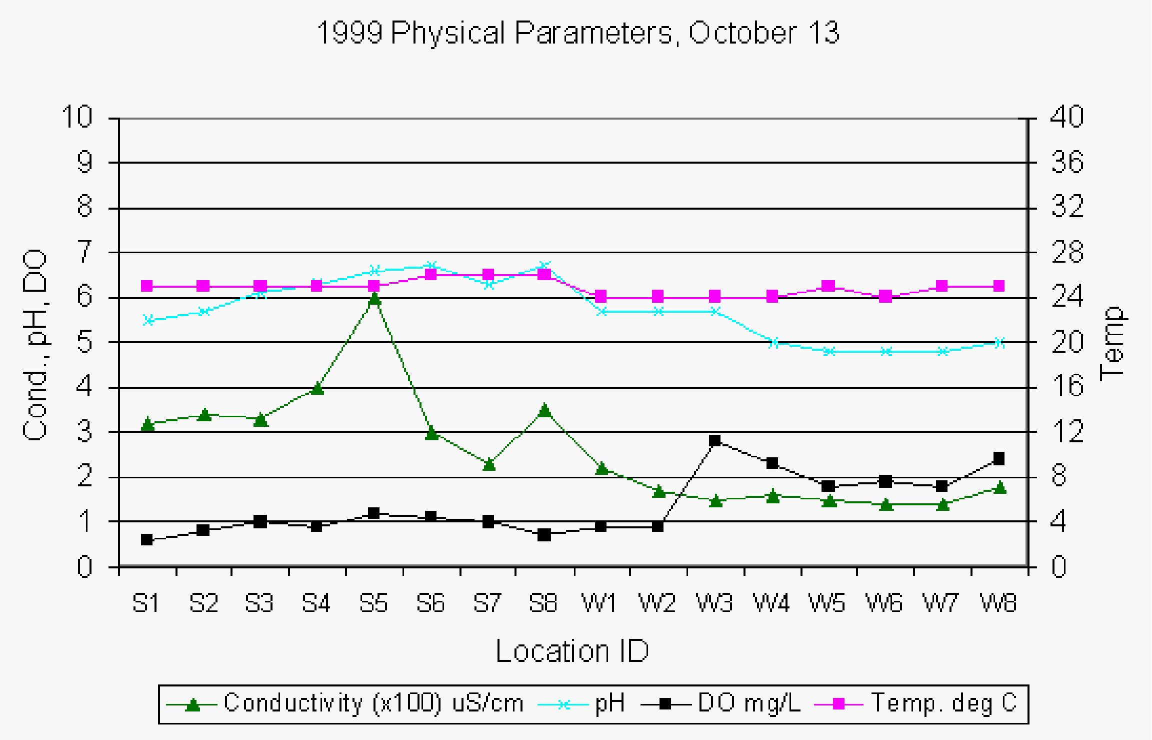


Figure 6.1.7. Summary of physical parameter measurements for each pasture plot on October 13, 1999.

Table 6.1.12. Summer pastures water quality physical parameter measurements (control plots highlighted).

Site	Date	Depth (feet)	Temperature (deg C)	Conductivity (x100) µS/cm	pH	DO (mg/L)
S1	10-Jun	2.5	26.0	3.1	5.3	1.0
	25-Jun	1.0	28.0	2.6	6.1	0.3
	17-Sep	1.0	27.0	1.1	5.1	0.7
	22-Sep	1.5	26.0	2.9	5.4	0.4
	29-Sep	1.0	26.0	2.8	5.4	0.5
	13-Oct	1.0	25.0	3.2	5.5	0.6
S2	10-Jun	1.5	26.0	3.1	5.6	0.5
	25-Jun	1.0	28.0	3.6	6.1	0..5
	17-Sep	1.5	26.0	0.7	5.8	0.6
	22-Sep	1.0	26.0	2.7	5.5	0.4
	29-Sep	1.5	27.0	3.0	5.6	0..7
	13-Oct	0.5	25.0	3.4	5.7	0.8
S3	10-Jun	1.0	26.0	3.3	5.9	1.0
	25-Jun	1.0	30.0	3.3	6.1	0.6
	17-Sep	1.0	27.0	0.6	6.1	0.8
	22-Sep	1.0	27.0	2.9	5.7	1.0
	29-Sep	1.0	28.0	3.2	5.9	0.2
	13-Oct	0.5	25.0	3.3	6.1	1.0
S4	10-Jun	1.5	25.0	3.4	5.9	2.0
	25-Jun	1.0	28.0	3.3	6.0	0.4
	17-Sep	1.0	26.0	0.5	5.4	0.4
	22-Sep	2.0	26.0	3.1	5.6	0.7
	29-Sep	1.0	26.0	3.3	5.8	0.8
	13-Oct	1.5	25.0	4.0	6.3	0.9
S5	10-Jun	1.0	26.0	4.9	6.3	1.0
	25-Jun	1.0	27.0	6.5	6.0	0.4
	17-Sep	1.5	26.0	0.5	5.6	0.6
	22-Sep	2.5	26.0	4.5	5.4	0.5
	29-Sep	1.0	27.0	5.5	6.2	0.5
	13-Oct	1.0	25.0	6.0	6.6	1.2
S6	10-Jun	1.0	26.0	4.8	6.3	0.5
	25-Jun	1.0	28.0	3.1	5.9	0.4
	17-Sep	1.0	27.0	0.4	6.0	0.6
	22-Sep	0.5	26.0	4.7	6.3	0.6
	29-Sep	1.0	26.0	5.7	6.3	0.6
	13-Oct	1.0	26.0	3.0	6.7	1.1
S7	10-Jun	1.0	26.0	3.4	6.1	0.9
	25-Jun	1.0	27.0	3.0	5.6	0.4
	17-Sep	1.0	29.0	0.4	5.9	1.0
	22-Sep	0.5	26.0	3.2	6.2	0.9
	29-Sep	1.0	27.0	4.5	6.5	0.5
	13-Oct	1.5	26.0	2.3	6.3	1.0
S8	10-Jun		27.0	3.2	6.5	0.9
	25-Jun	1.0	29.0	3.6	5.6	0.5
	17-Sep	1.5	28.0	1.6	6.0	1.2
	22-Sep	0.5	28.0	3.3	5.9	0.9
	29-Sep	1.0	27.0	3.6	6.7	0.5
	13-Oct	1.0	26.0	3.5	6.7	0.7

Table 6.1.13. Winter pastures water quality physical parameter measurements (control plots highlighted).

Site	Date	Depth (feet)	Temperature (deg C)	Conductivity (x100) µS/cm	pH	DO (mg/L)
W1	10-Jun	1.0	25.0	2.0	5.1	1.7
	25-Jun	1.0	29.0	1.8	6.7	0.9
	17-Sep	1.0	24.0	1.7	5.8	0.8
	22-Sep	1.0	25.0	1.5	5.4	2.0
	29-Sep	1.0	25.0	2.0	5.6	1.0
	13-Oct	1.0	24.0	2.2	5.7	0.9
W2	10-Jun	1.0	26.0	1.6	4.4	1.7
	25-Jun	1.0	29.0	2.0	5.7	0.7
	17-Sep	2.0	26.0	1.5	4.7	1.1
	22-Sep	1.0	25.0	1.7	4.6	0.9
	29-Sep	1.0	26.0	1.6	5.1	0.9
	13-Oct	1.0	24.0	1.7	5.7	0.9
W3	10-Jun	1.0	26.0	1.3	5.3	3.9
	25-Jun	1.0	33.0	1.2	5.7	5.6
	17-Sep	0.5	25.0	2.4	5.6	1.5
	22-Sep	1.0	24.0	1.4	5.3	2.2
	29-Sep	1.0	26.0	1.3	5.5	2.2
	13-Oct	1.0	24.0	1.5	5.7	2.8
W4	10-Jun	1.5	26.0	1.5	4.8	4.6
	25-Jun	1.0	33.0	1.7	5.1	4.7
	17-Sep	1.0	26.0	1.3	5.4	2.0
	22-Sep	1.0	25.0	1.5	5.0	1.8
	29-Sep	0.5	26.0	1.5	5.1	2.2
	13-Oct	0.5	24.0	1.6	5.0	2.3
W5	10-Jun	1.0	25.0	1.3	4.7	2.3
	25-Jun	1.0	31.0	1.6	4.7	2.6
	17-Sep	0.5	26.0	1.6	5.1	1.8
	22-Sep	1.0	25.0	1.3	4.8	2.2
	29-Sep	0.5	26.0	1.3	4.8	2.0
	13-Oct	0.5	25.0	1.5	4.8	1.8
W6	10-Jun	1.0	26.0	1.3	4.7	2.5
	25-Jun	1.0	33.0	1.8	4.7	3.0
	17-Sep	1.0	26.0	1.4	5.1	2.2
	22-Sep	1.0	26.0	1.4	4.7	2.9
	29-Sep	0.5	26.0	1.4	4.7	1.9
	13-Oct	0.5	24.0	1.4	4.8	1.9
W7	10-Jun	1.5	25.0	1.7	4.7	2.7
	25-Jun	1.0	32.0	1.9	4.7	1.9
	17-Sep	0.5	27.0	1.9	5.2	1.0
	22-Sep	1.5	25.0	2.2	5.0	1.7
	29-Sep	1.0	26.0	1.7	4.7	1.7
	13-Oct	1.0	25.0	1.4	4.8	1.8
W8	10-Jun			1.6	4.9	3.0
	25-Jun	1.0	33.0	1.7	4.9	4.4
	17-Sep	0.5	26.0	1.1	5.6	1.6
	22-Sep	1.0	26.0	1.9	5.0	1.6
	29-Sep	1.0	27.0	1.6	5.0	1.5
	13-Oct	1.0	25.0	1.8	5.0	2.4

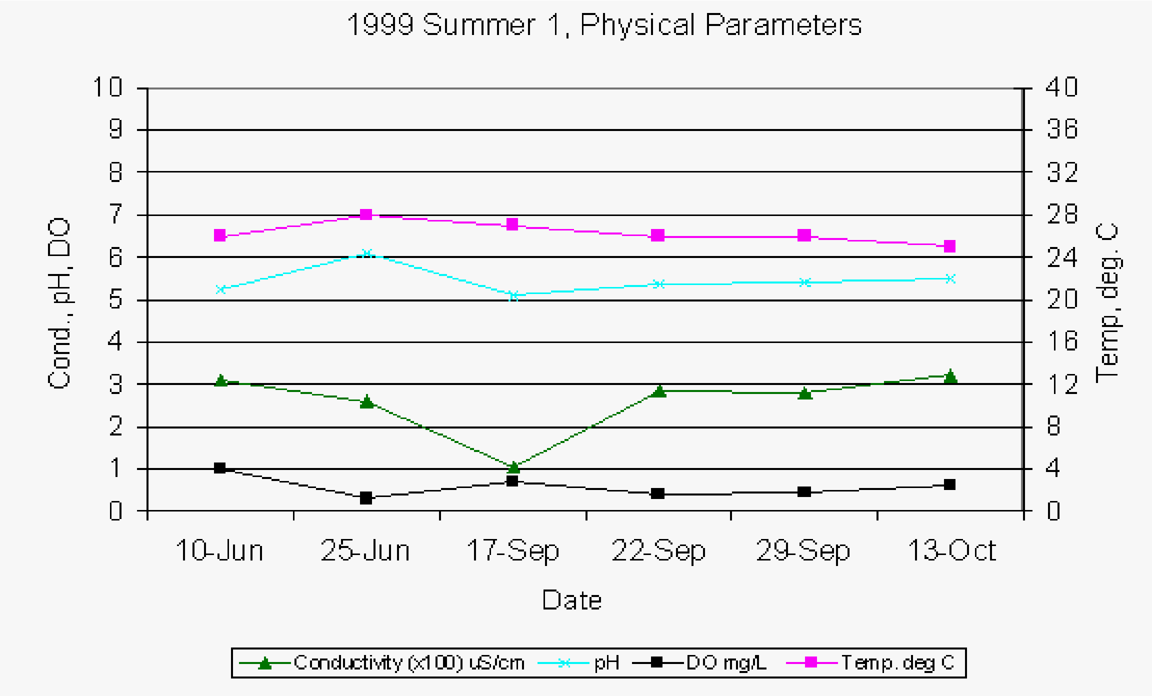


Figure 6.1.8. Mean values for water quality physical parameter measurement at summer pasture 1.

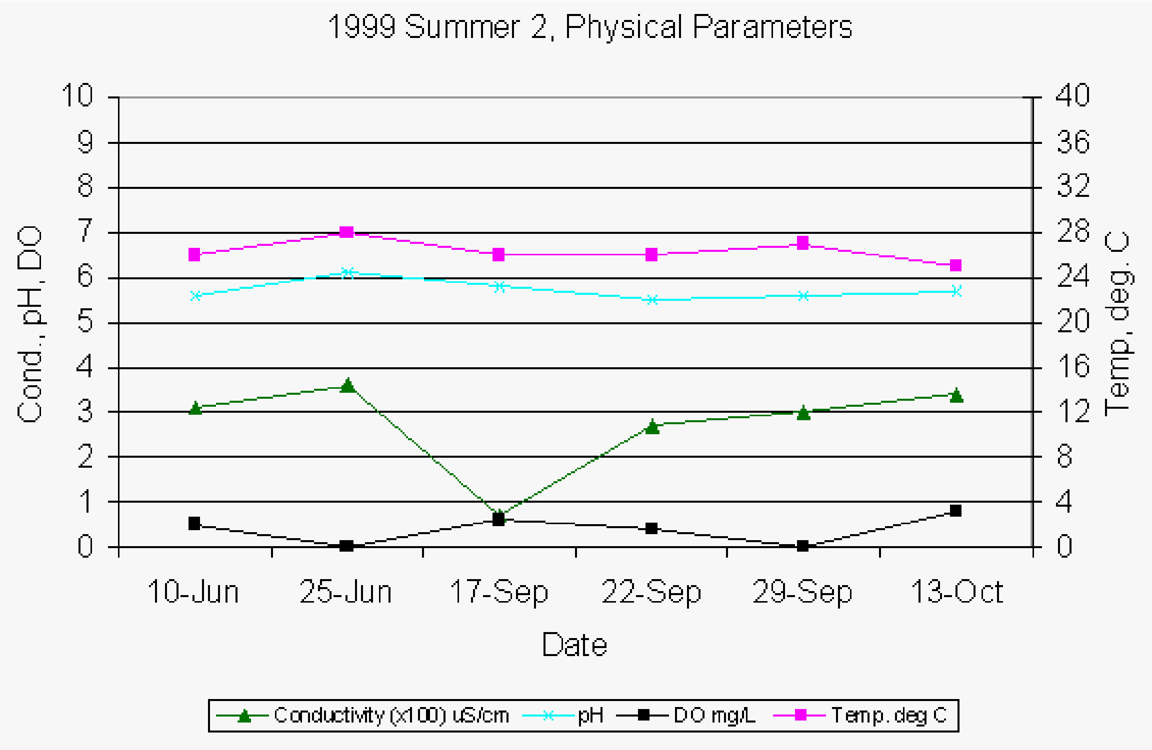


Figure 6.1.9. Mean values for water quality physical parameter measurement at summer pasture 2.

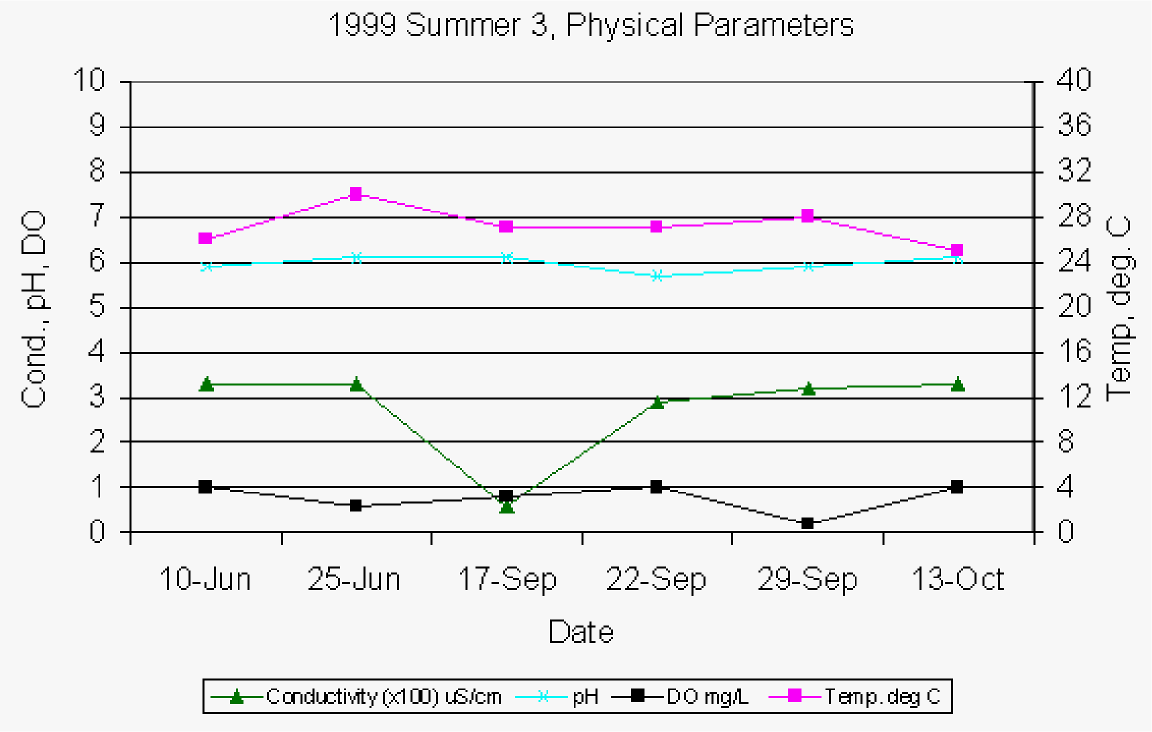


Figure 6.1.10. Mean values for water quality physical parameter measurement at summer pasture 3.

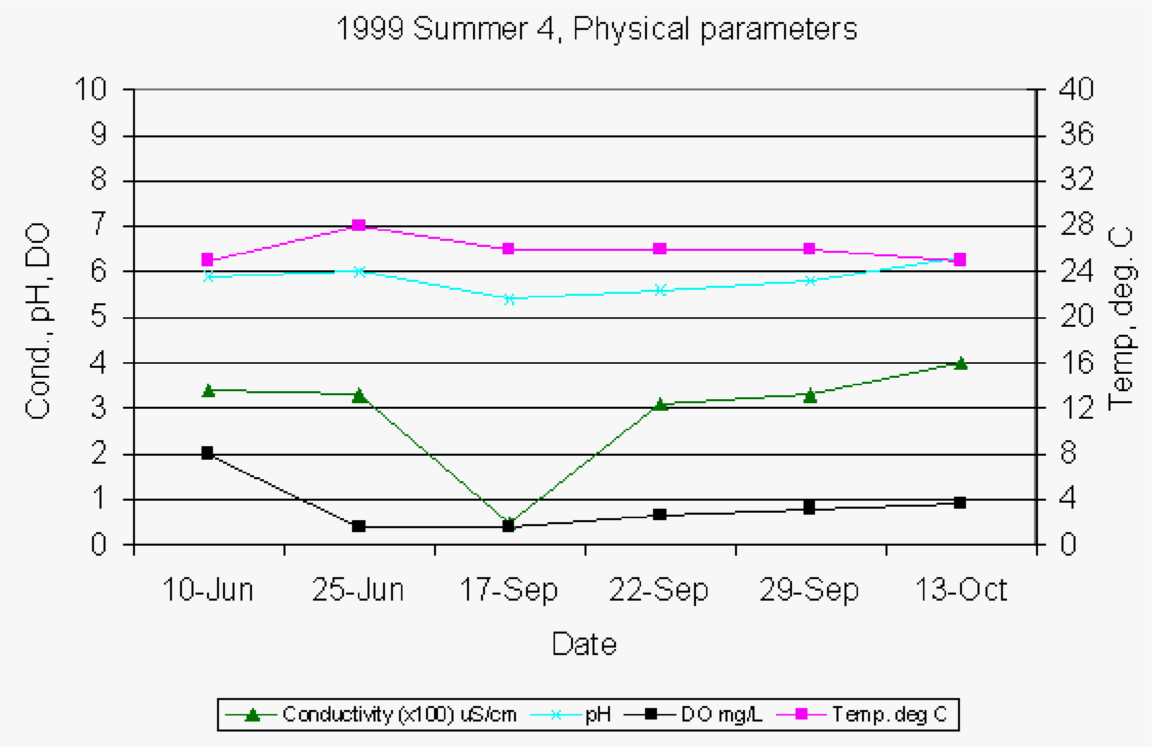


Figure 6.1.11. Mean values for water quality physical parameter measurement at summer pasture 4.

