Big Sky, Montana
Meadow Village Golf Course

Nutrient Management Plan

Created For:

Big Sky Water & Sewer District

April 2012

DOWL HKM
222 North 32nd Street
Suite 700
P.O. Box 31318
Billings, MT 59107-1318

RECEIVED
APR 27 2012

Montana Department of
ENVIRONMENTAL QUALITY
Brian Schweitzer, Governor
P. O. Box 200901 Helena, MT 59620-0901 (406) 444-2544 Website: www.deq.mt.gov

April 26, 2012

Mr. Ron Edwards, District Manager
Big Sky Water and Sewer District #363
PO Box 160670
Big Sky, MT 59716

Re: Big Sky Sewer District #363, Golf Course Nutrient Management Plan – Approval

Dear Mr. Edwards,

Thank you and your consultant Ray Armstrong for working with us to develop, submit and implement the nutrient management plan (NMP) for effluent application to the Meadow Golf Course. Via the authority provided the Department under the Public Water Supplies, Distribution & Treatment Act, MCA Title 75, we hereby approve the Nutrient Management Plan with the one following condition. We ask that a more detailed irrigation site map be developed and included in the NMP. The air photo as a background is fine, but we would like to see a depiction of the sprinklers, both existing and those to be added into operations by simply outlining the coverage areas with a hatch pattern or other such method. It should depict surface water setbacks where appropriate. Irrigation certainly can proceed as planned for the upcoming season.

We will share this plan and approval letter with the TMDL implementation crew here in the Department so that they are aware of the excellent steps that have been taken to address our concerns. It is our continued belief that effluent reuse practices are beneficial in preserving surface water quality and are a tool which must be allowed to address impairments.

Sincerely,

Terry Campbell, P.E.
Environmental Engineer
Technical & Financial Assistance Bureau
(406) 444-7343

Cc: Ray Armstrong, Dowl/HKM Engineering Inc., Billings
Todd Teegarden, DEQ PPAD, Helena
Jenny Chambers, DEQ PCD, Helena
Robert Ray, DEQ PPAD, Helena
Taylor Middleton, Big Sky Resort General Manager, Big Sky
Sam Woodger, Big Sky Resort golf course superintendent, Big Sky

DOWL HKM

Project #: 06M357.115	Date: 4/17/2012

To: Mr. Terry Campbell
Montana Department of Environmental Quality
P.O. Box 200901
Helena Montana, 59620-0901

APR 19 2012

Regarding: Big Sky Nutrient Management Plan

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We are sending you ☒ Attached ☐ Under Separate Cover

Via the following items:

☐ Shop drawings ☐ Prints ☐ Plans ☐ Specifications

☐ Copy of letter ☐ Change order ☐ Other ☐ Samples

Copies	Date	Description
2		Copies of the Meadow Village Nutrient Management Plan

These are transmitted as indicated below:

☒ For approval	☐ Approved as submitted	☐ Resubmit	copies for approval
☒ For your use	☐ Approved as noted	☐ Submit	copies for distribution
☐ As requested	☐ Returned for corrections	☐ Return	corrected prints
☐ For review & comment		☐ Prints returned after loan to us	
☐ Bids due	☐ Other:		

Remarks:

Copy to: Ron Edwards with 2 Copies

Typed Name: Ray Armstrong

Signature: [signature]

Table of Contents

List of Tables and Figures

1 Introduction and Purpose

Reclaimed wastewater is increasingly being used to irrigate turf grasses. Irrigation with reclaimed wastewater is a beneficial use that reduces the amount of fresh water needed for the course and supplies needed nutrients, primarily nitrogen, for turf growth. The Meadow Village golf course has used treated wastewater for irrigation since the course was constructed in the early 1970's. In 2004, a new advanced wastewater treatment plant was constructed that greatly improved the quality of the irrigation water applied to the course. While nitrogen is vital for turf growth, over application can result in leaching of nitrogen into the groundwater and potentially result in nitrogen reaching the Middle Fork West Fork Gallatin River. Once excess nitrogen reaches a surface stream it can result in undesirable algae growth that influences aquatic life in the stream. The Nutrient Management Plan described in this document is intended to provide the framework to ensure nutrients from the golf course irrigation do not reach surface streams.