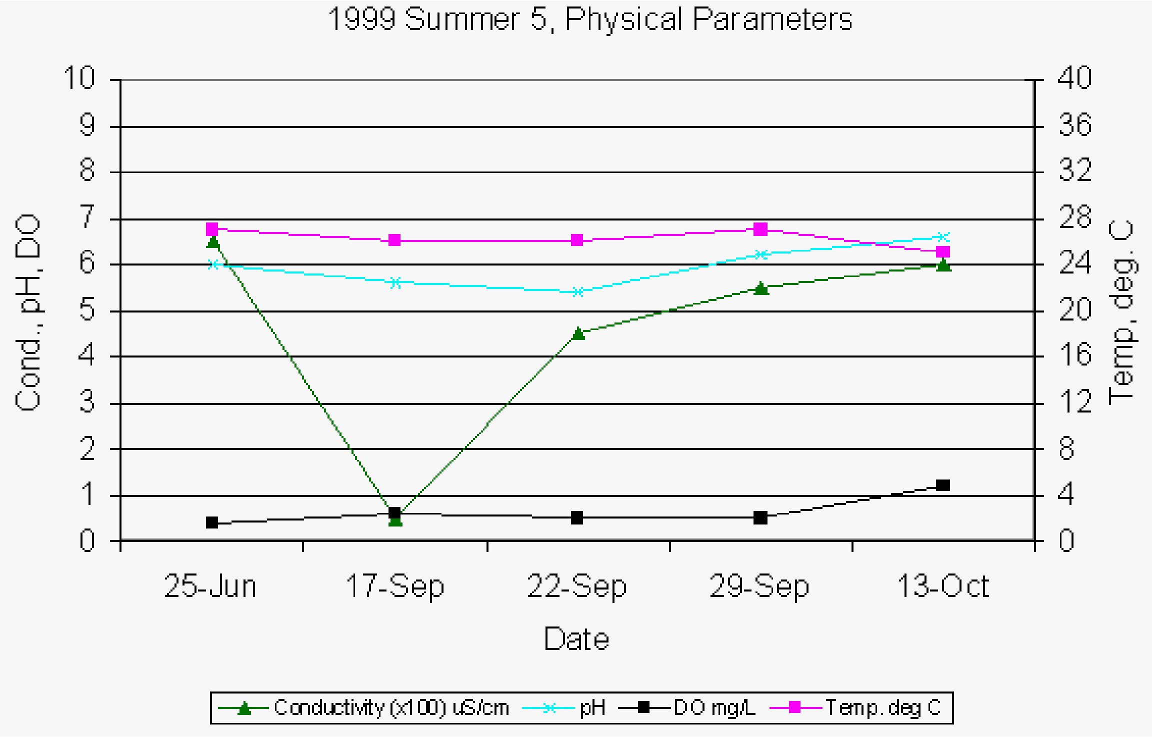


Figure 6.1.12. Mean values for water quality physical parameter measurement at summer pasture 5.

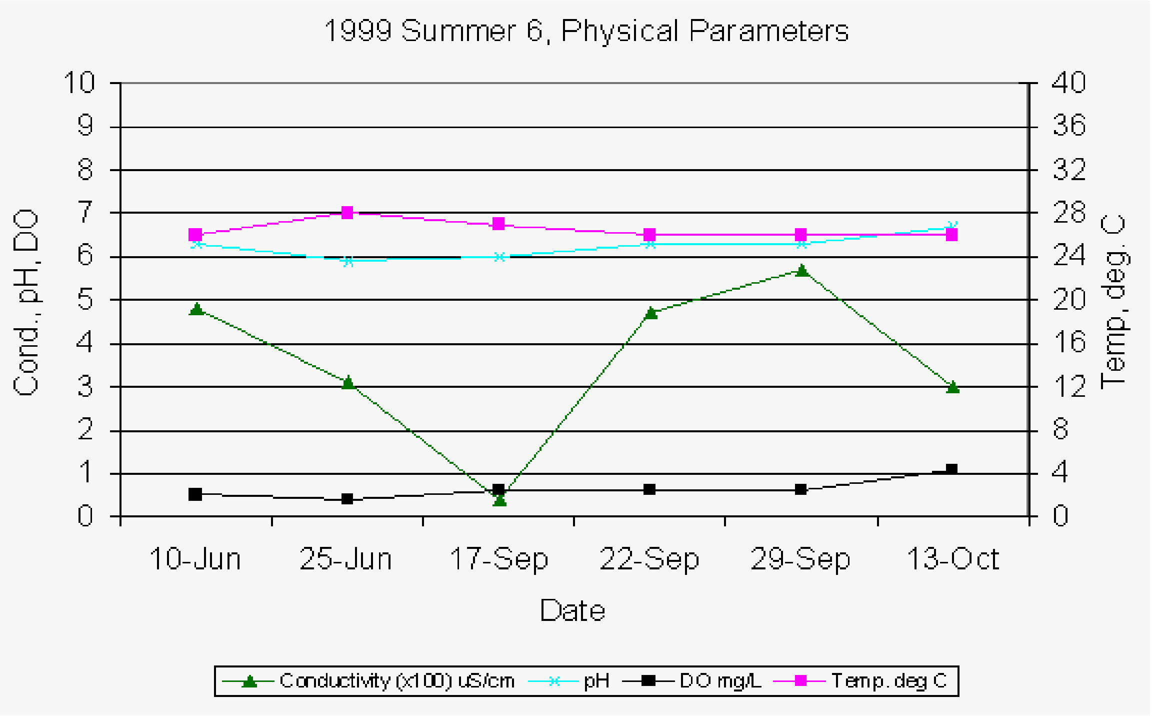


Figure 6.1.13. Mean values for water quality physical parameter measurement at summer pasture 6.

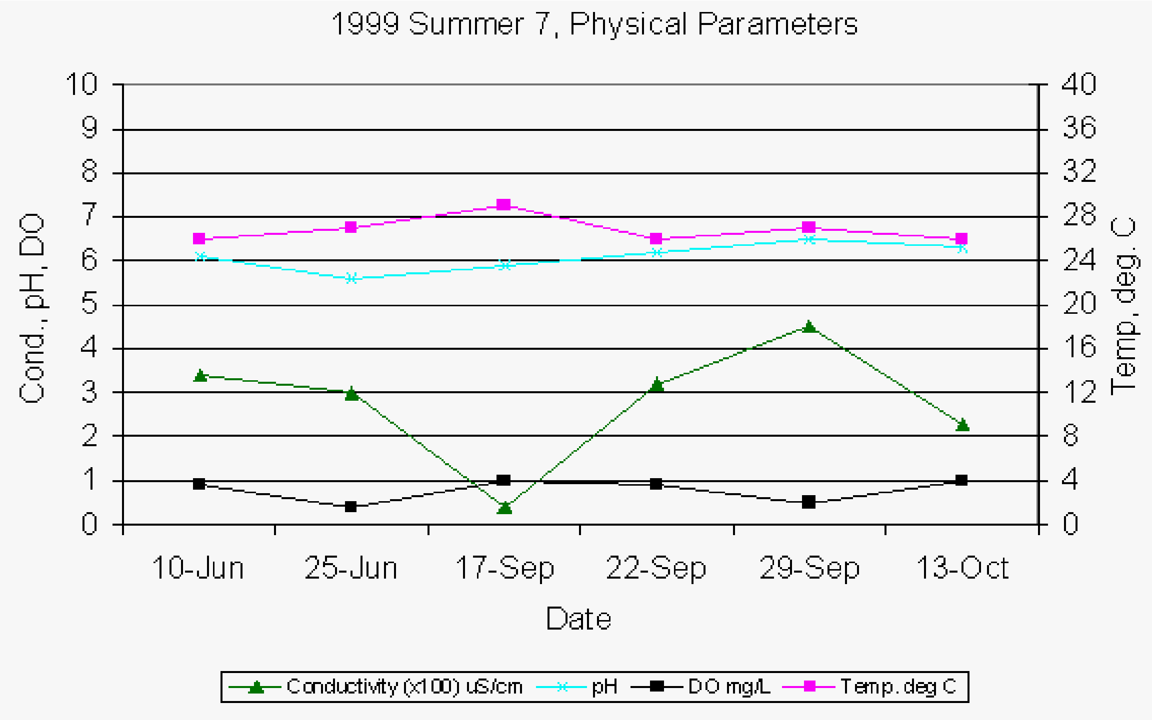


Figure 6.1.14. Mean values for water quality physical parameter measurement at summer pasture 7.

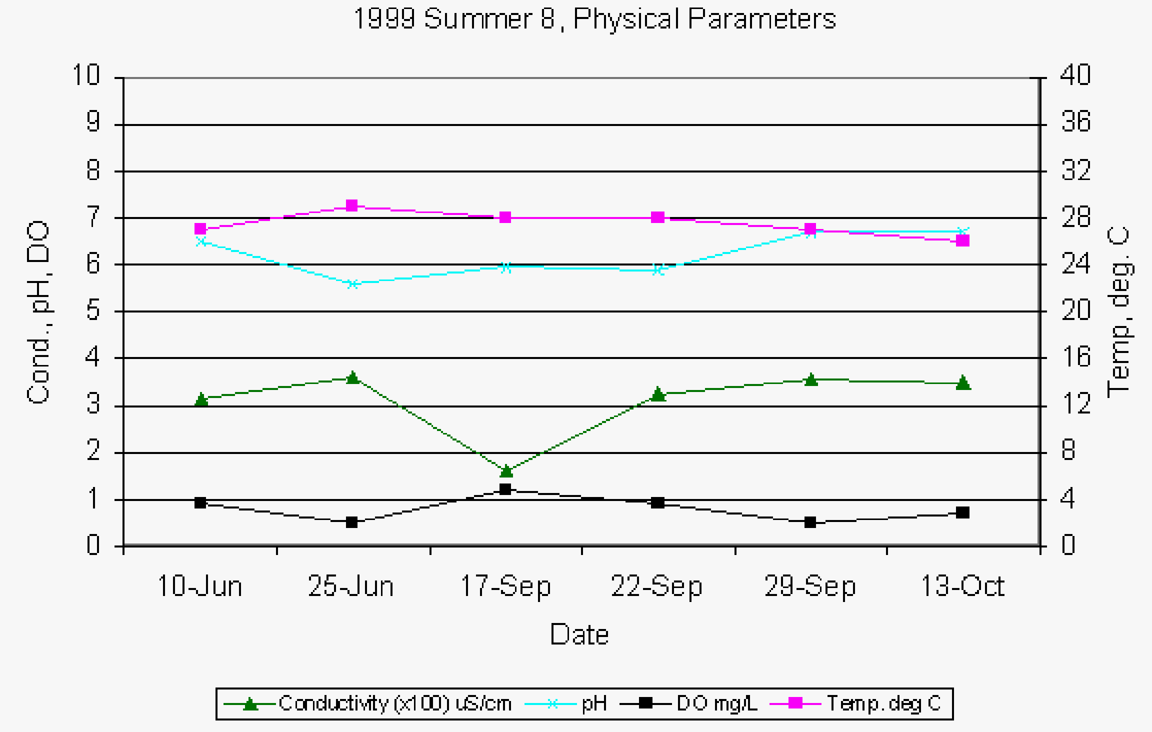


Figure 6.1.15. Mean values for water quality physical parameter measurement at summer pasture 8.

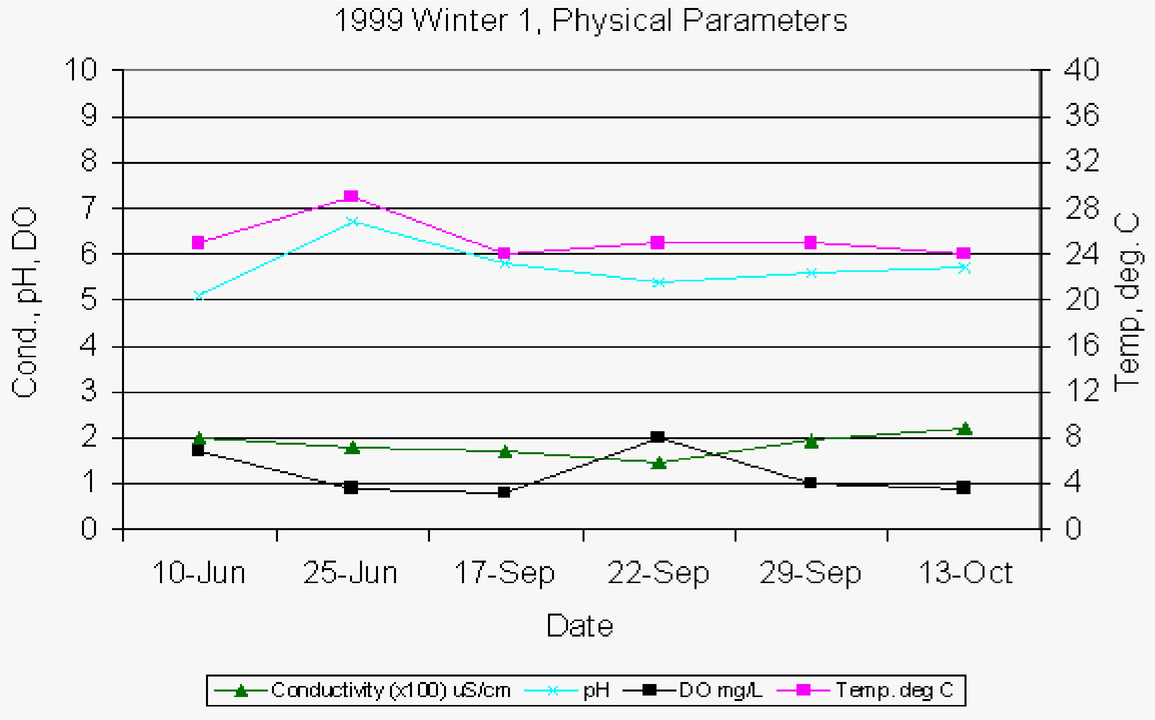


Figure 6.1.16. Mean values for water quality physical parameter measurement at winter pasture 1.

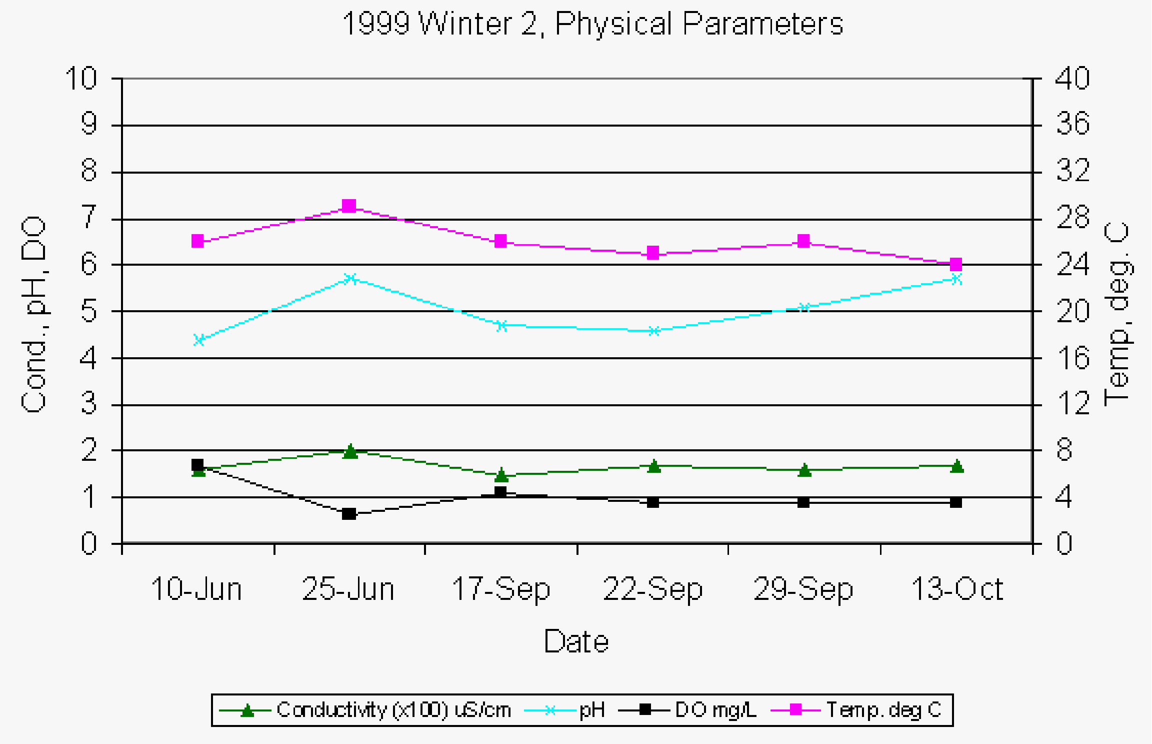


Figure 6.1.17. Mean values for water quality physical parameter measurement at winter pasture 2.

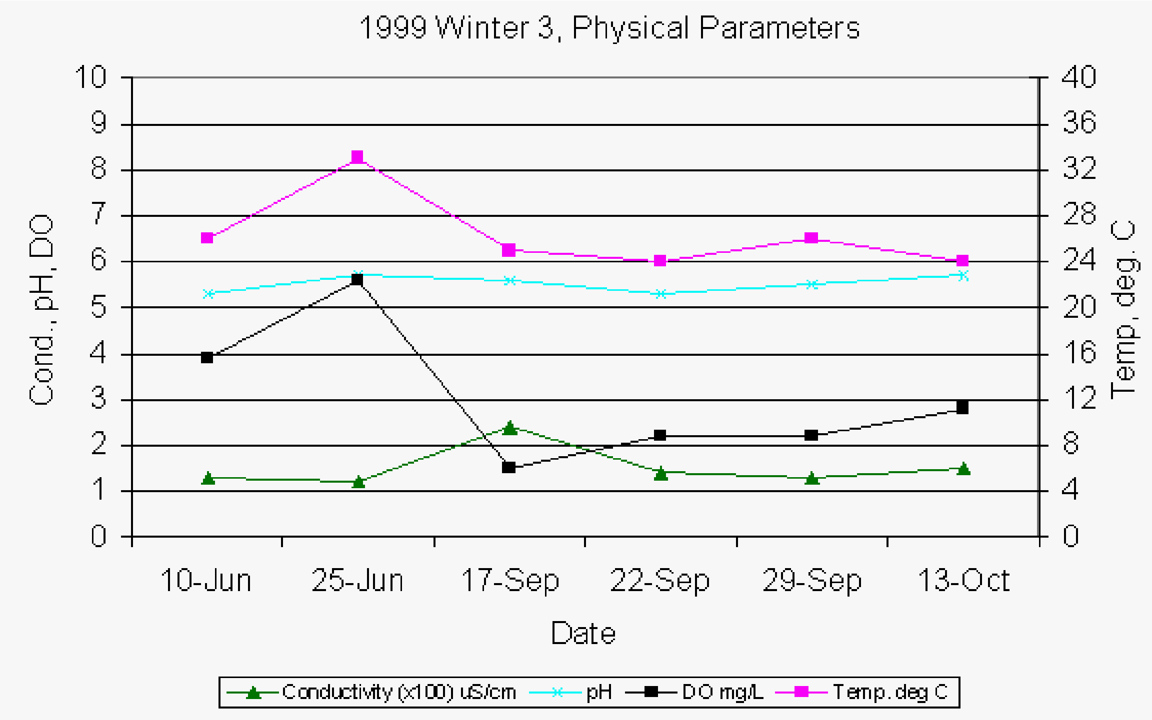


Figure 6.1.18. Mean values for water quality physical parameter measurement at winter pasture 3.

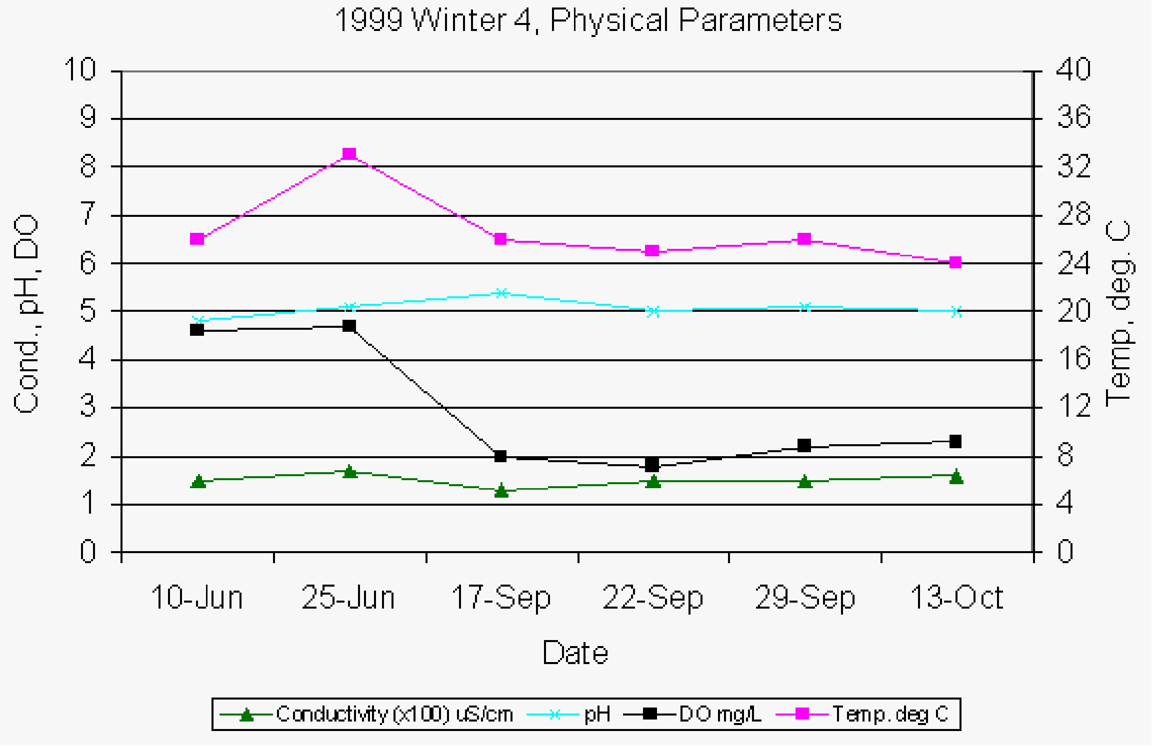


Figure 6.1.19. Mean values for water quality physical parameter measurement at winter pasture 4.