Irrigation of the golf course with reclaimed wastewater was approved by the Montana Department of Environmental Quality (MDEQ) based on the applied nitrogen being equal to or less than the agronomic uptake rate of the turf grass. The facility was approved to apply 150 pounds of Total Nitrogen (TN) per acre per year) to 185 acres of defined golf course and adjacent roughs with a 50 foot setback from surface streams. The 150 pounds of allowed total nitrogen application includes inorganic applied fertilizers, nitrogen in the irrigation water, and nitrogen available in grass clipping that is returned to the soil and is available for plant uptake. Figure 1-1 shows the approved irrigation area.

Figure 1-1
Meadow Village Golf Course

1.1 Governing Standards

Section 75-5-317(2) h of the Montana Annotated Code considers land application of treated wastewater a non-significant impact when the application is based on the agronomic uptake of the applied nutrients. At this time, April 2012, draft irrigation and reuse standards are being proposed in Circular DEQ 2. The proposed standards define four classes of reclaimed wastewater. For unrestricted access areas, such as a golf course, the reclaimed wastewater must meet the Class A treatment standards. Table 1-1 shows the treatment standards required for irrigation on the golf course.

Table 1-1
Class A Treatment Standards

Class	Treatment Standard
A	Class A reclaimed wastewater must, at all times, be oxidized, coagulated, filtered and disinfected, as described below or defined in the chapter. Following treatment, Class A reclaimed wastewater effluent quality should have 10 mg/L or less of BOD_5 and TSS. To achieve the turbidity requirements for Class A reclaimed wastewaters, a treatment process that incorporates coagulation, flocculation, sedimentation, and filtration is typically required. Class A reclaimed wastewater must be disinfected such that the median number of total coliforms organisms in the wastewater after disinfection, does not exceed 2.2 colony forming units per 100 milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed and such that the number of total coliforms does not exceed 23 CFU per 100 milliliters in any sample. The minimum monitoring level required during periods of use (including prior to seasonal startup) must include: continuous turbidity analysis with recorder, weekly total coliform analysis, and monthly total nitrogen analysis. Weekly disinfectant residual analysis if chemical disinfection is being utilized.

In addition, the irrigation system must be operated with a drying/wetting ratio of 3 to 1.

2 Golf Course Setting and Site Conditions

2.1 Geology and Soil

Figure 2-1 shows a map of the soils on the golf course and the locations of monitoring wells, lysimeters, and where permeameter tests were conducted. The predominate soil is designated 280B a Libeg cobbly loam well drained moderately permeable soil. The Natural Resource Conservation Service soil report lists the soil as having a saturated conductivity of 0.57 to 1.98 inches per hour. The Libeg soil is reported to have a low water holding capacity of about 5.1 inches. A ring permeameter test conducted on the golf course in 1995 showed this soil to have percolation rate of 3.5 inches per hour. Two additional tests in a similar soil classification, but not on the golf course, showed test results of 1.19 inches per hour and 3.98 inches per hour.

The 608B soil borders the Middle Fork West Fork of the Gallatin and is called a Beehive –Mooseflat complex soil. The permeability is classified as moderate in the upper part and rapid in the lower part. A permeameter test conducted in 1995 showed a permeability of 17 inches per hour.

The third soil in the irrigation area is designated 482C a Philipsburg-Libeg complex which is a well-drained soil with a moderately high saturated conductivity of 0.2 to 0.57 inches per hour. A permeameter test showed a percolation rate of 0.33 inches per hour.

The irrigated area for each soil type, from Figure 2-1 is tabulated below:

482C Philipsburg Libeg	**Acres**	**Irrigation Loop**
Area 1	**6**	North Loop
280 B Libeg Cobbly Loam		
Area 2	37	North Loop
Area 5	9	South Loop
Area 7	7	South Loop
Area 8	81.5	South Loop
Subtotal 280B	**134.5**	
608B Beehive Mooseflat complex		
Area 3	27	North Loop
Area 4	3.5	South Loop
Area 6	5.5	South Loop
Subtotal 608B	**36**	
Total Irrigation area	**176.5**	**North Loop Total = 70 Acres**
		South Loop Total 106.5 Acres

Table 2-1 lists the physical characteristics of the soils on golf course.