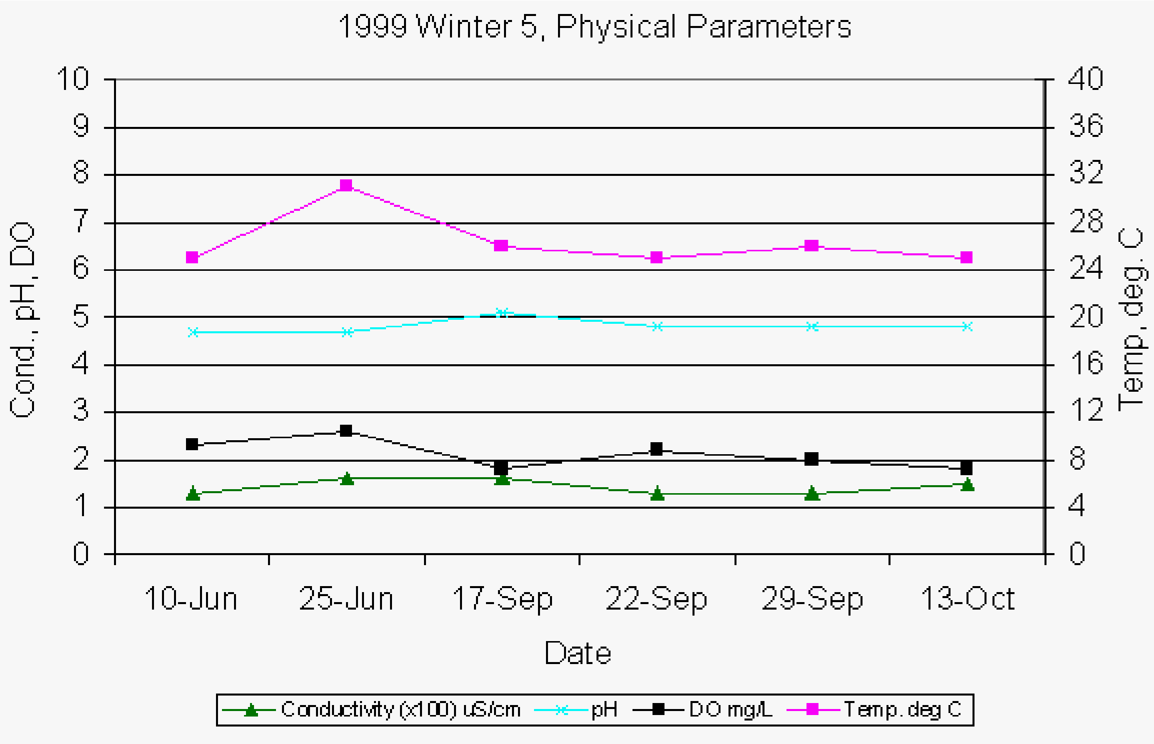


Figure 6.1.20. Mean values for water quality physical parameter measurement at winter pasture 5.

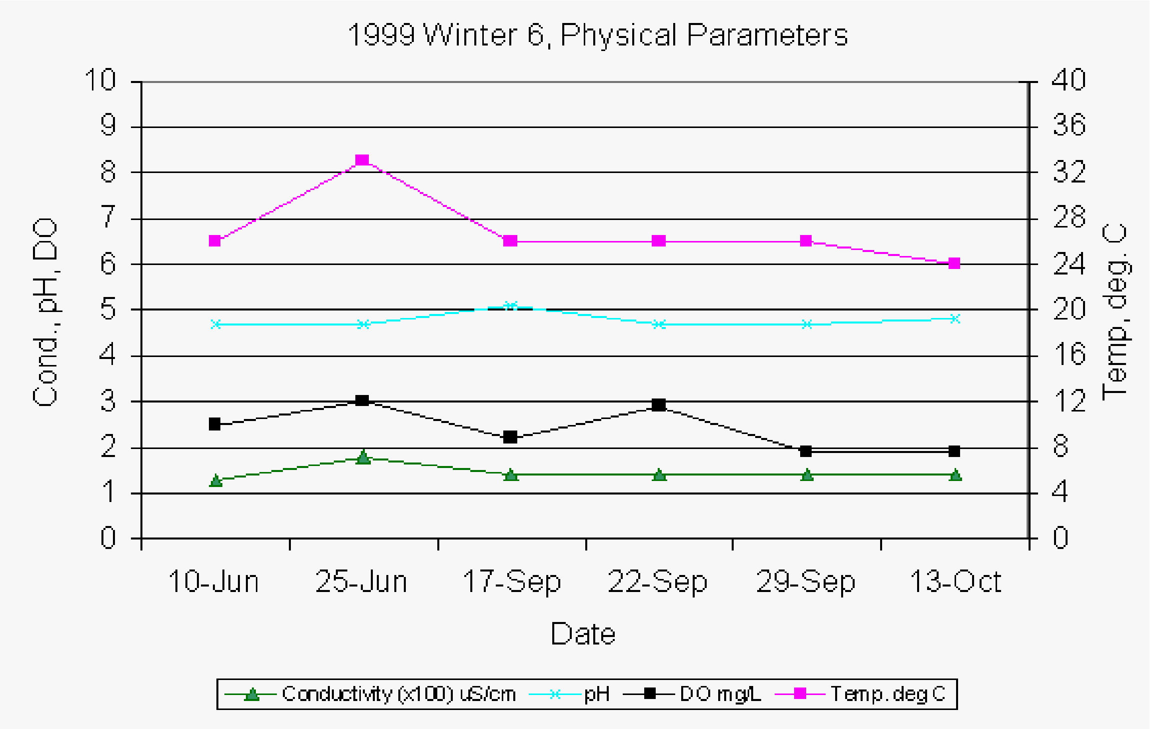


Figure 6.1.21. Mean values for water quality physical parameter measurement at winter pasture 6.

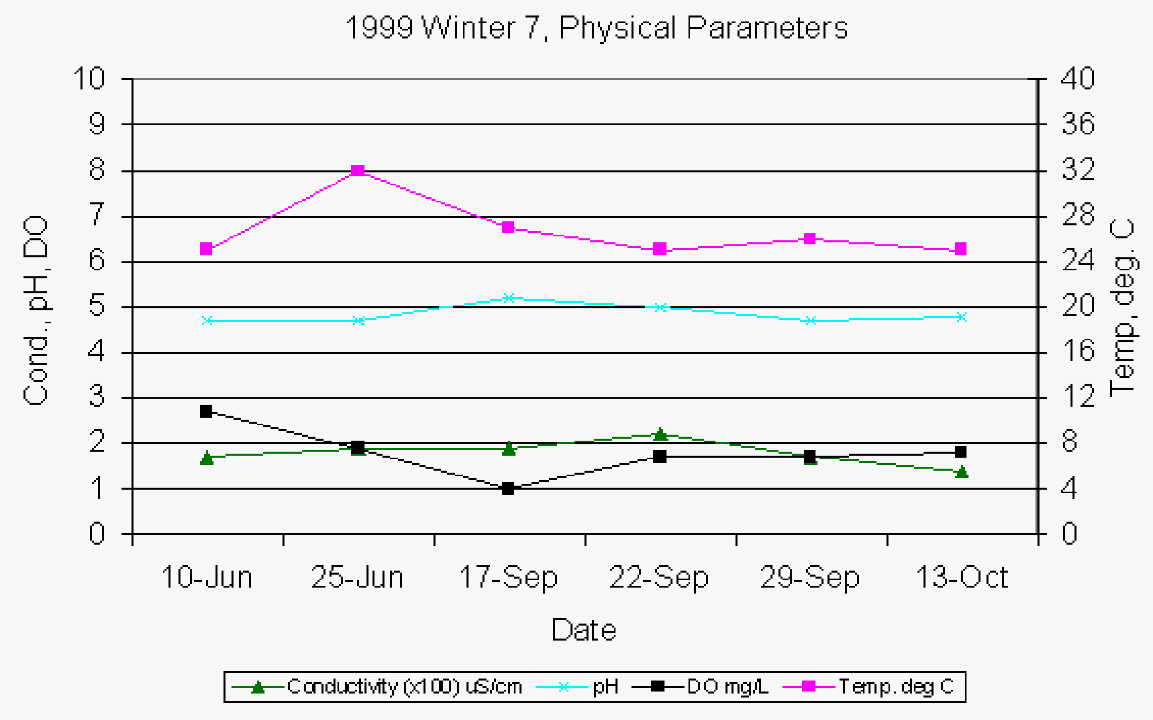


Figure 6.1.22. Mean values for water quality physical parameter measurement at winter pasture 7.

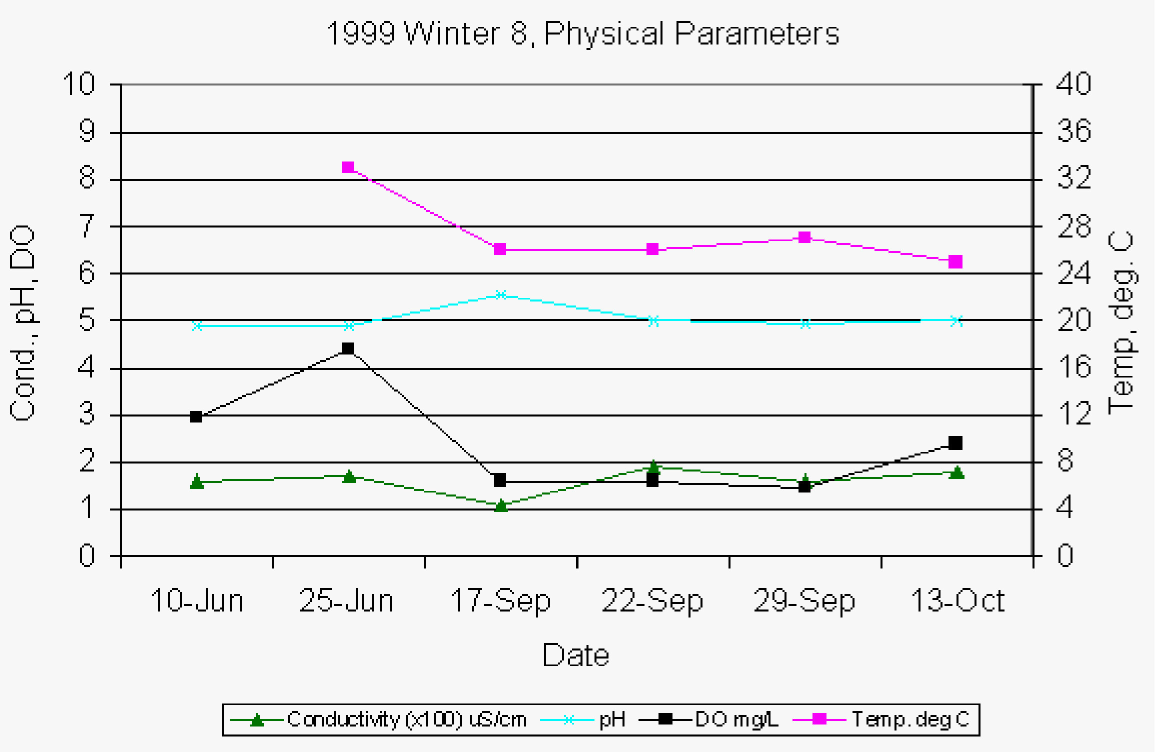


Figure 6.1.23. Mean values for water quality physical parameter measurement at winter pasture 8.

Table 6.2.1. Coefficient of variation of pH for grab sample field duplicates (control plots highlighted).

Site	Date	pH		CV
		FD1	FD2	
S1	10-Jun	5.3	5.2	1
	17-Sep	5.1	5.1	0
	22-Sep	5.3	5.4	1
	29-Sep	5.4	5.4	0
	13-Oct	5.5	5.5	0
S8	10-Jun	6.5	6.5	0
	17-Sep	5.9	6.0	1
	22-Sep	5.9	5.9	0
	29-Sep	6.7	6.7	0
	13-Oct	6.7	6.7	0
W1	10-Jun	5.1	5.1	0
	17-Sep	5.8	5.8	0
	22-Sep	5.5	5.3	3
	29-Sep	5.6	5.6	0
	13-Oct	5.7	5.7	0
W8	10-Jun	4.9	4.9	0
	17-Sep	5.6	5.5	1
	22-Sep	5.0	5.0	0
	29-Sep	4.9	5.0	1
	13-Oct	5.0	5.0	0
Average				0.5

Table 6.2.2. Coefficient of variation of temperature for grab sample field duplicates (control plots highlighted).

Site	Date	Temperature (deg. C)		CV
		FD1	FD2	
S1	10-Jun	26	26	0
	17-Sep	27	27	0
	22-Sep	26	26	0
	29-Sep	26	26	0
	13-Oct	25	25	0
S8	10-Jun	27	27	0
	17-Sep	28	28	0
	22-Sep	28	28	0
	29-Sep	27	27	0
	13-Oct	26	26	0
W1	10-Jun	25	25	0
	17-Sep	24	24	0
	22-Sep	25	25	0
	29-Sep	25	25	0
	13-Oct	24	24	0
W8	10-Jun			
	17-Sep	26	26	0
	22-Sep	26	26	0
	29-Sep	27	27	0
	13-Oct	25	25	0

Average	0.0

Table 6.2.3. Coefficient of variation of conductivity for grab sample field duplicates (control plots highlighted).

Site	Date	Conductivity (µS/cm) FD1	Conductivity (µS/cm) FD2	CV
S1	10-Jun	310	310	0
	17-Sep	100	110	7
	22-Sep	280	290	2
	29-Sep	280	280	0
	13-Oct	320	320	0
S8	10-Jun	310	320	2
	17-Sep	180	120	28
	22-Sep	330	320	2
	29-Sep	360	350	2
	13-Oct	350	350	0
W1	10-Jun	200	200	0
	17-Sep	170	170	0
	22-Sep	150	140	5
	29-Sep	190	200	4
	13-Oct	220	220	0
W8	10-Jun	160	160	0
	17-Sep	110	110	0
	22-Sep	190	190	0
	29-Sep	160	160	0
	13-Oct	180	180	0
Average				2.6

Table 6.2.4. Coefficient of variation of DO for grab sample field duplicates (control plots highlighted).

Site	Date	DO (mg/L)		CV
		FD1	FD2	
S1	10-Jun	1.0	1.0	0
	17-Sep	0.7	0.7	0
	22-Sep	0.4	0.4	0
	29-Sep	0.4	0.5	16
	13-Oct	0.6	0.6	0
S8	10-Jun	0.9	0.9	0
	17-Sep	1.2		
	22-Sep	0.9	0.9	0
	29-Sep	0.5	0.5	0
	13-Oct	0.7	0.7	0
W1	10-Jun	1.7	1.7	0
	17-Sep	0.8	0.8	0
	22-Sep	2.1	1.9	7
	29-Sep	1.0	1.0	3
	13-Oct	0.9	0.9	0
W8	10-Jun	3.0	2.9	2
	17-Sep	1.6	1.6	0
	22-Sep	1.6	1.6	0
	29-Sep	1.2	1.7	24
	13-Oct	2.4	2.4	0
Average				9.7

Table 6.2.5. Equipment blanks (control plots highlighted).

Site	Date	Temp (deg C)	Conductivity (µS/cm)	pH	DO (mg/L)
S1	10-Jun	26	0	7.3	5.7
	17-Sep				
	22-Sep	30	0	6.7	5.0
	29-Sep	26	0	6.4	7.6
	13-Oct	28	0	6.5	5.4
W1	10-Jun	27	0	7.2	5.8
	17-Sep	24	0	6.2	3.0
	22-Sep				
	29-Sep	24	0	7.3	3.5
	13-Oct	22	0	6.4	7.0

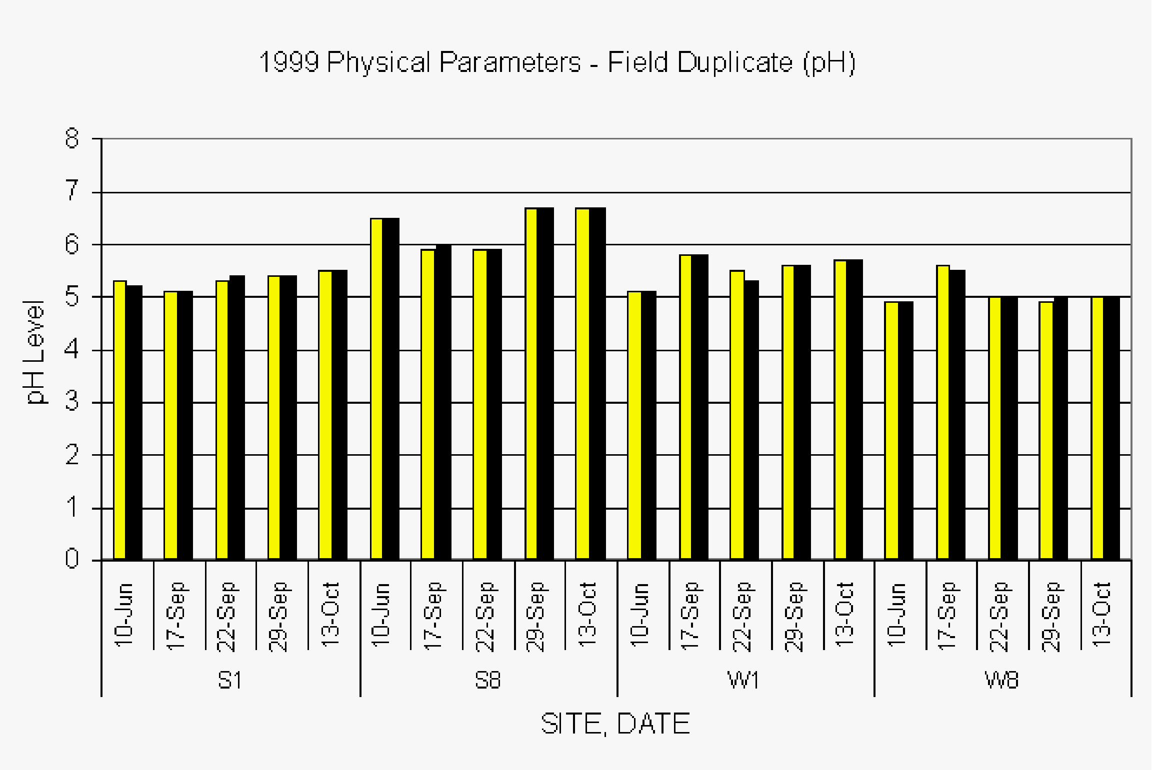


Figure 6.2.1. Comparisons of field duplicate grab sample pH measurements for pasture plots.