Table 2-1
Physical Soil Characteristics

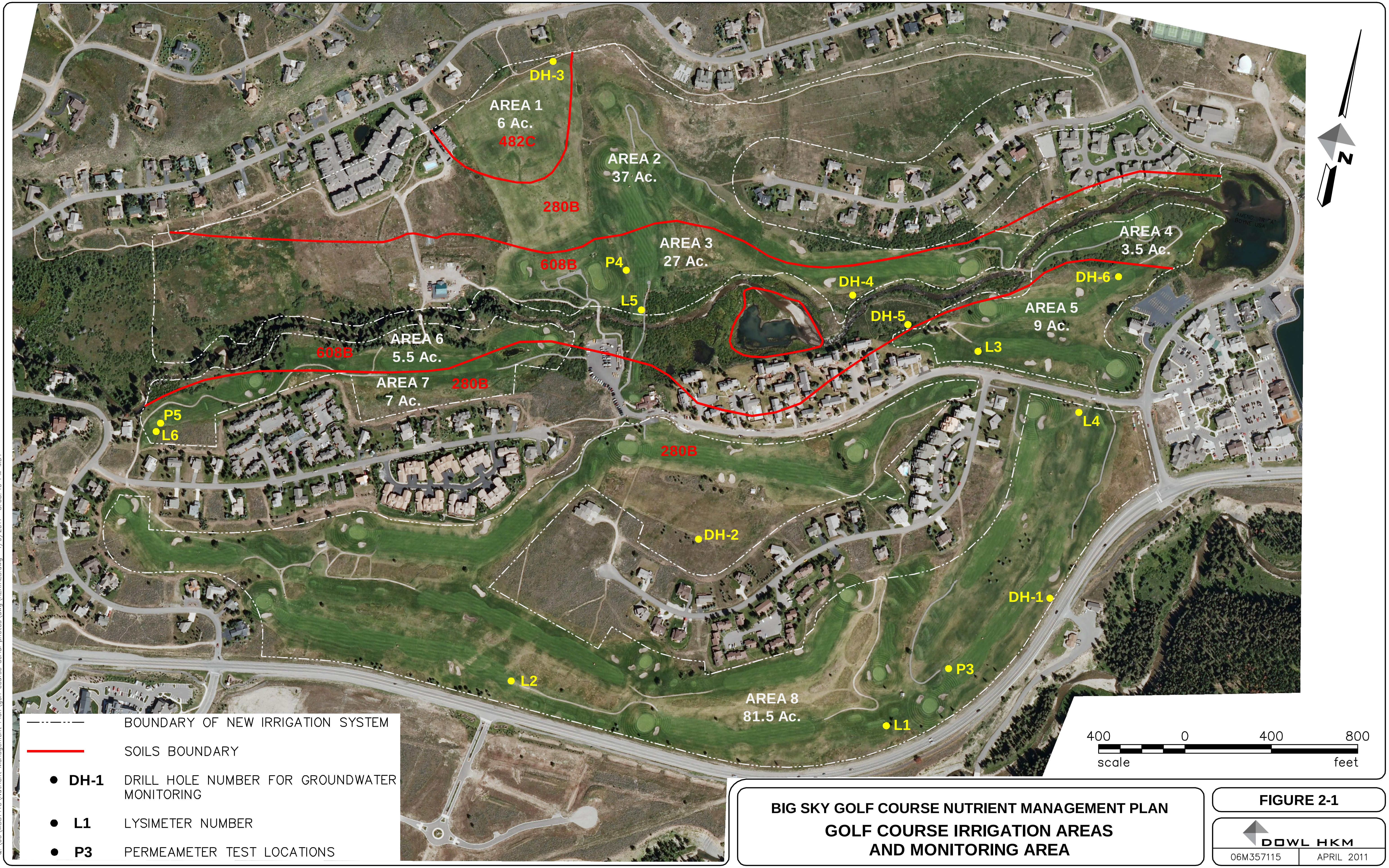
Map Unit	Depth Inches	Sand %	Silt %	Clay %	Organic Matter %	Saturated hydraulic Conductivity In/hr	Available Water Capacity In/in
280B-Libeg	0-7	40	38	22.6	2.0-4.0	0.57-1.98	0.12-0.14
	7-60	56	18	26.6	0.5-1.0	0.57-1.98	0.07-0.08
608B Mooseflat	0-2	39	37	23.6	55-90	0.56-5.95	0.3-0.6
	2-12	39	37	23.6	4.0-6.0	0.56-1.98	0.17-0.2
	12-24	18	54	27	1.0-2.0	0.56-1.98	0.1-0.14
	24-60	82	11	7	0.0-1.0	5.95-19.98	0.03-0.04
482C Philipsburg-	0-1	40	38	22.6	65-95	5.98-99.9	0.15-0.45
	1-15	40	38	22.6	4.0-8.0	0.56-1.98	0.18-0.2
	15-28	34	37	30	1.0-3.0	0.20-0.56	0.14-0.16
	28-60	34	37	26.3	0.0-1.0	0.56-1.98	0.12-0.14