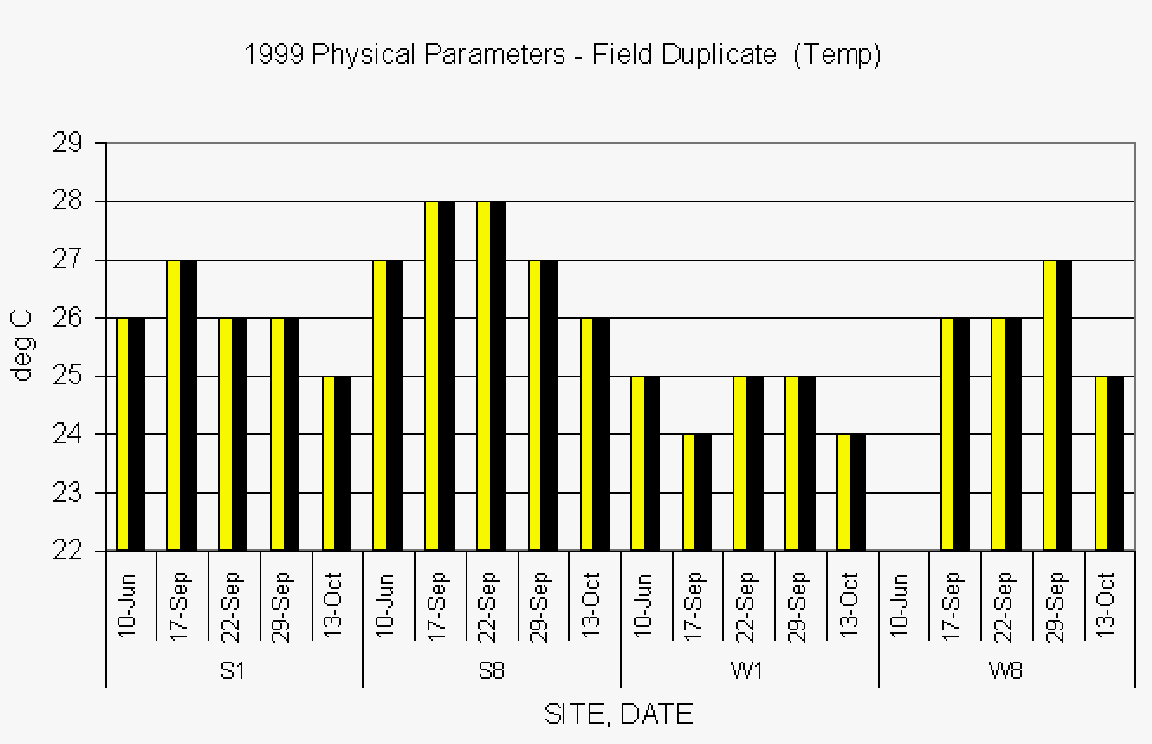


Figure 6.2.2. Comparisons of field duplicate grab sample temperature measurements for pasture plots.

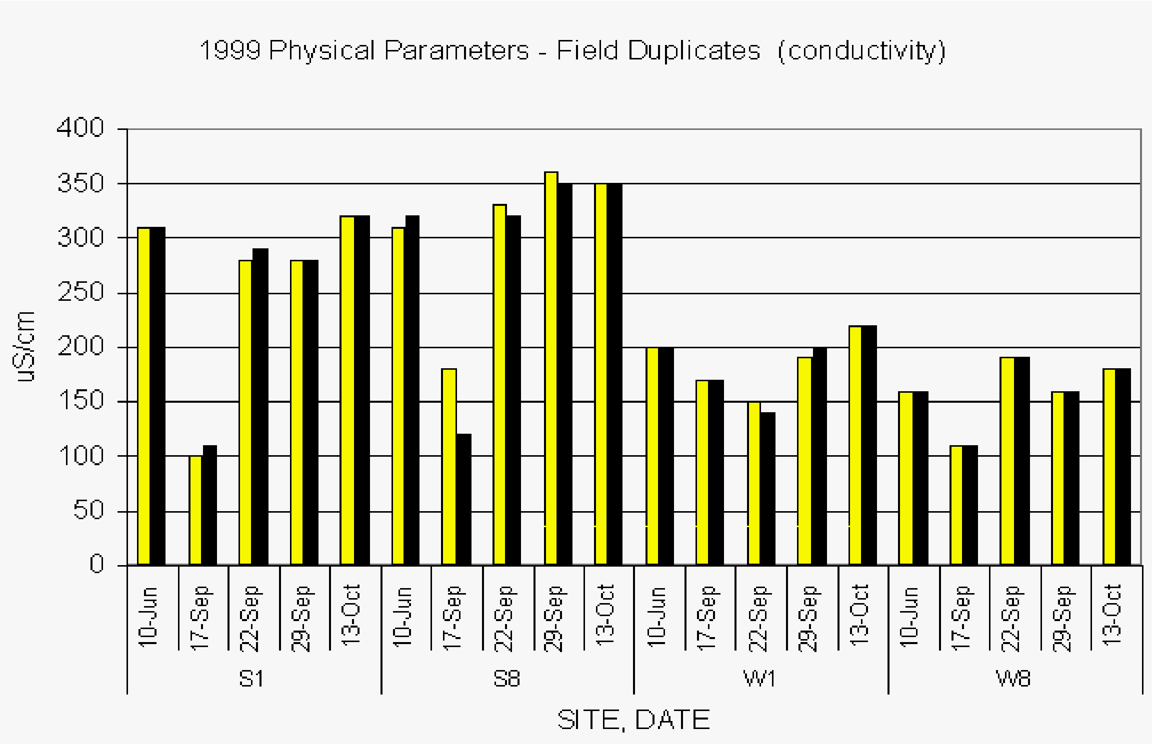


Figure 6.2.3. Comparisons of field duplicate grab sample conductivity measurements for pasture plots.

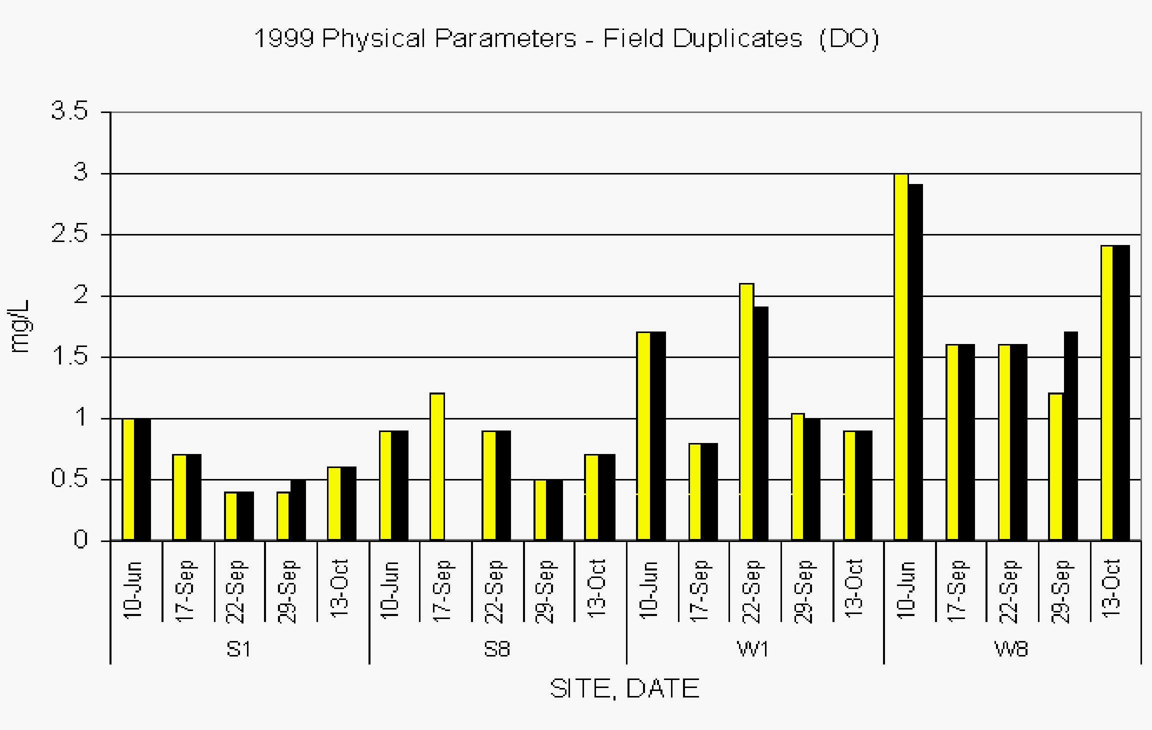


Figure 6.2.4. Comparison of field duplicate grab sample dissolved oxygen measurements for pasture plots.

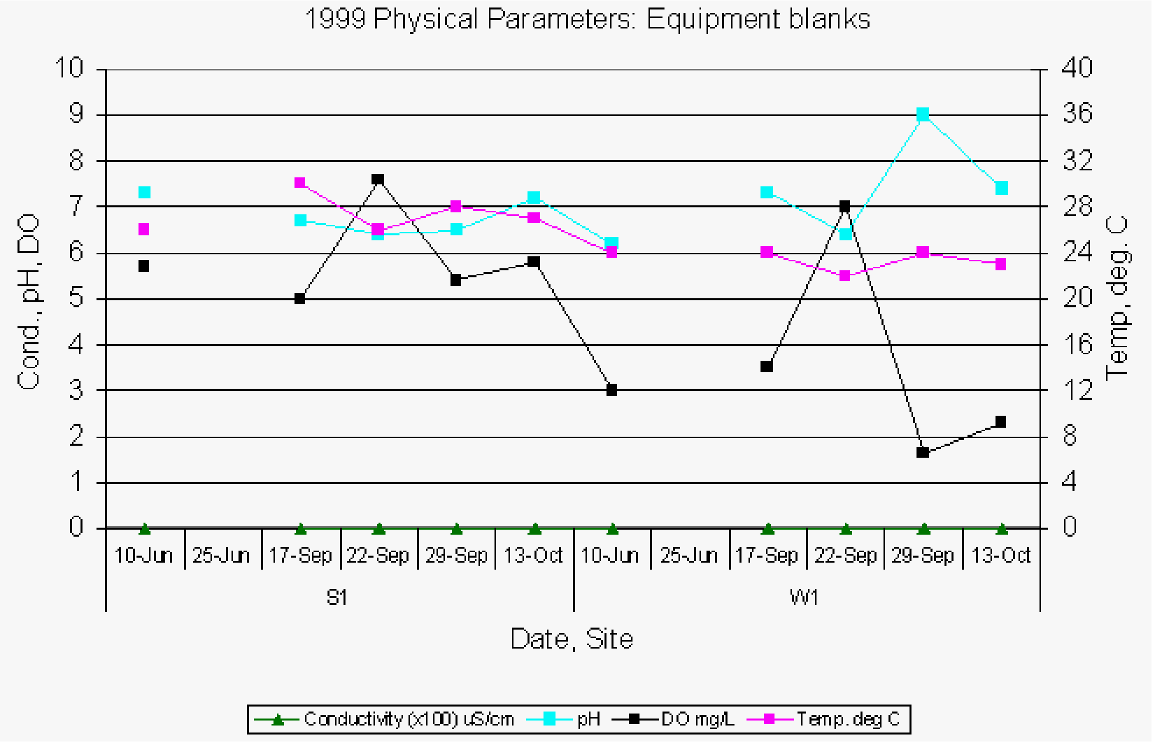


Figure 6.2.5. Physical parameter measurement results for equipment blanks at pasture plots.

7. Soils

7.1. Soil-P Tests

As shown in Figure 7.1 and 7.2, each winter and summer pastures plot was divided into five equal components. Two sampling locations were randomly selected within each of the five components and marked for subsequent sampling dates. Soil was sampled to a depth of 30 cm in increments of 0-5, 5-10, 10-20, and 20-30 cm. Pastures are being sampled at the end of each cattle stocking cycle. Each sample was analyzed for water-soluble P (WSP) and “Soil Test” (Mehlich I) elements including P, Fe, Al, Ca, and Mg. Water soluble phosphorus is ortho-P extractable from the soil using analyte free water. Pretreatment WSP concentrations for the winter pastures averaged over all pastures were 19, 4.5, 1.0, and 0.3 μg/g for the 0-5, 5-10, 10-20, and 20-30 cm depth increments, respectively. Corresponding values for the summer pastures were 41, 5.6, 1.4 and 0.7 μg/g (see Table 7.1 and Figure 7.3).

As shown in Figures 7.4, 7.5 and 7.6, the highest concentration of soil phosphorus is located within the first 5 cm of soil. Deeper horizons have lower concentrations of P and the values are fairly similar between the summer and the winter soils. A comparison between 1998 (Figure 7.4) and 1999 (Figure 7.5) for the summer pastures reveals a slight increase of the soil-P level. The higher shallow WSP concentrations in the summer pastures (Figure 7.3) reflects the greater intensity of management, in this case P fertilization, in the summer pastures relative to winter pastures. Phosphorus concentrations in the Mehlich I extracts were only slightly greater than in the water extracts which suggests that the sorbed P in these soils is highly labile. Analyses of soil samples taken after the first grazing cycle have not been completed; therefore treatment effects cannot be ascertained at this time.

An additional study was conducted to determine the phosphorus status of seasonal wetlands within selected grazing treatments in the summer and winter pastures. The detrital layer and upper 15 cm of underlying mineral soil were sampled at three randomly selected locations in the interior and along the edge of each wetland. Soil analyses included water-soluble phosphorus (WSP), total P (TP) and P fractions. P fractions measured were: NH_4Cl-extractable P (labile P), NaOH-extractable P (Fe-Al associated inorganic P and organic P), HCl-extractable P (Ca-Mg associated P) and residual P (recalcitrant P is considered to be primarily organic in nature). TP concentrations were higher (240-660 μg P/g) in the detrital layer compared to the mineral layer (16-180 μg P/g). WSP comprised 1-9% of the TP and was higher in the wetland interior compared to the edge of the wetland. TP and WSP concentrations were greater in the improved pastures (summer) than in the semi-native range (winter) pastures. There was a significant relationship ($P < 0.01$) between WSP and TP for both the detrital layer and the mineral soil. The greatest portion of the TP was present in the residual P fraction that is considered to be recalcitrant. Relatively small percentages of TP were found in the labile form (NH_4Cl-P); however, greater percentages were found as NaOH-OP, which is often considered to be “easily mineralizable P”.

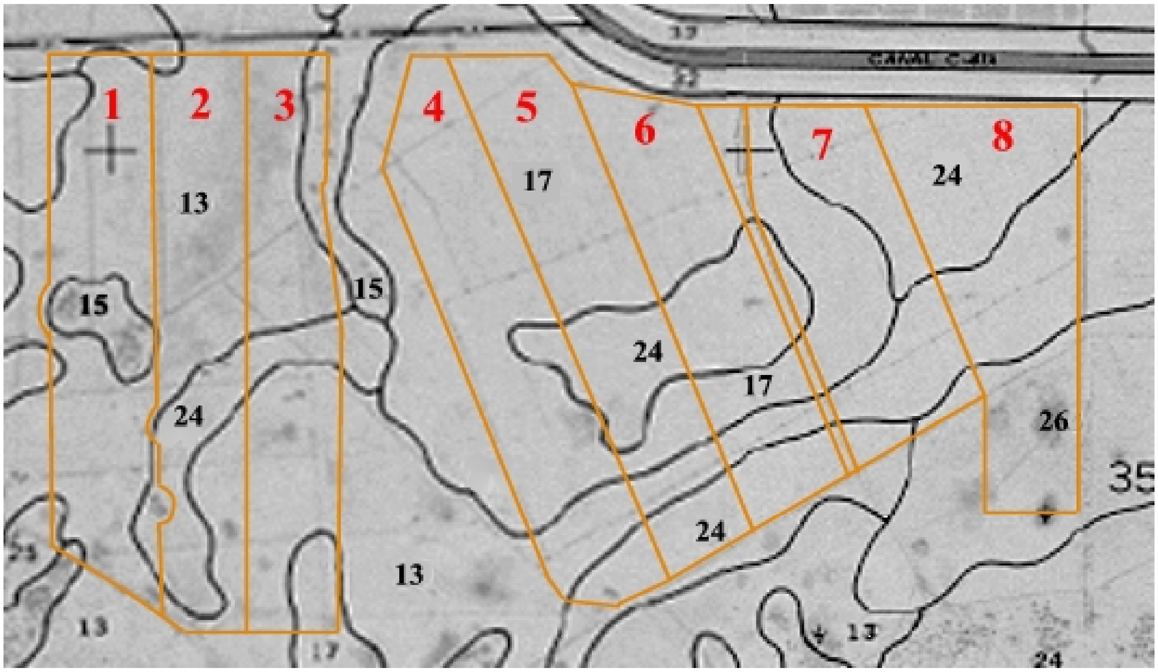


Figure 7.1. Winter pasture soil types. (See Table 7.1 for soils index.)

Figure 7.2. Summer pasture soil types. (See Table 7.2 for soils index.)

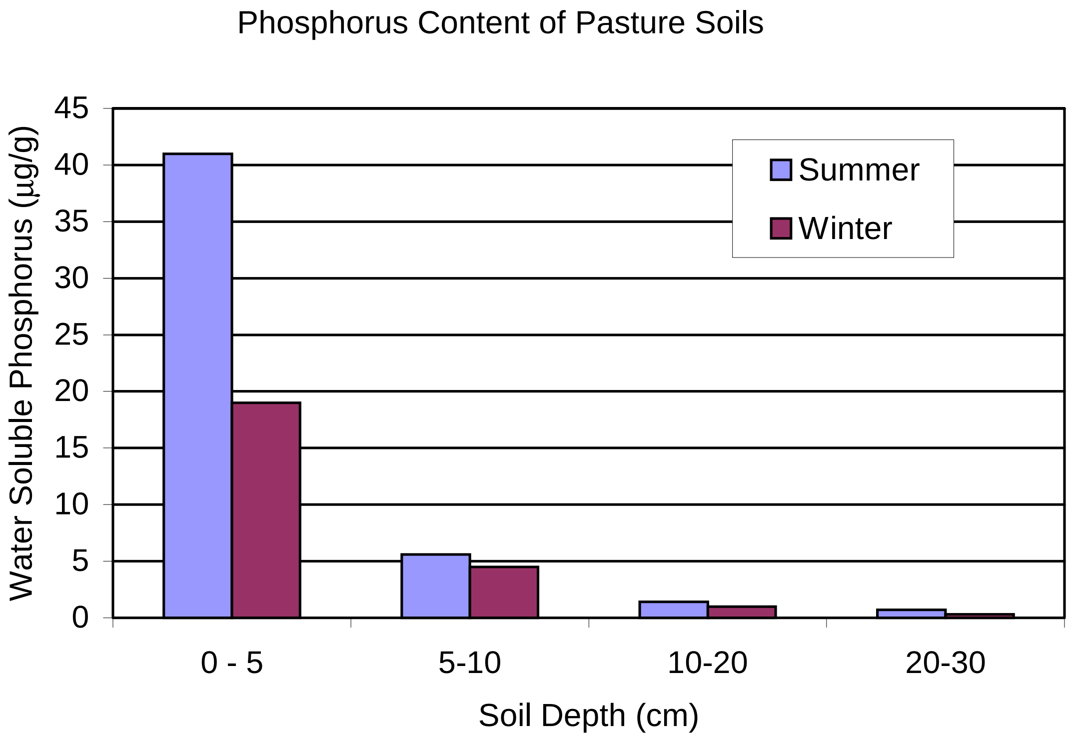


Figure 7.3. Phosphorus content of pasture soils.

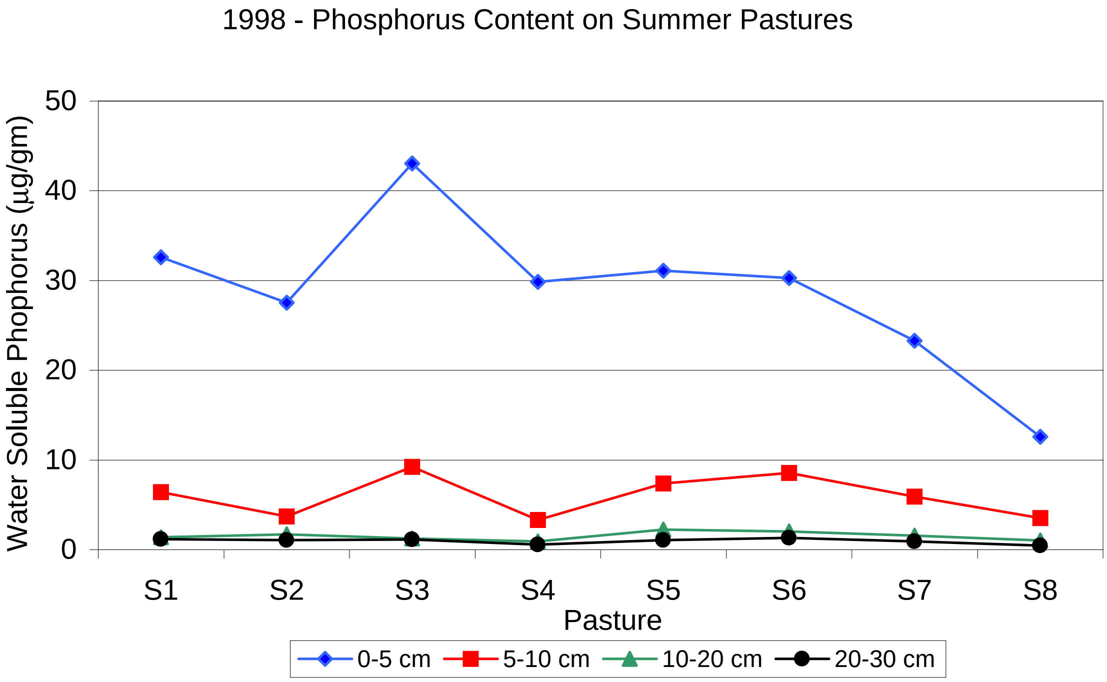


Figure 7.4. Phosphorus content on summer pastures for 1998.

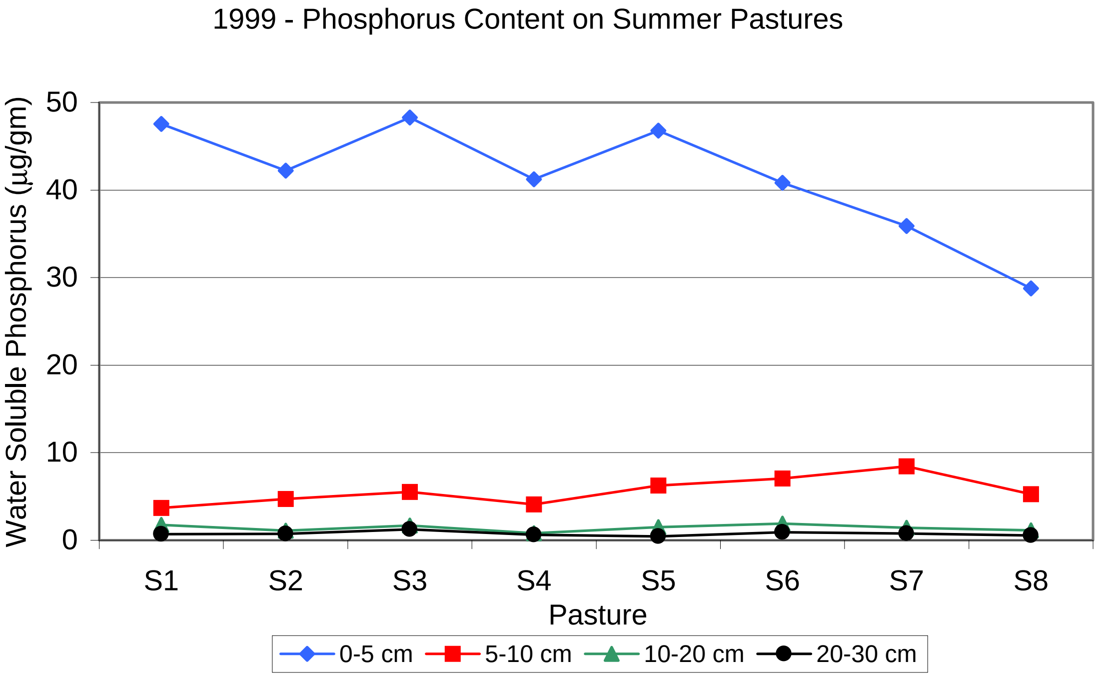


Figure 7.5. Phosphorus content on summer pastures for 1999.

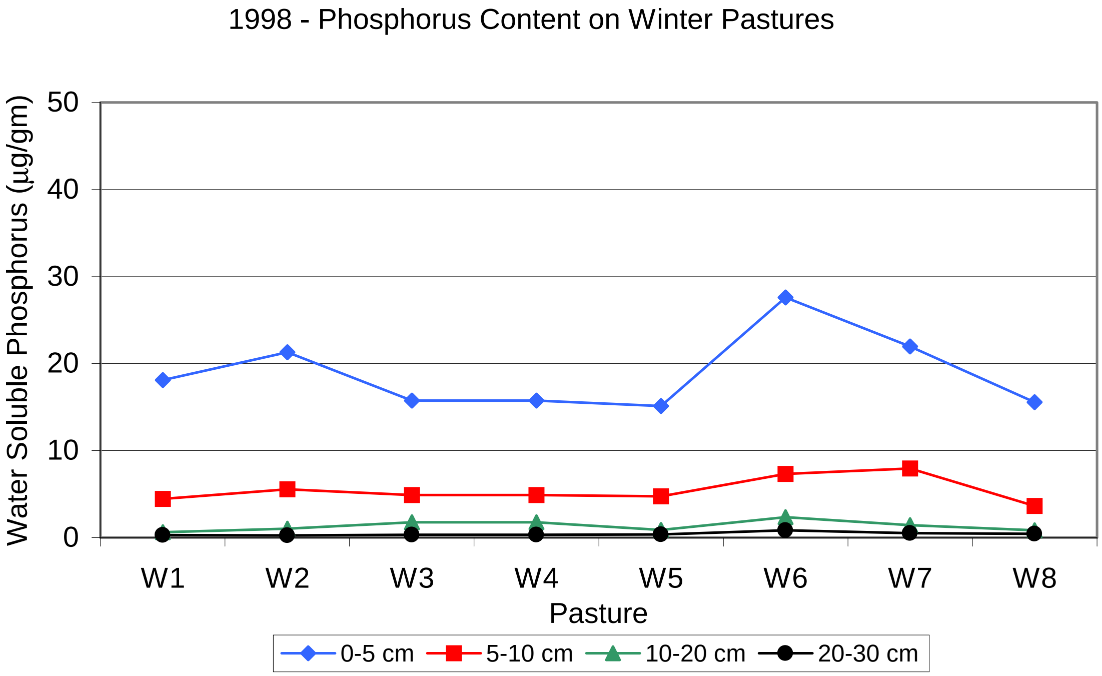


Figure 7.6. Phosphorus content on winter pastures for 1998.

7.2. Soil-Runoff Comparisons

As shown in Figure 7.7, soil phosphorus test results show correlation with water quality results. The summer pastures exhibit high phosphorus content in both the runoff water and the shallow soil horizons. Similarly, the winter pastures exhibited lower phosphorus content in both the shallow soil horizons and the runoff water.

While Figure 7.7 suggest a potential direct relationship between shallow soil-P and runoff-P, two individual pastures plots, summer pasture plot S8 and winter pasture plot W6, do not support this conclusion (see Figure 7.8). While W6 is a typical pasture by most measures, S8 is somewhat atypical. This plot is the nearest pasture to an adjacent citrus grove and contains wooded areas and many isolated wetlands.

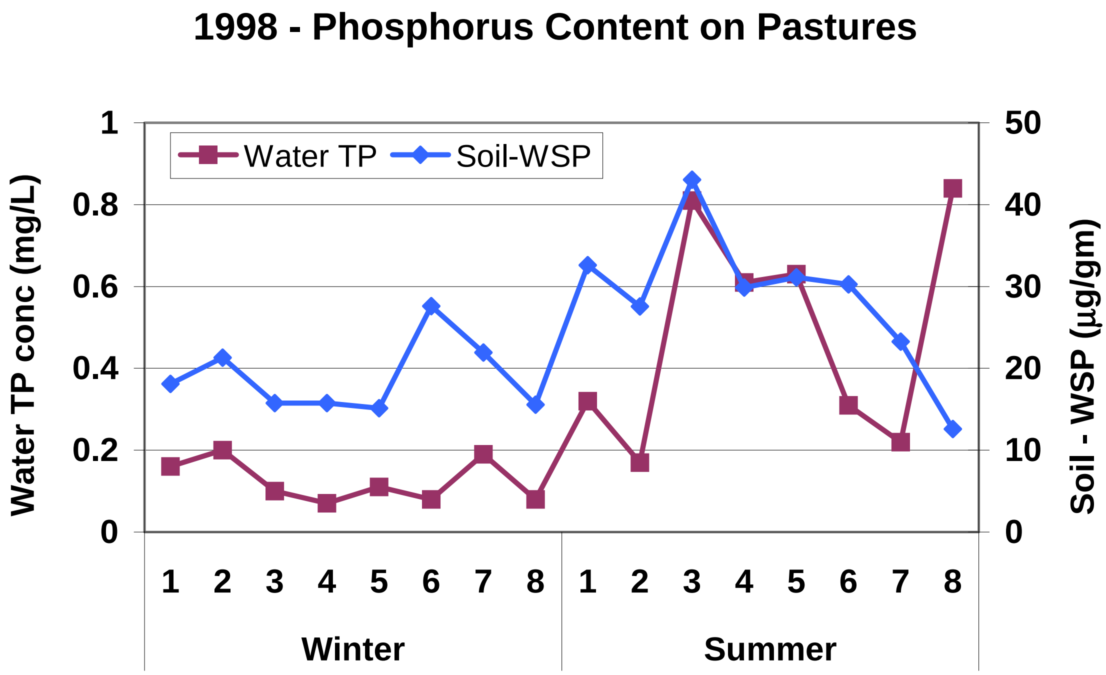


Figure 7.7. Phosphorus content on pastures for 1998.

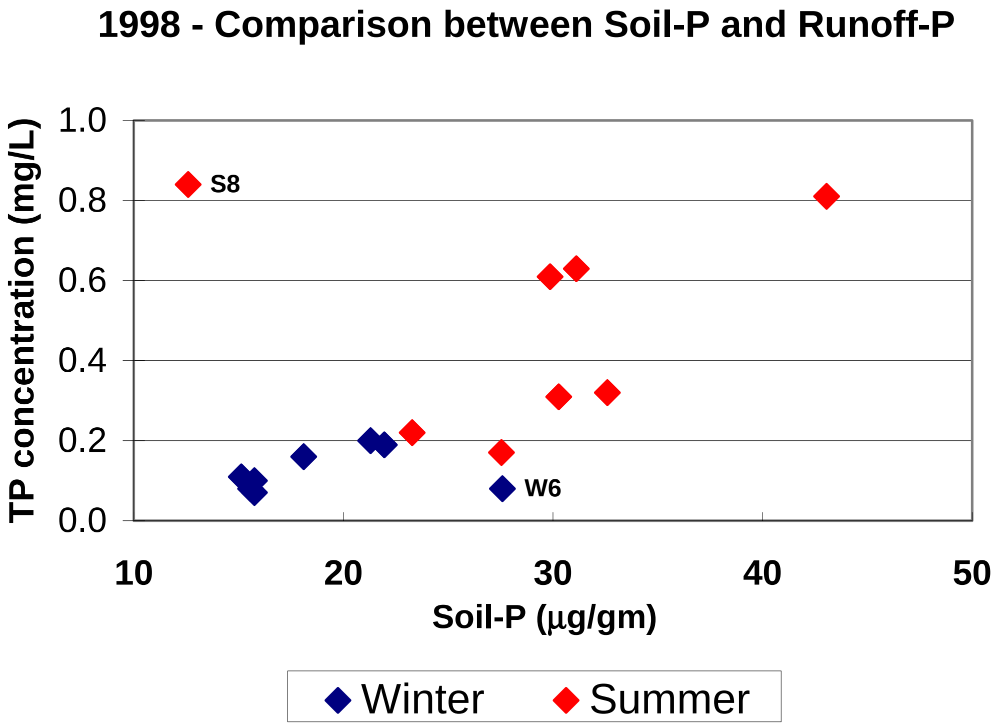


Figure 7.8. Comparison between Soil-P and Runoff-P for 1998. The R^2 omitting the S8 point is 0.69, while the R^2 value, including the S8 point is 0.21.

7.3. *Soil Type Distribution*

The specific types and coverages of these soils for each pasture plot are presented in Tables 7.1 and 7.2, and in Figures 7.9 and 7.10. Most are wetland type soils, including those of the summer pastures.

Table 7.1. Soil types distribution on winter pastures (control plots highlighted).

	Soil type proportion (%)						
Plot	Felda	Malabar	Pineda	Tequesta	Bradenton	Gator	Chobee
1	78	0	9	0	11	2	1
2	75	0	24	0	0	0	1
3	78	7	7	0	8	0	0
4	11	76	13	0	0	0	0
5	4	73	22	0	0	0	0
6	8	53	40	0	0	0	0
7	20	34	42	5	0	0	0
8	31	0	40	29	0	0	0
Total	37	32	24	4	2	0	0
Acres	237	202	156	27	15	1	1

13-FELDA	Arenic Ochraqualfs	drainage ways and depressions
17-MALABAR	Glossarenic Ochraqualfs	broad sloughs, drainage ways, and depressions
24-PINEDA	Arenic Glossaqualfs.	low flats, sloughs and large drainage ways
26-TEQUESTA	Arenic Glossaqualfs	marshes and depressions
15-BRADENTON	Typic Ochraqualfs	hammocks and open areas
23-GATOR	Terric Medisaprists	marshes, swamps, and depressed areas
25-CHOBEE	Typic Argiaquolls	large depressions, swamps and marshes.

Table 7.2. Soil types distribution on summer pastures (control plots highlighted).

	Soil type proportion (%)					
Plot	Felda	Tequesta	Hicoria	Chobee	Malabar	Bradenton
1	75	0	17	0	8	0
2	87	0	13	0	0	0
3	98	0	2	0	0	0
4	90	10	0	0	0	0
5	42	58	0	0	0	0
6	22	78	0	0	0	0
7	20	80	0	0	0	0
8	25	56	0	10	0	8
Total:	58	34	4	1	1	1
Acres:	233	136	17	5	5	4

13-FELDA	Arenic Ochraqualfs	drainage ways and depressions
26-TEQUESTA	Arenic Glossaqualfs	marshes and depressions
19-HICORIA	Typic Umbraqualfs	depressions
25-CHOBEE	Typic Argiaquolls	large depressions, swamps and marshes
17-MALABAR	Glossarenic Ochraqualfs	broad sloughs, drainage ways, and depressions
15-BRADENTON	Typic Ochraqualfs	hammocks and open areas

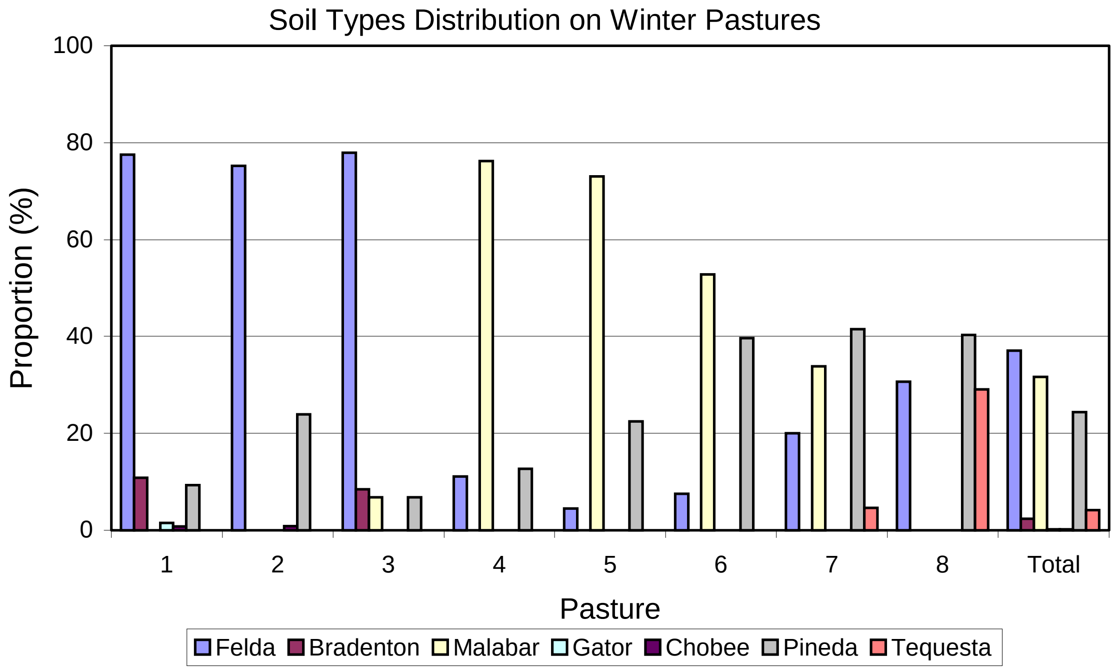


Figure 7.9. Soil types distribution on winter pastures.

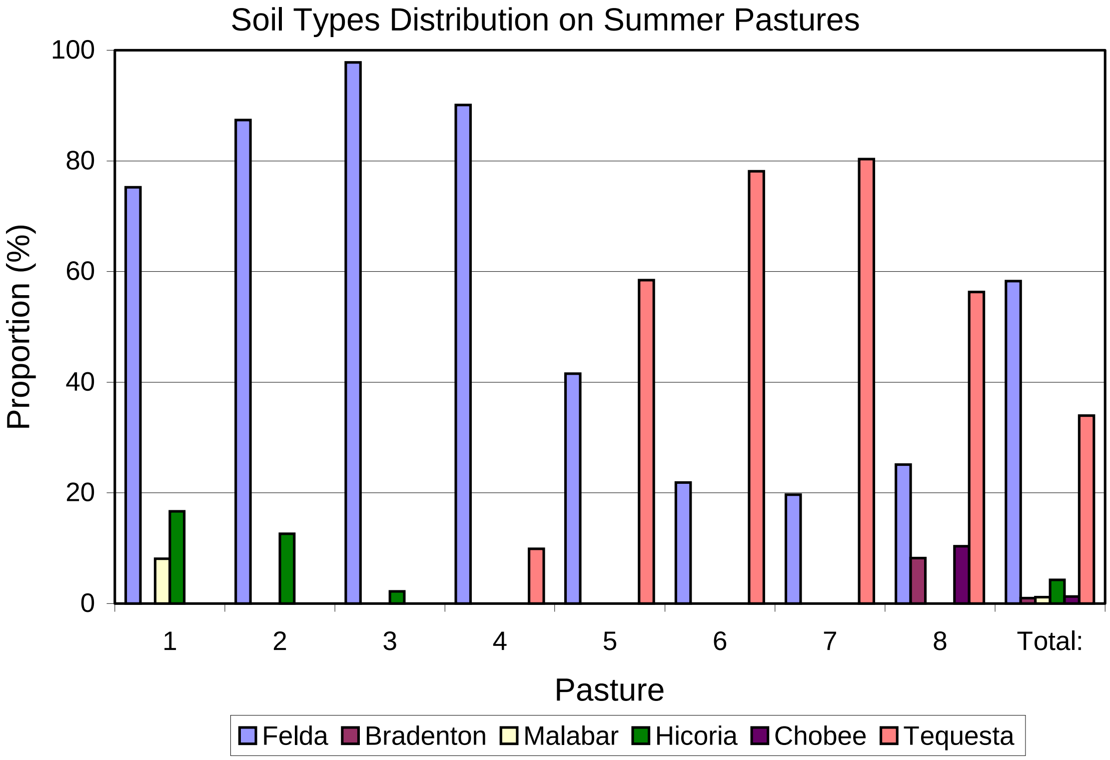


Figure 7.10. Soil types distribution on summer pastures.

Descriptions of the different soil types are given below. For an explanation of the code for the various layers, please refer to Table 7.11.

Felda Fine Sand (13)

The Felda series consists of nearly level, poorly drained and very poorly drained soils that formed in sandy and loamy marine sediment. These soils are in large drainage ways and depressions and on low flats in the flatwoods part of the county. The slopes range from 0 to 2 percent. These soils of the Felda series are loamy, siliceous, hyperthermic Arenic Ochraqualfs. Felda soils are closely associated with Bradenton, Malabar, Pineda and Valkaria soils.

Table 7.3. Typical Felda soil profile.

Horizon	Depth (inches)
Ap	0 – 7
Eg1	7 – 14
Eg2	14 – 21
Eg3	21 – 24
Btg	24 – 36
Cg1	36 – 68
Cg2	68 – 80

Bradenton Fine Sand (15)

The Bradenton series consists of nearly level, poorly drained soils that formed in loamy marine sediment influenced by calcareous materials. These soils are on hammocks and in open areas on the flatwoods. The slopes range from 0 to 2 percent. The soils of the Bradenton series are coarse-loamy, siliceous, hyperthermic Typic Ochraqualfs. Bradenton soils are closely associated with Felda, Hicoria, Malabar, Myakka, and Pineda soils.

Table 7.4. Typical Bradenton soil profile.

Horizon	Depth (inches)
Ap	0 – 4
E	4 – 14
Btg	14 – 29
Btgk	29 – 44
Cgk1	44 – 68
Cgk2	68 – 80

Malabar Fine Sand (17)

The Malabar series consists of nearly level, poorly drained and very poorly drained soils that formed in sandy and loamy marine sediment. These soils are in narrow to broad sloughs, poorly defined drainage ways, and depressions on the flatwoods part of the county. The slopes range from 0 to 2 percent. These soils of the Malabar series are loamy, siliceous, hyperthermic, Glossarenic Ochraqualfs. Malabar soils are closely associated with Basinger, Felda, Myakka, Smyrna, and Valkaria soils.

Table 7.5. Typical Malabar soil profile.

Horizon	Depth (inches)
Ap	0 – 4
E	4 – 14
Bw1	14 – 30
Bw2	30 – 37
Bw3	37 – 44
Bw4	44 – 48
Btg	48 - 80

Chobee Fine Sandy Loam, Depressional (25)

The Chobee series consists of nearly level, very poorly drained soils that formed in thick beds of loamy marine sediment. These soils are in small to large depressions on the flatwoods and some in some swamps and marshes in the county. The slopes range 0 to 1 percent. The soils of the Chobee series are fine-loamy, siliceous, hyperthermic Typic Argiaquolls. Chobee soils are closely associated with Basinger, Felda, Hicoria, and Tequesta soils.