With the current irrigation system it is not possible to measure the volume of irrigation water applied to each soil type. Therefore, a weighted average has been used to calculate the allowed hydraulic loading rate for the golf course. Using the percolation rates and areas in Table 2-2 a weighted average permeability of 1.58 inches/hour is calculated.

Table 2-2
Summary of Soil Types and Percolation Rates

Soil Type	Area	Percolation Rate
• 280B Libeg Cobbly loam	134.5 acres	1.19 inches/hour(lowest measured result from permeameter tests)
• 608B Beehive-Mooseflat Complex	36 acres	3.25 inches/hour (average of lowest published saturated conductivity values)
• 482C Philipsburg _Libeg Complex	6 acres	0.33 inches/hour (measured result from permeameter test)

The EPA recommends using 4-10 percent of the saturated vertical conductivity for design. In this Nutrient Management Plan we have used 4% of the percolation rate listed above (1.58 in/hr). Therefore, a percolation rate of 0.063 inches/hour is used in calculating the hydraulic capacity of the golf course.



BIG SKY GOLF COURSE NUTRIENT MANAGEMENT PLAN

GOLF COURSE IRRIGATION AREAS AND MONITORING AREA

FIGURE 2-1

DOWL HKM

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2.2 Turf Types, Locations, and Fertilization Requirements

The golf course fairways are seeded with Kentucky Blue Grass and the greens are seeded with Penncross and Penneale bent grasses. Kentucky Blue Grass has a nitrogen uptake rate of approximately 150 to 200 pounds per acre per year. The total nitrogen application supplied by manmade fertilizer, reuse irrigation, and nitrogen available in the grass clipping is based on not exceeding an application rate of 150 pounds per acre per year.

The bent grasses used on the greens are reported to have nitrogen requirements of 175 to 350 pounds per acre per year.

There are a wide variety of factors that influence the form and amount of nitrogen in the soil and the amount available to the turf grass. Grass clipping that are not removed can represent a significant source of nitrogen for new grass growth, while denitrification can remove nitrogen as an available nitrogen source for grass growth. While estimates vary, for this Nutrient Management Plan it is estimated that 36 pounds per acre of nitrogen are supplied through the decomposition of grass clipping left on the course. The golf course manager indicated they apply approximately 5.5 pound of nitrogen per acre per year. Based on an approved nitrogen application rate of 150 pound/acre/ year, 108 pounds of nitrogen can be supplied through irrigation with the reclaimed wastewater.

Based on an approved nitrogen application rate of 150 pound/acre/ year, 108 pounds of nitrogen can be supplied through irrigation with the reclaimed wastewater.

2.3 Groundwater

Groundwater in the area of the golf course is generally 25 feet or less below ground surface. The groundwater generally flows to the east with a gradient of 0.028.

2.4 Surface Water

The Middle Fork West Fork Gallatin River flows through the golf course and therefore has the greatest potential of being impacted by nutrient runoff or leaching of nutrients from the golf course.

3 Irrigation System

3.1 Pumps

The main pumps for the irrigation system are housed in the basement of the filtration building. There are five pumps that can pump to the course. Pump 1 pumps to the north loop of the golf course while pump 3 pumps to the south loop. Pump 2 can pump to either loop.