Table 7.6. Typical Chobee soil profile.

Horizon	Depth (inches)
A	0 – 18
Btg1	19 – 36
Btg2	36 – 57
Cg	57 – 80

Tequesta Muck (26)

The Tequesta series consists of nearly level, very poorly drained soils that formed in thick beds of loamy marine sediment. These soils formed in conditions favorable for the accumulation of organic material. They are in marshes and depressions in the county and are generally about 5 to 300 acres in size. The slopes range from 0 to 2 percent. The soils of the Tequesta series are loamy, siliceous, hyperthermic Arenic Glossaqualfs. Tequesta soils are closely associated with Basinger, Chobee, Hicoria and Kaliga soils.

Table 7.7. Typical Tequesta soil profile.

Horizon	Depth (inches)
Oa	0 – 12
A	12 – 17
Eg	17 – 32
Btg	32 – 77
Cg	77 – 80

Hicoria Mucky Sand, Depressional (19)

The Hicoria series consists of nearly level, very poorly drained soils that formed in thick beds of loamy marine sediment. These soils are in depressed areas on the flatwoods and along the edges of swamps and marshes in the county. The slopes range from 0 to 2 percent. The soils of the Hicoria series are loamy. Siliceous, hyperthermic Typic Umbraqualfs. Hicoria soils are closely associated with Basinger, Chobee, Felda, Kaliga, and Tequesta soils.

Table 7.8. Typical Hicoria soil profile.

Horizon	Depth (inches)
Oa1	0 – 15
Oa2	15 – 65
C	65 – 73
Cg	73 – 80

Gator Muck (23)

The Gator series consists of nearly poor level, very poorly drained, organic soils that formed in moderately thick deposits of sapric material underlain by loamy mineral layers. These soils are in marshes, swamps, and depressed areas throughout the county. The slopes range from 0 to 1 percent. The soils of the Gator series are loamy, siliceous, euic, hyperthermic Terric Medisaprists. Gator soils are closely associated with Chobee, Felda, Hicoria, and Tequesta soils.

Table 7.9. Typical Gator soil profile.

Horizon	Depth (inches)
Oa	0 – 18
Cg1	18 – 36
Cg2	36 – 55
Cg3	55 – 80

Pineda Sand (24)

The Pineda series consists of nearly level, poorly drained soils that formed in sandy and loamy marine sediment. These soils are on broad, low flats, in sloughs and large, poorly defined drainage ways in the flatwoods part of the county. The slopes range from 0 to 2 percent. The soils of the Pineda Series are loamy, siliceous, hyperthermic Arenic Glossaqualfs. Pineda soils are closely associated with Basinger, Felda, Malabar, Myakka, Smyrna, and Valkaria soils.

Table 7.10. Typical Pineda soil profile.

Horizon	Depth (inches)
A	0 – 4
E	4 – 12
Bw	12 – 30
Btg1	30 – 50
Btg2	50 – 56
Cg1	56 – 63
Cg2	63 – 80

Table 7.11. Soils horizon symbol descriptions.

Code	Description
O	Fresh organic horizon
A	Surface mineral horizon
E	Leached mineral horizon
B	Accumulative horizon
C	Parent material horizon
a	Highly decomposed organic material
g	Strong gleying
h	Illuvial accumulation of organic matter
k	Accumulation of carbonates
p	Tillage or other disturbance
t	Accumulation of silicate clay
w	Development of color structure

In the identification of soil horizons, an upper case letter represents the major horizon.

Numbers or lower case letters are subdivisions of the major horizon:

- Lower case letters are used as suffixes to designate specific kinds of master horizons and layers
- The Arabic numbers are used as suffixes to denote vertical subdivisions in a same layer.

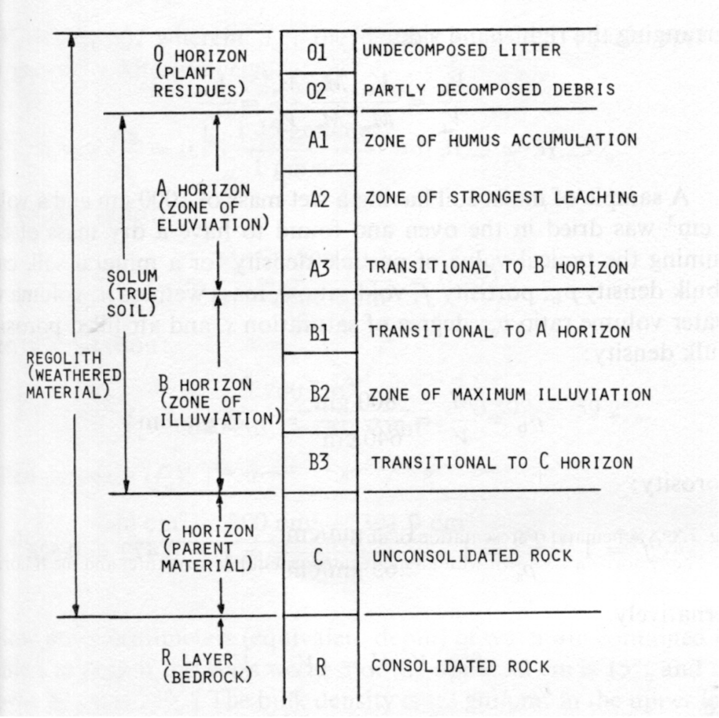


Figure 7.12. Descriptive terminology for soil profile horizon.

8. Cattle Management

8.1. Planning and Design

A cow-calf herd calendar (Table 8.1) describes all aspects of cow-calf management practices conducted by Buck Island Ranch under the supervision of Mr. Gene Lollis, Ranch Manager.

Table 8.1.1. Herd health and working schedule for cattle (dates are approximate).

Date	Activities
November	Vibrio/Lepto/Trich all early breeding cattle Bleed bulls, semen test, trich check, etc. (Bull Management)
December	Put bulls with early breeding females
January	Vibrio/Lepto/Trich booster cow herds Work early bred cows and calves - deworm, external parasites, bleed Castrate calves, implant, deworm, weigh calves Put bulls with all cows
February	Pull bulls from open breeders from prior year 75 days
March	Work all other calves deworm, implant, castrate, weigh calves Trich/vibrio/lepto replacement heifers Pull bulls from two year old breeders 95 days
April	Shipping shots early born calves; IBR, BVD, PI3, plus Lepto, 8-Way Blackleg, Deworm, weigh calves 2nd Trich shot for replacement heifers
May	Ship early calves Pull bulls from all cows May 17 Put bulls with replacement heifers
June	Shipping shots to all other calves, weigh calves
July	Pregnancy check all early bred cattle Give fall shots to bred cows Pull bulls from yearlings
August	Ship calves
September	Pregnancy check all cows Deworm, defluke, 8-Way blackleg, Vit. A-D, 3Way/lepto External parasite control all cows 2nd round of shots to weaning retained calves
October	Pregnancy check yearling cattle Start cycle over again

The treatment units of this project (the cattle) were selected, identified with individual ear tags, and assigned to one of four stocking densities (Table 8.1.2). The four stocking densities are replicated in the eight winter array 80-acre pastures and in the 8 summer array 50-acre pastures. Each animal assigned to specific stocking density remains in that particular stocking density when moved between the winter and summer arrays.

Table 8.1.2. Cattle stocking rate treatments and pasture plot assignments (control plots highlighted).

Block	Plot IDs	Treatment (Cow-Calf Units)		
		Level	Units/Plot	Acres/Unit
Winter Pastures (80 acres)	W4 & W7	Control	0	N/A
	W1 & W6	Low	15	5.3
	W2 & W8	Medium	20	4.0
	W3 & W5	High	35	2.3
Summer Pastures (50 acres)	S1 & S8	Control	0	N/A
	S4 & S6	Low	15	3.3
	S2 & S7	Medium	20	2.5
	S3 & S5	High	35	1.4

8.2. *Management and Measurements*

Cattle operations, herd movements, and animal physical parameters have been documented since commencement of the stocking rate treatments. The demonstration project was structured with a two-year schedule. The first year, 1998, was an equilibration period with treatments not applied to the pasture plots. In October 1998, the cattle were introduced to the winter plots. Table 8.2.1 provides the cattle status by plot as of June 1998 and Table 8.2.2 summarizes all significant cattle operations conducted during the project.

Table 8.2.1. Summary of cattle physical data as of June 1998.

Summer	# Head	Avg Age	BCS	Calves, Steers		Calves, Heifers	
				Number	Weight	Number	Weight
#2	20	8	7	9	448	12	428
#3	35	10	5	18	401	17	413
#4	15	10	7	6	437	9	405
#5	35	11	5	7	379	28	358
#6	15	8	5	7	379	8	409
#7	20	10	7	12	422	8	371

Note: All ages and BCS are rounded up.

BCS = body condition score

Table 8.2.2. Experimental array activities.

Date	Activity	Notes		
Oct 21, 1998	Stock Winter Pastures	Plot	Cattle	
		W2	20	
		W3	35	
		W4	15	
		W5	34	Pulled one stiffled & removed
		W6	15	
		W8	20	
Nov 4, 1998	Stock Summer Pastures	Plot	Cattle	Winter pastures too wet, moved cattle to summer plots
		S2	20	Moved 11/04/98
		S3	35	Moved 11/04/98
		S4	15	Moved 11/04/98
		S5	34	Moved 11/06/98
		S6	15	Moved 11/06/98
		S8	19	Moved 11/06/98, one cow missing, jumped out of pasture
Nov 23, 1998	Burned winter pastures			
Nov 23-24, 1998	Burned missed spots			
Dec 10, 1998	Burned missed plot W4			
Oct-Nov, 1998	Mowed summer pastures			
Feb 2, 1999	Bulls put into winter plots			
Feb 3, 1999	Stock winter pastures	Plot	Cattle	Added cattle w/calves to make all pairs & replace missing ones. All cows dewormed and given vibro/lepto and trich shots, calves castrated, dewormed, marked, branded, and steers implanted.
		W2	20	
		W3	35	
		W4	15	
		W5	34	
		W6	15	
		W8	20	
Feb 3, 1999	Burned summer pastures			
Apr 13, 1999	Stock summer pastures	Plot	Cattle	
		S2	20	
		S3	35	
		S4	15	
		S5	34	
		S6	15	
		S8	19	
May 20, 1999				Bull removed from S1. Time in plot less than 2 weeks.
				Bull removed from S5. Time in plot less than 2 weeks.
Jun 1-2, 1999	Temporary Cattle Removal			Temporarily destocked summer pastures, holding cattle in one group. Drought condition high stocking, short grass time out 7-14 days. Cows were BCS, dewormed, and tagged. Calves given shots, dewormed, tagged & weighed. One calf died in grass exclosure while in winter pasture. One cow died in S2.
Dec 2-3, 1999	Stocked winter pastures	Plot	Cattle	
		W2	20	
		W3	35	
		W4	15	
		W5	34	
		W6	15	
		W8	20	

8.3. Public Education

The stocking rate demonstration project has been accompanied by an education component that includes public information sessions, site tours, Internet-based information dissemination, and a video report. A complete description of the Internet website is provided in Appendix A.

The primary target group for this information campaign has been the cattle ranching community of south Florida. The majority are members of the Florida Cattlemen's Association (FCA). Therefore access to this group is best accomplished through meetings of this association. Each summer FCA holds an annual meeting in Marco Island. Project representatives have made formal and informal presentations at the Marco Island meeting describing the status of the demonstration project. In addition, poster exhibits have been presented to the FCA members thus facilitating additional discussion about the project.

Increased awareness of the importance of water quality issues on cattle ranches has resulted in the FCA adoption of a set of water quality guidelines at their 1998 annual convention. The draft manual on BMPs provide guidelines for 1) water quality risk assessment to help identify potential problems, 2) practices that will help improve the quality of water discharged from grazing lands, 3) sources of obtaining further information and/or technical assistance on water quality related problems, and 4) methods to conduct other activities associated with ranching to meet Florida water quality standards. Highlights of the BMP guidelines are:

1.State Statutes: State water quality standards generally apply to all water features (rivers, lakes, streams, springs, wetlands, fresh, brackish, saline, tidal, surface or underground waters) that run through your property and are not entirely owned by you.

2.Livestock Concentration: Areas where cattle tend to congregate or have access to water bodies, tend to have the greatest potential to contribute to water pollution and should be planned and watched carefully.

3.Ranch Conservation Plan: A written water quality conservation plan should be used to document all planned completed activities designed to impact water quality on your property. This plan should contain all activities that have a potential impact on soil, water, air, plant, animal and human resources on your farm since all are interrelated.

4.Vegetative Cover: Maintenance of adequate vegetative cover especially in fragile watershed areas is highly recommended. This may be accomplished by adjusting stocking rate and by adoption of rotational grazing management systems to prevent overgrazing.

5.Watering and Feeding Sites: Develop alternative water sources to attract animals away from streams, drainage canals, and lakes. Place supplemental feeding and mineral troughs at least 100 ft from storm water drainage ways, streams, drainage canals, lakes, wetlands, wells and sinkholes.

6.Holding Pens: Locate new cow pens more than 200 ft from drainage ways, canals, streams and lakes or include a berm to prevent runoff into the water body. Use filter strips, grassed waterways, berms or a waste management system to minimize pollution to water bodies from existing pens.

7.Pollution Abatement Structures: Plugging of canals and/or diversion of natural surface flow through internal marshes, cypress ponds or other wetlands that assimilate nutrients may be used to reduce pollution by sediments, nutrients and organic matter from holding pens but such activities may require permitting from your Water Management District.

8.Minimizing Off-site Discharge: Plug unnecessary drainage canals to retain water on your property. Use control structures such as flashboard riser on culverts to retard water flow. Utilize artificial ponds in upland areas to reduce cattle use of natural wetland systems. When cleaning ditches, mechanically remove vegetation instead of using herbicides and pile vegetation and sediments away from the ditch so nutrients released from decomposition do not wash back into the water.

9.Source Control: Use a nutrient management plan by using IFAS soil and plant nutrient tests and fertilizer and sludge application rate recommendations. Use a pesticide management plan by following directions on pesticide labels, preventing accidental spills, properly disposing of empty containers, having a spill response plan in place, and carefully storing all chemical materials (pesticides, fertilizers, animal drugs, fuels)

10.Erosion Prevention: Ensure quick replacement of vegetative cover after land clearing. Plant grass buffer strips during land clearing along drain areas. Follow DEP's erosion and sedimentation control practices during construction. Minimize vehicular crossing through streams and canals but instead use stabilized culverts or hard surface crossings. Leave some vegetative cover when mowing canal banks.

11.Employee Training: Properly inform all employees about the BMPs. Review your conservation plan, priorities and goals with your employees. Re-train employees annually and whenever changes are made. Train employees to document and retain records of activities.

The entire BMPs manual is currently in print and request for copies may be directed to the Florida Cattlemen's Association, P.O. Box 421929, Kissimmee, FL 34742-1929.

Hopefully, management practices of Florida cattle ranches will continue to improve as the demonstration project releases it results and communicates these findings to the ranchers. The video report provided to DEP/EPA will be made available to FCA members at the FCA annual conference in June 2000 and 2001.

9. Statistical Analysis

9.1. *Demonstration Project Design*

The demonstration project seeks to evaluate four stocking rates of cow-calf units on bahiagrass pasture sites. Each stocking rate treatment is applied on two plots of each pasture block (see Table 9.1.1).

Table 9.1.1. Design of the stocking rate treatments demonstration project (control plots highlighted).

Block	Plot ID	Treatment		
		Description	Cow-Calf Units	Acres/Unit
Winter	W4 & W7	Control	0	N/A
	W1 & W6	Low	15	5.3
	W2 & W8	Medium	20	4.0
	W3 & W5	High	35	2.3
Summer	S1 & S8	Control	0	N/A
	S4 & S6	Low	15	3.3
	S2 & S7	Medium	20	2.5
	S3 & S5	High	35	1.4

Four-runoff water quality parameters (NH_3, $N0_x$, TKN and TP) were measured for each of the 16 pasture plots. The objective of these measurements was to determine if the cow-calf stocking rates affect nutrient concentrations and loads of pasture runoff. In evaluating results of these treatments we performed several statistical analyses. Each statistical analysis assumes that the data are normally distributed. Therefore the first step is to check the data distribution. This was accomplished by producing frequency histograms using the Minitab software package (Minitab, Inc., 1998). The histogram shown in Figure 9.1.1 does not exhibit a normal distribution. Water quality data typically manifest a log-normal distribution. Therefore a log transformation is likely to yield a normal frequency distribution. In Figure 9.1.2 we observe a more normal distribution histogram as a result of the log transformation. All analyses were run using the log transformation of the concentration data.

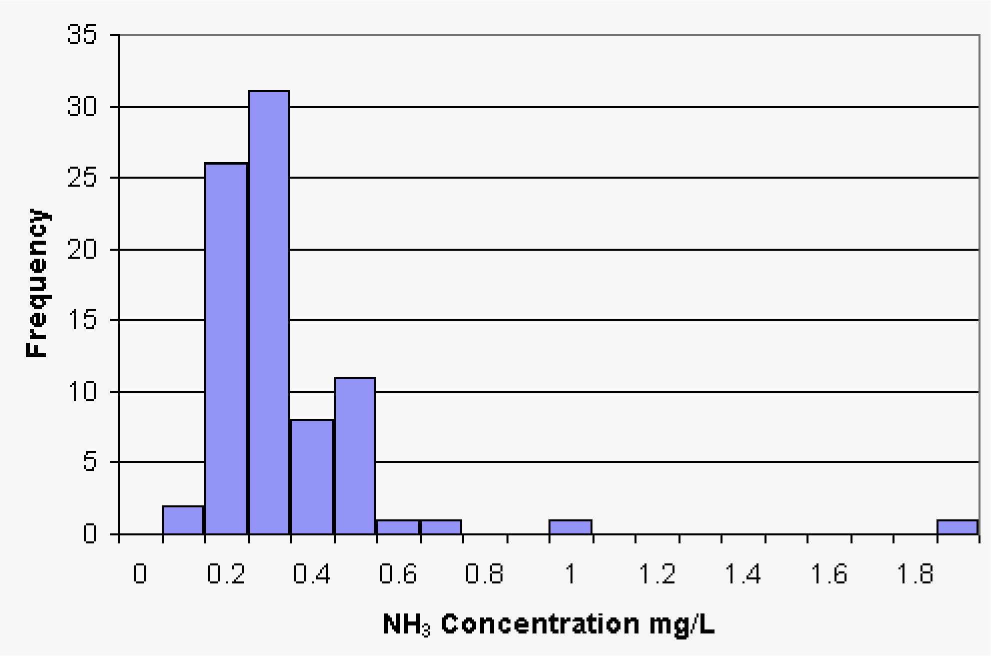


Figure 9.1.1. Frequency distribution for the NH_3 concentration at Site S8 in 1998.

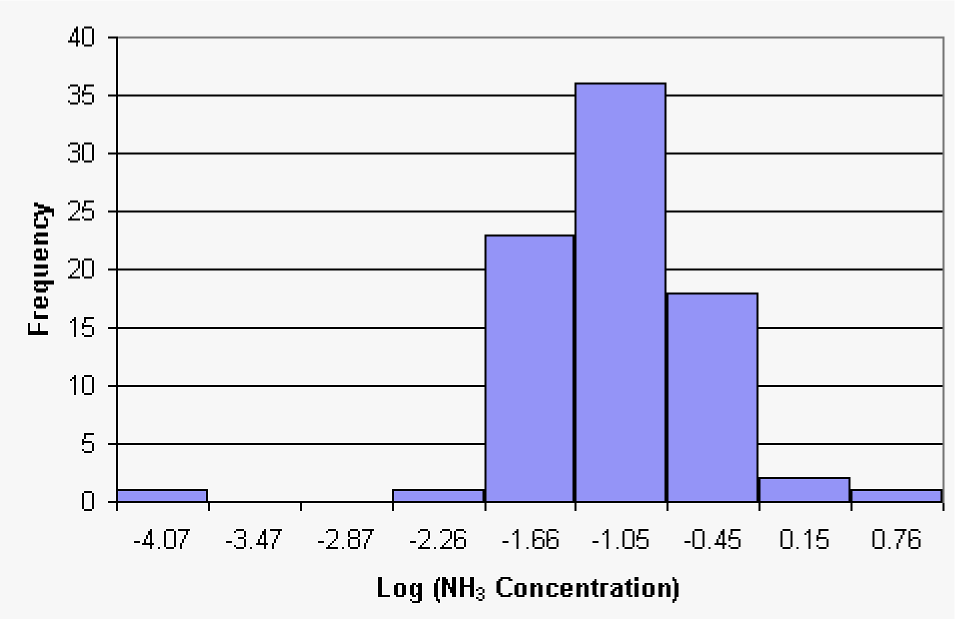


Figure 9.1.2. Frequency distribution for the log(NH_3 concentration) data at site S8 in 1998.

9.2. Statistical Methods

The Nonparametric Option

Most hypothesis-testing procedures are based on the assumption that the random samples are selected from normal populations. Nonparametric statistics permit us to avoid the assumption of a normal distribution in a data set. The Wilcoxon – Mann – Whitney two-sample test or the Kraukal – Wallis test, tests the null hypothesis that two population medians are equal. These procedures are potentially applicable to our set of data, and could be run using the Minitab software. These nonparametric procedures are an equivalent approach to the F test for testing the equality of means in the one-way analysis of variance. The others nonparametric tests are based on paired samples approach. But since our samples are not paired, these tests are not applicable to our statistical analyses. Although nonparametric statistics seems to be simpler, statistics books agree in saying that if the parent population is known to be reasonably close to a distribution for which there is a standard theory, or if the data can be transformed so that such is the case, then nonparametric procedures extract less information than is available in the data.

The efficiency of nonparametric procedures relative to the parametric ones is quite high for small samples, and it decreases as the sample size increases. In summary, if a parametric and a nonparametric test are both applicable to the same set of data, we should use the more efficient parametric techniques. Therefore, as the log transformation allows us to use the parametric statistics, we will not use the nonparametric alternatives in our statistical analyses.

The section below will describe the tests used to analyze our data set:

T-test:	Replicate validity confirmation
ANOVA:	Main effect evaluation
Multiple Comparison:	Treatment mean differences

Means Test

By analyzing the treatment replicate results we seek to verify that they are valid replicates (means not significantly different). One option in performing this verification is to run a paired test, but this test requires equal sample sizes and the assumption that our samples are dependent rather than independent measurements. Since neither of these assumptions holds true in our case, we instead choose to run a two sample t-test. This allows us to assume independent samples and to test the difference between means calculated from unequal size samples.

<u>Procedure</u>

The mean expresses the central tendency of a data set:

$$\overline{X} = \frac{\sum X}{n}$$

Where: X = a single water quality concentration measurement in our case, and
n = the number of measurements.

As an example we will compare controls S_1 and S_8 for total phosphorus concentration in 1998. The S_1 mean ($\overline{X_1}$) is calculated from 97 values whereas the S_8 mean ($\overline{X_8}$) is calculated from 83 values. In this example the sample sizes are unequal, however the procedure for a situation with equal sample sizes is available at http://davidmlane.com/hyperstat/B58842.html.

The assumptions adopted for this project dataset are: (1) the populations are log-normally distributed, (2) the variances in the two populations are equal, and (3) the measurements are independent. Given these assumptions, the t-test procedure is a three-step process of determining the test hypothesis, choosing the level of significance, and calculating the t statistic.

(1) For projects testing statistical significance of differences between means, the null hypothesis states that the difference between means is some specified value. Usually the specified value is zero. For this example, the null and alternative hypotheses are:

H_o: $\overline{X}_1 - \overline{X}_8 = 0$

H_1: $\overline{X}_1 - \overline{X}_8 \neq 0$

(2) The most common alpha value (level of significance), 0.05, will be used in this evaluation.

(3) The t statistic is calculated as:

$$t = (\overline{X}_1 - \overline{X}_8)/S$$

The calculation method for the standard deviation (S) depends upon the variance between the two populations assumption. If unequal variances are assumed, then the sample standard deviation of $\overline{X}_1 - \overline{X}_8$ is

$$S = \sqrt{\left(\frac{S_1^2}{n_1} + \frac{S_8^2}{n_8}\right)}$$

$$\text{And } df = \frac{(\mathrm{var}_1 + \mathrm{var}_8)^2}{\left[\mathrm{var}_1^2/(n_1 - 1)\right] + \left[\mathrm{var}_8^2/(n_8 - 1)\right]}$$

$$\text{Where } \mathrm{var}_1 = \frac{S_1^2}{n_1} \text{ and } \mathrm{var}_8 = \frac{S_8^2}{n_8}$$

If equal variances are assumed, then the standard deviation of $\overline{X}_1 - \overline{X}_8$ is

$$S = S_p\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_8}\right)}$$

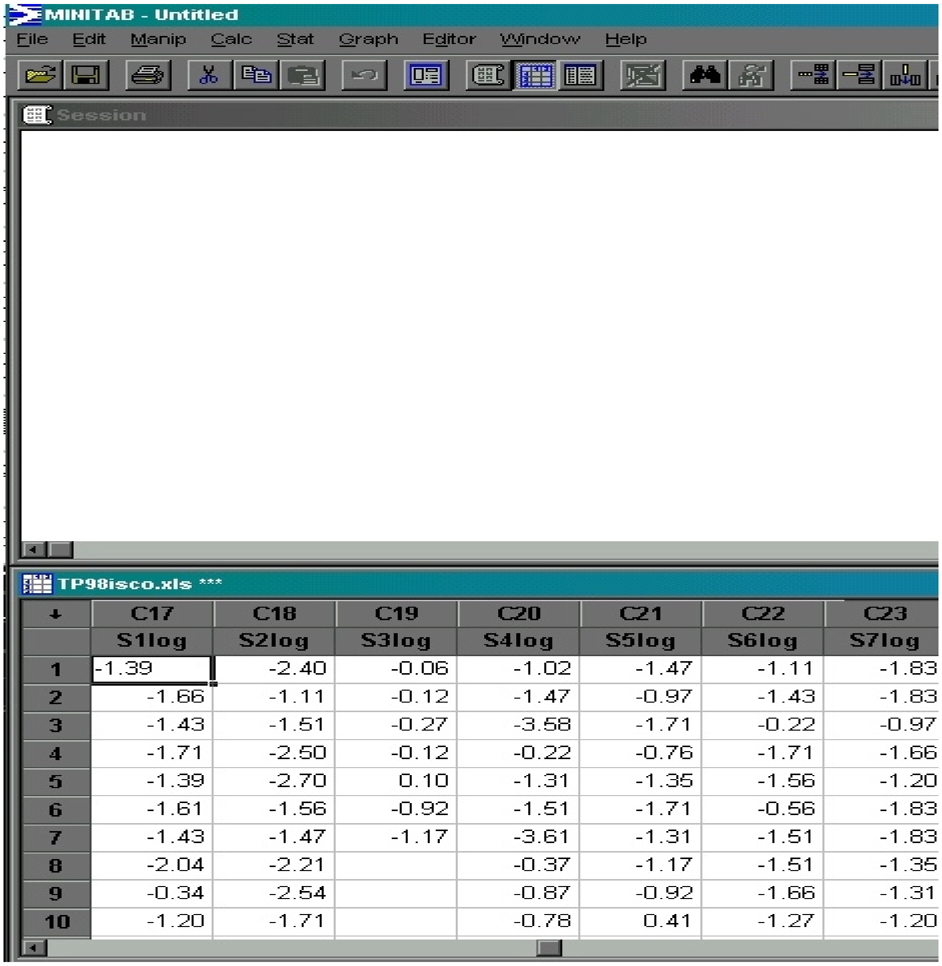
$$\text{And } df = (n_1 + n_8 - 2)$$

The common variance is estimated by the pooled variance

$$S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_8 - 1)S_8^2}{n_1 + n_8 - 2}$$

Minitab Implementation

The Minitab computer display is composed of two windows (see Figure 9.2.1); one is the session window (where the results appear) and the other is the worksheet window (containing the data). Instead of entering the data manually we simply open an existing Excel spreadsheet.



↓	C17	C18	C19	C20	C21	C22	C23
	S1log	S2log	S3log	S4log	S5log	S6log	S7log
1	-1.39	-2.40	-0.06	-1.02	-1.47	-1.11	-1.83
2	-1.66	-1.11	-0.12	-1.47	-0.97	-1.43	-1.83
3	-1.43	-1.51	-0.27	-3.58	-1.71	-0.22	-0.97
4	-1.71	-2.50	-0.12	-0.22	-0.76	-1.71	-1.66
5	-1.39	-2.70	0.10	-1.31	-1.35	-1.56	-1.20
6	-1.61	-1.56	-0.92	-1.51	-1.71	-0.56	-1.83
7	-1.43	-1.47	-1.17	-3.61	-1.31	-1.51	-1.83
8	-2.04	-2.21		-0.37	-1.17	-1.51	-1.35
9	-0.34	-2.54		-0.87	-0.92	-1.66	-1.31
10	-1.20	-1.71		-0.78	0.41	-1.27	-1.20

Figure 9.2.1. Minitab windows.

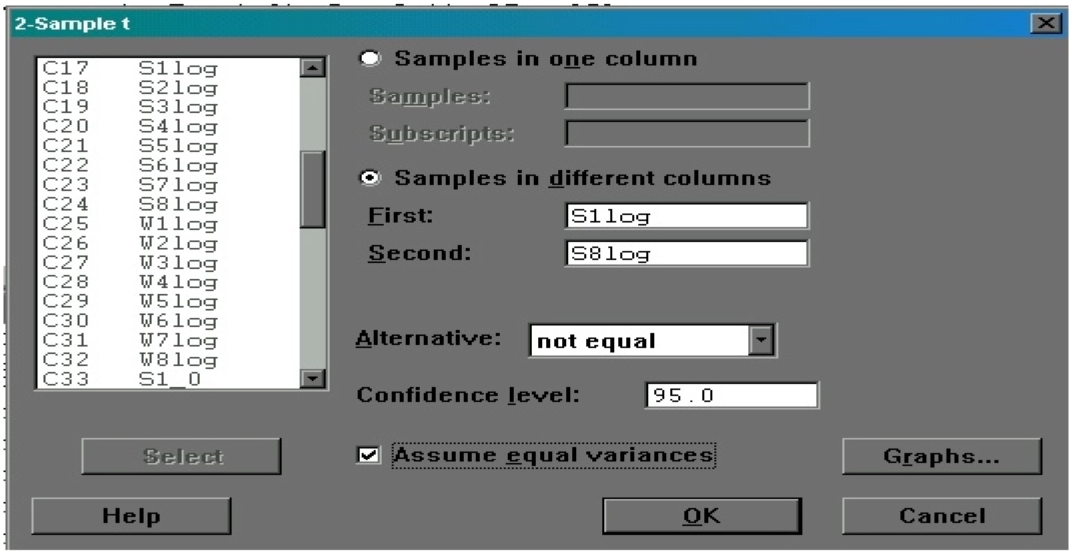
Once the data are in the Minitab worksheet the statistics may be calculated by choosing in the stat menu ➢ Basics statistics ➢2 Sample T-test. In the dialog box (see Figure 9.2.2) we chose the following options:

(a) The data column to be analyzed (S_1 log and S_8 log),
(b) The alternative means hypothesis,
(c) The confidence level (95% in our case), and
(d) The variance option (equal or unequal).

Prior to selecting one of the variance options we need to check the variance. We do this using an F-test between the two variances to evaluate the null hypothesis $S_1^2 = S_8^2$ and the alternative hypothesis $S_1^2 \neq S_8^2$.

$$F = \frac{\text{the larger } S^2}{\text{the smaller } S^2}$$

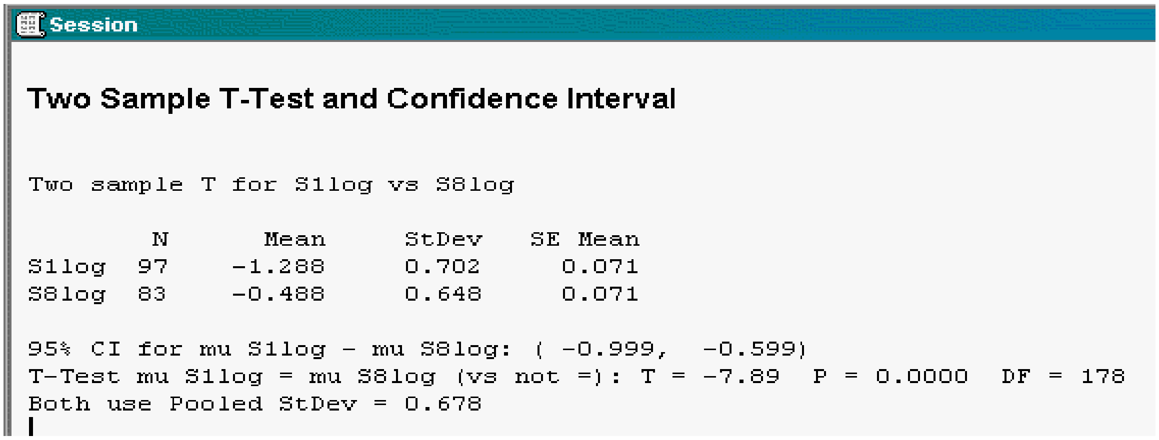
If the calculated F is larger than the tabulated F value then we reject the null hypothesis and accept the alternative hypothesis. In the equal variance case we check the "Assume equal variance" option, in the dialog box shown in Figure 9.2.2.



C17 S1log
C18 S2log
C19 S3log
C20 S4log
C21 S5log
C22 S6log
C23 S7log
C24 S8log
C25 W1log
C26 W2log
C27 W3log
C28 W4log
C29 W5log
C30 W6log
C31 W7log
C32 W8log
C33 S1_0

○ Samples in one column
Samples:
Subscripts:
● Samples in different columns
First: S1log
Second: S8log
Alternative: not equal
Confidence level: 95.0
☑ Assume equal variances

Figure 9.2.2. Two sample T-test dialog box.



```
Two Sample T-Test and Confidence Interval


Two sample T for S1log vs S8log

         N      Mean      StDev   SE Mean
S1log  97    -1.288      0.702     0.071
S8log  83    -0.488      0.648     0.071

95% CI for mu S1log - mu S8log: ( -0.999,  -0.599)
T-Test mu S1log = mu S8log (vs not =): T = -7.89  P = 0.0000  DF = 178
Both use Pooled StDev = 0.678
```

Figure 9.2.3. Minitab two sample T-test result.

Minitab displays the result in the session window as shown in Figure 9.2.3. The results contain the mean, the standard deviations, the mean square errors, and the interval of confidence for a 95% level, the T value, the probability level, and the degrees of freedom. Because the P value is less than 0.05 we can conclude the difference between the means is not equal to zero and is within the interval of [-0.999,-0.599]. From a statistical table check we can conclude that the means of the replicates are significantly different from one another given that the calculated T value (-7.89) is greater than the reference table T value (1.64) given a degrees of freedom of 178 and 95% level of significance. The probability that this conclusion is incorrect is reflected in the P value. In this case P=0.000 indicates that there is very strong evidence for a difference between the two means. The resulting conclusion is that the control plots S_1 and S_8 in 1998 are not statistically valid replicates with respect to total phosphorus concentration.

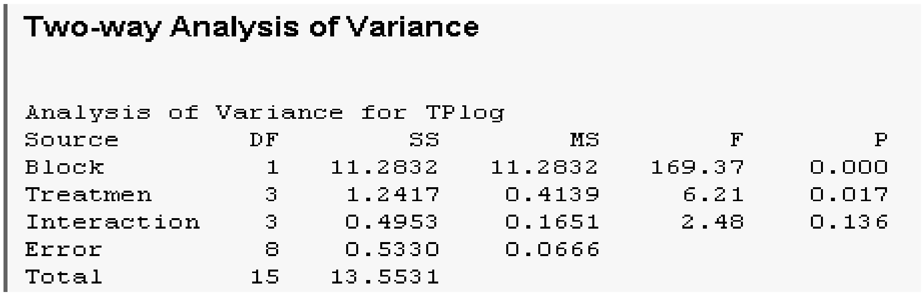
Analysis of Variance (ANOVA)

By performing an analysis of the variance we seek to assess the significance of main effects on the nutrient concentrations and runoff loads. For this determination we use a two-way analysis of variance. The two factors are the type of Block (winter or summer pasture) and the Treatment (cow-calf stocking rates). The two-way variance analysis is explained below:

Procedure

A two-factor analysis of variance consists of three significance tests: a test of each of the two main effects and a test of the interaction of the variables. An analysis of variance summary as shown in Table 9.2.1 is a convenient way to display the results of the significance tests.

Table 9.2.1. Two way analysis of variance results.



```
Two-way Analysis of Variance

Analysis of Variance for TPlog
Source         DF        SS        MS        F        P
Block           1   11.2832   11.2832   169.37    0.000
Treatmen        3    1.2417    0.4139     6.21    0.017
Interaction     3    0.4953    0.1651     2.48    0.136
Error           8    0.5330    0.0666
Total          15   13.5531
```

Sources of Variation

The summary table shows four sources of variation: (1) Pasture Block, (2) Stocking Rate Treatment, (3) Pasture Block x Stocking Rate Treatment interaction, and (4) Error.

Degrees of Freedom

The total degrees of freedom are always equal to the total number of measurements in the analysis minus one. The demonstration project had a total of 16 observations per year. Therefore, df total = 16 - 1 = 15. The degrees of freedom for the main effect of a factor is always equal to the number of levels of the factor minus one: df Block = 2 - 1 = 1 since there were two Blocks (summer and winter) and df Treatment = 4 - 1 = 3 since there were four stocking rates (0, 15, 20, 35). The degrees of freedom for an interaction are equal to the product of the degrees of freedom of the variables in the interaction. Thus, the degrees of freedom for the Pasture Block x Stocking Rate Treatment interaction is the product of the degrees of freedom for Block (1) and the degrees of freedom for Treatment (3) which yields df = 1 x 3 = 3. The Error degrees of freedom is equal to the degrees of freedom total minus the degrees of freedom for all the effects: df Error = 15 - 1 - 3 - 3 = 8.

Mean Squares

As in the case of a one-factor design, each mean square is equal to the sum of squares divided by the degrees of freedom. The sum of squares (SS) for an effect is calculated as the sum of the squares of the difference between each measurement and the mean of all measurements for that effect.

$$SS = \sum_i \left(X_i - \overline{X}\right)^2$$

F Ratios

The F ratio for an effect is computed by dividing the mean square for the effect by the mean square error. For the example show in Table 9.2.1, the F ratio for the Pasture Block x Stocking Rate Treatment interaction is computed by dividing the mean square for the interaction (0.1651) by the mean square error (0.0666). The resulting F ratio is:

F = MS effect/ MS error = 0.1651/0.0666 = 2.48

Probability Values

Using statistical tables to determine the threshold probability value corresponding to a calculated F ratio first requires determination of the degrees of freedom associated with the computed F ratio. The numerator df is equal to the degrees of freedom for the effect. The denominator df is equal to the Error degrees of freedom. Therefore, the df values of the F for the Block effect are 1 and 8, the df values for the F for the Stocking Rate Treatment effect are 3 and 8, and the df values of the F for the Pasture Block x Stocking Rate Treatment interaction effect are 3 and 8. Entering an F-table (such as the one at http://faculty.vassar.edu/~lowry/apx_d.html) with the F value and the df values yields the approximate threshold probability. Minitab performs this same function automatically and reports the critical probability (P value) in the result window (see Table 9.2.1).

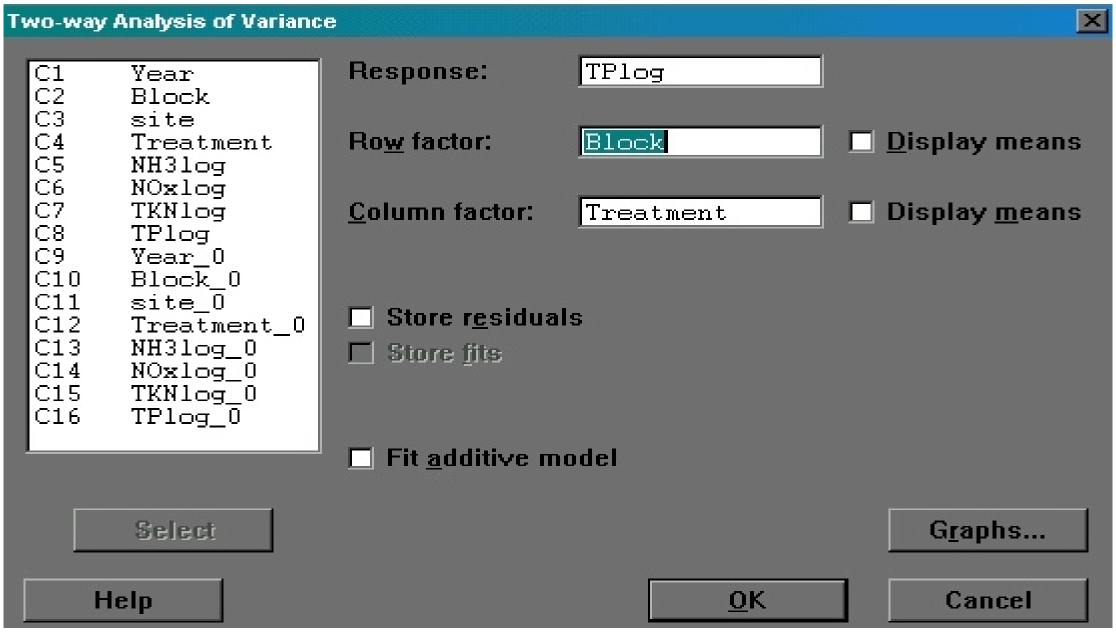
Drawing Conclusions

In an ANOVA the null hypothesis states that there is no main effect (Block or Treatment). To reach a conclusion regarding the null hypothesis we compare the F values. If the calculated F value for an effect is greater than the reference table F value then we reject the null hypothesis and we can conclude that the factor (Block or Treatment) is statistically significant. In this example the calculated F value for the Block is 169.37 and the reference table F value for df (1, 8) is 5.32. Therefore we can conclude that the type of Block is a statistically significant factor for TP concentration, whereas Treatment and the interaction (Block x Treatment) are apparently not significant factors.