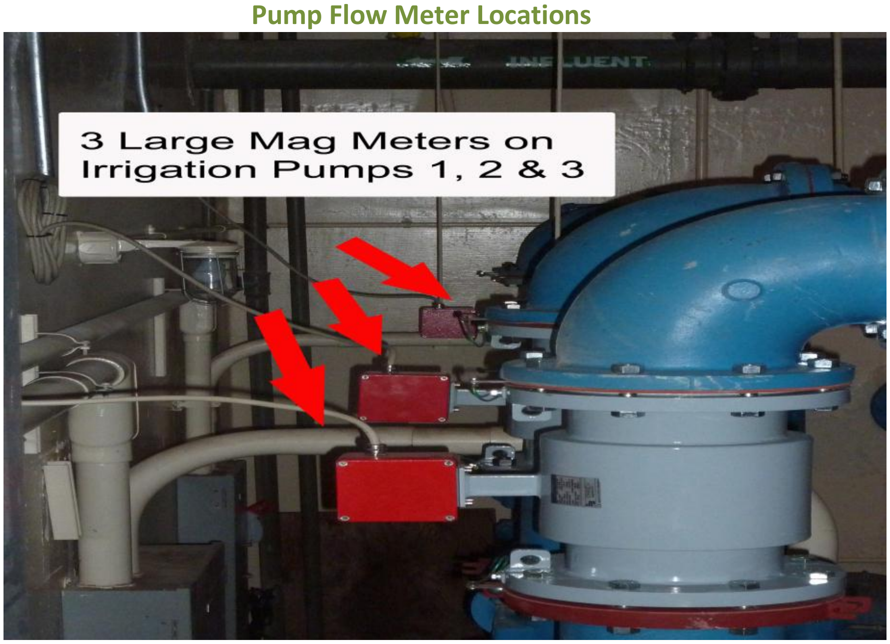
Table 3-1 lists the pumps rated capacities but all of the pumps operate on variable frequency drives (VFD) and therefore pumping rates will vary based on the number of sprinklers operating on the golf course. The VFD varies the pump speed to maintain a constant discharge pressure. The pumps speed up to increase the flow rate while maintaining a constant discharge pressure.

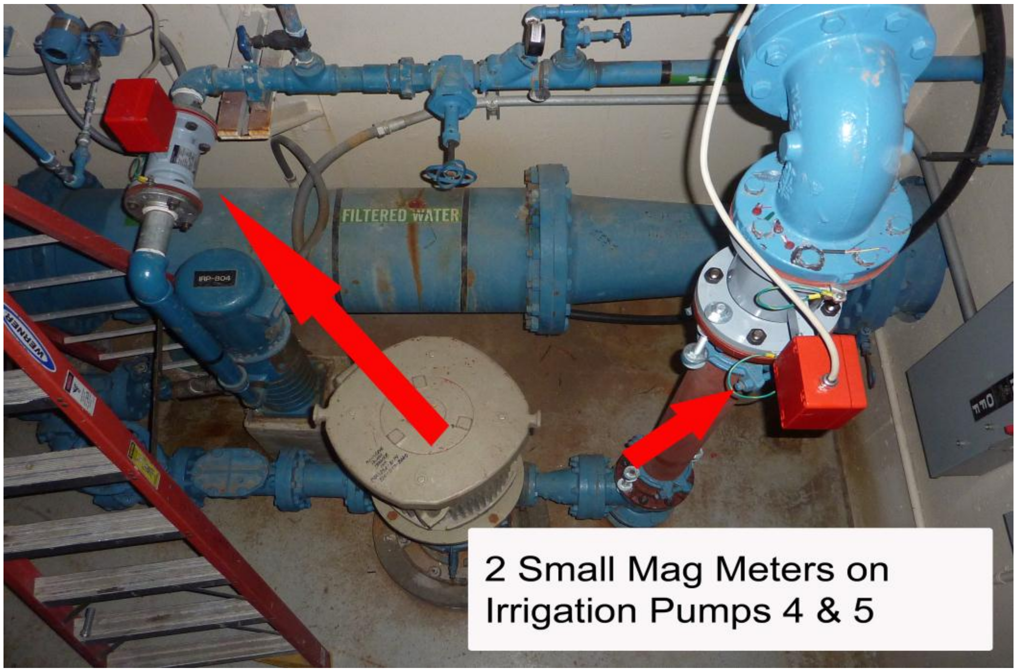
Table 3-1
Pump Horsepower and Capacities