Minitab Implementation

Minitab can perform Two-way Analysis of Variance by selecting in the menu Stat ➢ ANOVA ➢ Two-way…. In the dialog box (see Figure 9.2.4) we choose which variable response we want to study, then the two factors. Minitab displays the results in the session window. The result contains:

- df	(degree of freedom)
- SS	(Sums of Squares)
- MS	(Means Squares)
- F	(F ratio)
- P	(Probability value)



```
C1      Year
C2      Block
C3      site
C4      Treatment
C5      NH3log
C6      NOxlog
C7      TKNlog
C8      TPlog
C9      Year_0
C10     Block_0
C11     site_0
C12     Treatment_0
C13     NH3log_0
C14     NOxlog_0
C15     TKNlog_0
C16     TPlog_0
```

Response: TPlog

Row factor: Block ☐ Display means

Column factor: Treatment ☐ Display means

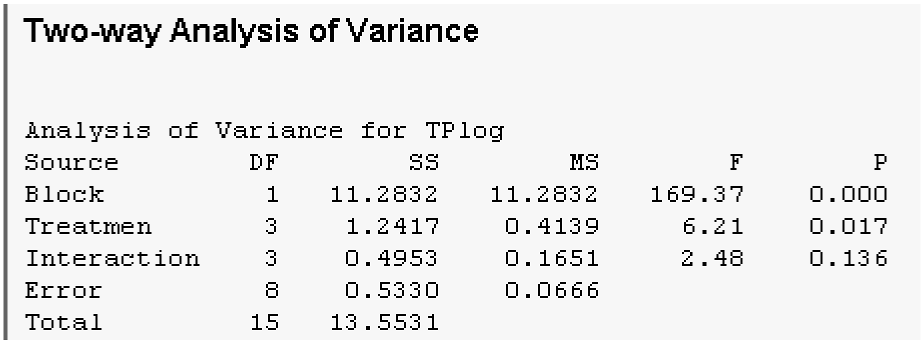
☐ Store residuals

☐ Store fits

☐ Fit additive model

Figure 9.2.4. Minitab Two-way Analysis of Variance dialog box.

Table 9.2.2. Two way analysis of variance results.



Two-way Analysis of Variance

```
Analysis of Variance for TPlog
Source          DF        SS        MS         F         P
Block            1   11.2832   11.2832    169.37     0.000
Treatmen         3    1.2417    0.4139      6.21     0.017
Interaction      3    0.4953    0.1651      2.48     0.136
Error            8    0.5330    0.0666
Total           15   13.5531
```

By inspecting Table 9.2.2 we can conclude with the F value that the main effect on the TP concentration is due to the type of Block but Treatment has no apparent effect nor does the interaction among the two. The F table threshold value is 5.32 for 1 & 8 degrees of freedom.

9.3. Results

Means Test

The purpose of this means test is to determine if the replicate means are similar. Dissimilar means are marked with an “x” in Table 9.3.1.

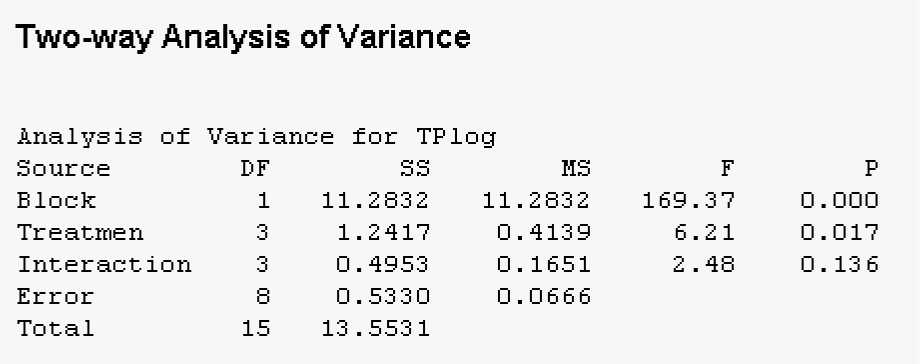
Table 9.3.1. Significantly different replicates means are indicated by “x” (control plots are highlighted).

	W4:W7 Control	W1:W6 Low	W2:W8 Medium	W3:W5 High	S1:S8 Control	S4:S6 Low	S2:S7 Medium	S3:S5 High
TP 98	x	x	x	x	x			
TP 99		x						
TKN 98	x	x	x	x	x	x		
TKN 99							x	
NOx 98	x			x	x		x	
NOx 99				x	x			
NH3 98	x					x		
NH3 99		x	x	x	x		x	

Analysis of Variance

The purpose of the analysis of variance tests is to determine which factors affect the nutrient concentration means. The “Block” effect is statistically significant for TP-98/99, NH_3-98/99, NO_x-98, and TKN-99. We can also notice that the Treatment effect is statistically significant for TP-98 and NH_3-98.

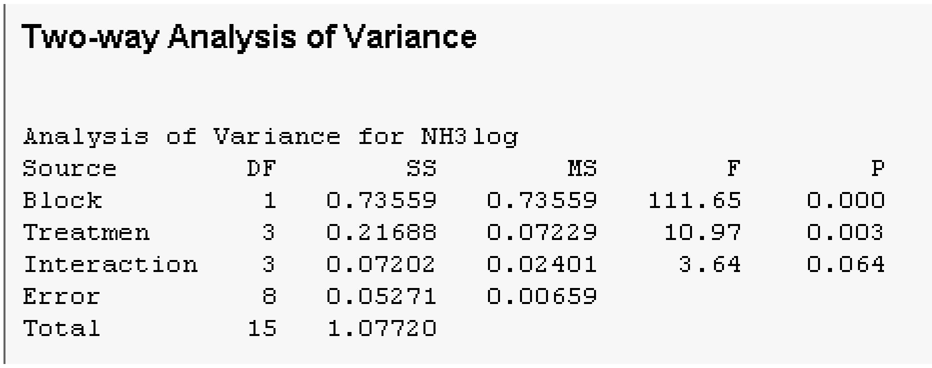
Table 9.3.2. Two-way analysis of variance for TP in 1998 results.



Two-way Analysis of Variance

```
Analysis of Variance for TPlog
Source          DF        SS        MS         F         P
Block            1   11.2832   11.2832    169.37     0.000
Treatmen         3    1.2417    0.4139      6.21     0.017
Interaction      3    0.4953    0.1651      2.48     0.136
Error            8    0.5330    0.0666
Total           15   13.5531
```

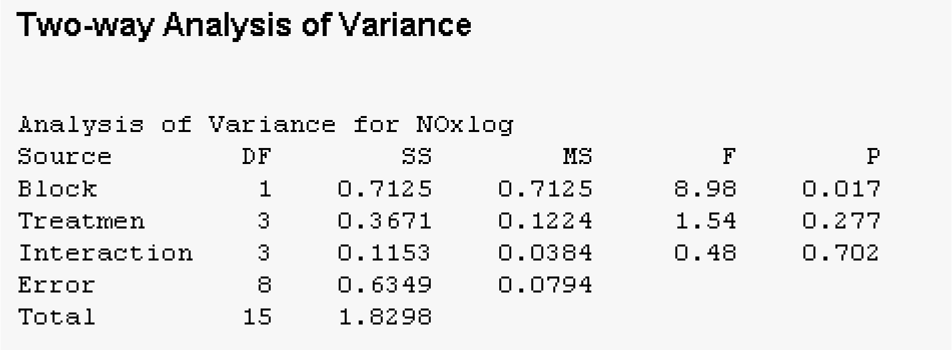
Table 9.3.3. Two-way analysis of variance for NH_3 in 1998 results.



Two-way Analysis of Variance

```
Analysis of Variance for NH3log
Source         DF        SS        MS        F        P
Block           1   0.73559   0.73559   111.65    0.000
Treatmen        3   0.21688   0.07229    10.97    0.003
Interaction     3   0.07202   0.02401     3.64    0.064
Error           8   0.05271   0.00659
Total          15   1.07720
```

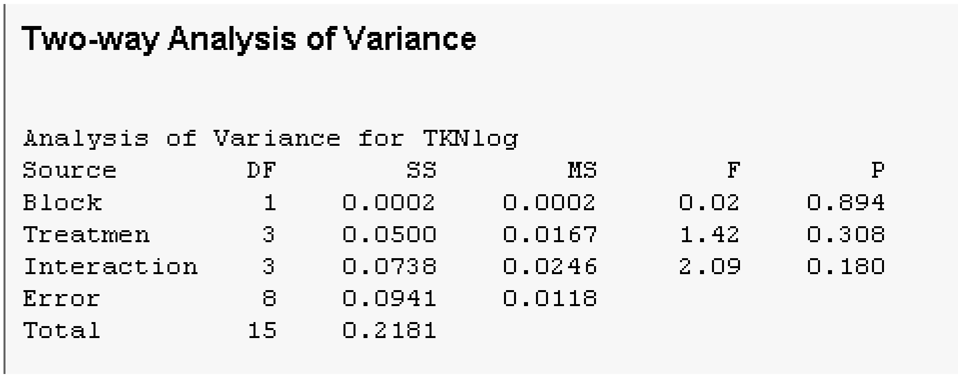
Table 9.3.4. Two-way analysis of variance for NO_x in 1998 results.



Two-way Analysis of Variance

```
Analysis of Variance for NOxlog
Source         DF        SS        MS        F        P
Block           1    0.7125    0.7125     8.98    0.017
Treatmen        3    0.3671    0.1224     1.54    0.277
Interaction     3    0.1153    0.0384     0.48    0.702
Error           8    0.6349    0.0794
Total          15    1.8298
```

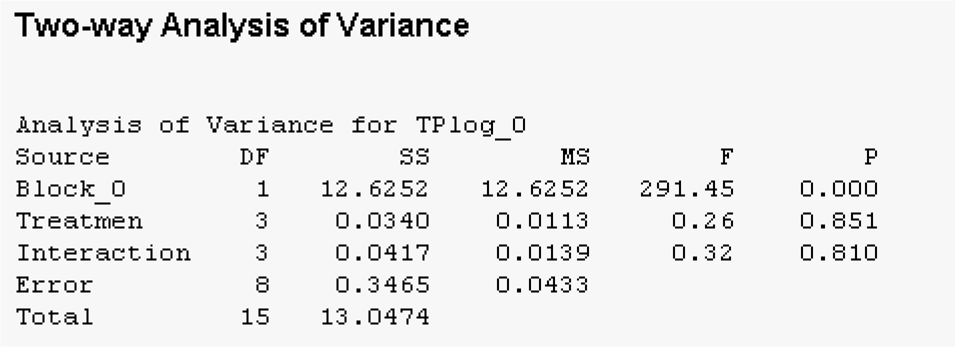
Table 9.3.5. Two-way analysis of variance for TKN in 1998 results.



Two-way Analysis of Variance

```
Analysis of Variance for TKNlog
Source         DF        SS        MS        F        P
Block           1    0.0002    0.0002     0.02    0.894
Treatmen        3    0.0500    0.0167     1.42    0.308
Interaction     3    0.0738    0.0246     2.09    0.180
Error           8    0.0941    0.0118
Total          15    0.2181
```

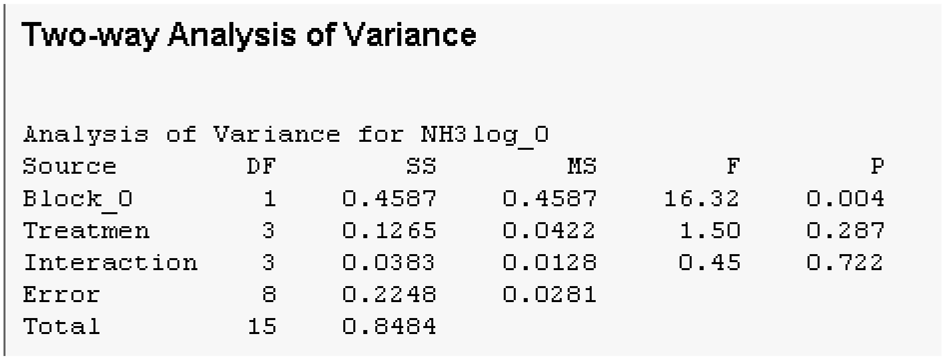
Table 9.3.6. Two-way analysis of variance for TP in 1999 results.



Two-way Analysis of Variance

```
Analysis of Variance for TPlog_O
Source         DF        SS        MS        F        P
Block_O         1   12.6252   12.6252   291.45    0.000
Treatmen        3    0.0340    0.0113     0.26    0.851
Interaction     3    0.0417    0.0139     0.32    0.810
Error           8    0.3465    0.0433
Total          15   13.0474
```

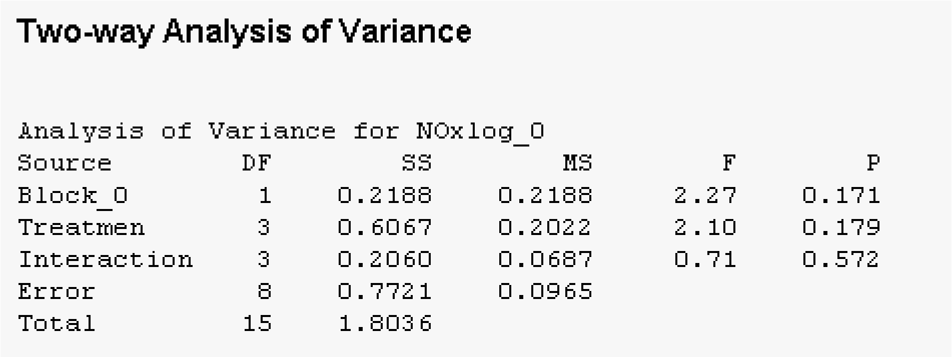
Table 9.3.7. Two-way analysis of variance for NH_3 in 1999 results.



Two-way Analysis of Variance

```
Analysis of Variance for NH3log_O
Source         DF        SS        MS        F        P
Block_O         1    0.4587    0.4587    16.32    0.004
Treatmen        3    0.1265    0.0422     1.50    0.287
Interaction     3    0.0383    0.0128     0.45    0.722
Error           8    0.2248    0.0281
Total          15    0.8484
```

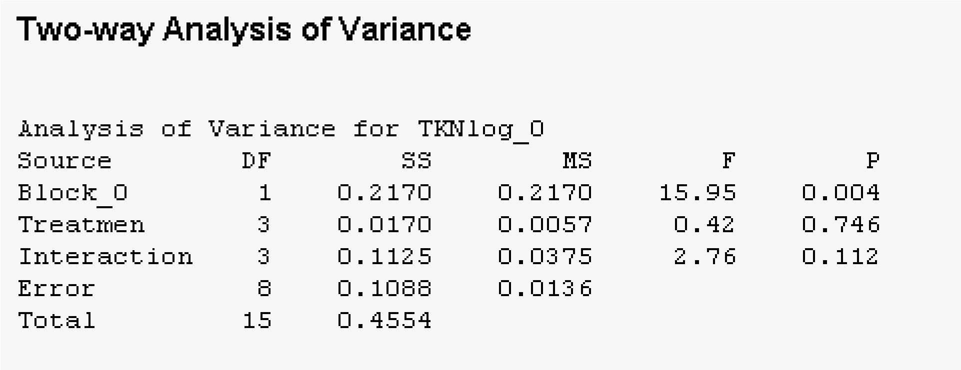
Table 9.3.8. Two-way analysis of variance for NO_x in 1999 results.



Two-way Analysis of Variance

```
Analysis of Variance for NOxlog_O
Source         DF        SS        MS        F        P
Block_O         1    0.2188    0.2188     2.27    0.171
Treatmen        3    0.6067    0.2022     2.10    0.179
Interaction     3    0.2060    0.0687     0.71    0.572
Error           8    0.7721    0.0965
Total          15    1.8036
```

Table 9.3.9. Two-way analysis of variance for TKN in 1999 results.



Two-way Analysis of Variance

```
Analysis of Variance for TKNlog_O
Source        DF        SS        MS        F        P
Block_O        1    0.2170    0.2170    15.95    0.004
Treatmen       3    0.0170    0.0057     0.42    0.746
Interaction    3    0.1125    0.0375     2.76    0.112
Error          8    0.1088    0.0136
Total         15    0.4554
```

The analysis of 1998 and 1999 data (see Tables 9.3.2 to 9.3.9) show that the Block (type of pasture) has a statistically significant effect for most nutrient concentrations, whereas the Treatment (stocking rate) is significant only for TP-98 and NH_3-98. The 1998 treatment effects are meaningless since this was prior to implementation of the BMP's

Not addressed in this initial statistical analysis is the potential for significant serial correlation in measurements, such as these, that are essentially non-uniform time series. This has a big impact on the two independent sample t-tests used to compare the two replications for any treatment. While the means are not affected by this correlation, the variances are highly affected. With serial correlations in the data, the "effective" sample sizes would be much less, potentially leading to conclusions that the two reps are not statistically different. This issue will be addressed in subsequent reports.

Another test presented in this report is the pair wise tests on the replicates. The results may be of interest, but the test is highly inefficient relative to data utilization. This test assumes that the 8 plots within a block are true replicates and that the observed variation across the plots represents the response effect. The treatments assigned to fields are then assumed to shift the average constituent response up or down. The best statistical analysis for these data takes advantage of these assumptions and models response accordingly. The analysis approach is one of looking at a series of increasingly complex models starting with the simple mean model (i.e. no treatment, no block effects) to a model that has both treatment and block effects, interaction and allows for heterogeneity of variance across fields with temporal serial correlations. This issue will also be addressed in subsequent reports.

A whole range of possible 'ANOVA' models are examined and the simplest one that most adequately explains the variation in the response would be used to actually say something about treatment and block effects. The ANOVA performed in this report is just one of the simpler models. It pools temporal measurements into one mean. It disregards that fact that potentially each field could have a different variance in measurements and certainly each field has a different sample size. While the ANOVA test presented in this report is useful as an initial data inspection, the data require a more rigorous approach for any findings to be conclusive.

10. Conclusions

10.1. Concentrations and Loads

Initial statistical analysis of both the concentration and load results show only a block effect reflecting differences between the winter and summer pasture arrays. The summer improved pastures show much greater total phosphorus concentrations and loads as compared to the winter native range areas. This difference may be an artifact of prior land use history. The summer pastures were used as clover fields many years ago and thus subject to intense fertilization. Total phosphorus concentrations and loads were five times higher on the summer pastures than on the winter pastures.

Statistical differences resulting from the different cattle stocking rates would not be expected to be evident this early in the project. 1998 represented an equilibration period and 1999 represents the first year of grazing density treatments. With an impressive monitoring infrastructure currently in place at Buck Island Ranch, the next two years of the project should yield good results towards quantifying the water quality impacts of grazing density.

10.2. OrthoP-TP Ratio

In addition to observing differences in the quantity of phosphorus in runoff water, between the two sites. A notable difference was also observed in the proportion of ortho-P contained in the runoff. For the winter pastures, the ortho-P to TP ratio was approximately 0.23 while for the summer pastures the ratio was 0.72. Not only did the summer pastures export more phosphorus but they also exported a more biologically available form of phosphorus.

10.3. Soils Results

Meaningful results were also found in the soils data. On both the summer and winter pastures the highest concentrations of soil phosphorus are located within the first 5 cm of the pasture soils. The high TP content in the summer pasture runoff water was matched by correspondingly high water soluble P concentration in the summer pasture soils. This apparent relationship between soil P and runoff P warrants further investigation.

10.4. Future Implementation

The success of the next two years will depend greatly on the ability of the project team to properly maintain the pasture ditches and the measurement instruments. With over 20 dataloggers and over 100 sensors in operation, the task of keeping up with equipment failures is challenging. Also important to the project will be the timely review of incoming data, reliability of controller software, and the strict adherence to SOP requirements for runoff sample collections and handling. The frequency of grab samples will also need to be increased while the extent of autosamples may be decreased or at least reduced by implementing sample compositing schemes.

10.5. Recommendations

Given the preliminary nature of the project results only limited recommendations can be distilled from the data.

1. Soil Phosphorus tests can be an effective tool in evaluating pasture sites potential for P loading.
2. BMP’s should be targeted on those pastures where soil P tests (0-5 cm WSP) document high nutrient levels.
3. In developing nutrients reduction plans, do not expect stocking rate BMP’s to significantly reduce P loads in less than 2 years.

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