Pump Designation	Horsepower	Capacity
Pump 1	150	1150 gpm at 120 psi
Pump 2	150	1150 gpm at 120 psi
Pump 3	100	1250 gpm at 78 psi
Pump 4	25	160 gpm at 108 psi
Pump 5	7-1/2	38 gpm at 117 psi

Flow meters (Mag-meters) were installed on each pump discharge line in the fall of 2010. Figure 3-1 shows the location of each meter. Each meter has a separate totalizer to allow the combined pumping rate to be determined. The flow meters are tied into the District's SCADA system so flow data can be downloaded on a daily basis.

Figure 3-1
Pump Flow Meter Locations





3.2 Irrigation layout

The irrigation system and sprinkler layout is shown on the map bound in the back of this report. The system consists of approximately 1800 sprinkler heads. In order to eliminate wind drift and overspray into surface waters, the heads should all have a 50 foot set back from surface water. Where this is not possible, due to the existing course configuration, the use of a subsurface irrigation system should be evaluated to replace the conventional sprinkler system.

4 Nutrient Management

4.1 Monitoring

Monitoring and tracking of the nutrients applied to the golf course on a daily basis is a key component of the NMP. Table 4-1 shows the parameters in the irrigation water that should be measured and a recommended sampling frequency.

Table 4-1
Irrigation Water Sampling

Parameter	Sampling Frequency
Total Nitrogen	Weekly during irrigation season
Nitrate Nitrogen	Weekly during irrigation season
Ammonia Nitrogen	Weekly during irrigation season
Total Phosphorous	Weekly during irrigation season
E. Coli	Weekly during the irrigation season

The weekly data test data should be incorporated into a data base table with the flow data to calculate the pounds of nutrients applied per day along with a running total. Appendix A contains an example spreadsheet used to track the pounds of nitrogen and phosphorous applied during the 2011 irrigation season.

In addition to monitoring the nutrients in the applied irrigation water, there are six lysimeters with rain gauges and six monitoring wells located throughout the golf course (refer to Figure 2-1 for locations).

Table 4-2 shows the recommended monitoring schedule for the lysimeters and monitoring wells. The lysimeter measurements provide a means to verify that the nutrients applied through irrigation or through commercial fertilizers, are not leaching into the ground water.

The existing lysimeters are a bucket type lysimeter that must be pulled from the ground using a tripod and hoist in order to sample any water that has percolated through the soil layer. Routine sampling with the current lysimeters would be extremely labor intensive and time consuming. Therefore, it is recommended the District either replace the current lysimeters or install new lysimeters that can be sampled without having to pull the lysimeter from the ground. Appendix B illustrates a modified lysimeter that could be sampled without pulling the lysimeter. Appendix B also contains information on suction lysimeters that could be used for sampling soil water.

Table 4-2
Lysimeter and Monitoring Well Monitoring Schedule

Lysimeter	
Sample for volume of water	Every two weeks
Record volume in rain gauge	Every two weeks and after any rainfall event that exceeds 0.1 inches.
Test Water in lysimeter: • Total nitrogen • Nitrate • Chloride	Every two weeks when water is present in the lysimeter

Table 4-3 is modified from the 1997 Big Sky Golf Course Water Quality Monitoring Plan, and outlines the general data collection procedures if the existing lysimeters are used for sample collection.

Table 4-3
General Data Collection Guidelines

GENERAL	1. Record date of measurements 2. Record the total gallons from flow meter at the pumps 3. Measure precipitation from baseline rain gauge in ml and convert to inches.
FOR EACH LYSIMETER	1. Measure precipitation plus irrigation from rain gauge at lysimeters (convert ml to inches) 2. Measure lysimeter weight prior to draining 3. Drain lysimeter and measure volume of water collected (convert ml collected to inches) 4. Measure lysimeter weight after draining 5. Close drain valve and replace end cap on drain valve 6. Carefully replace lysimeter into PVC casing.

4.2 Irrigation Volumes

The allowable irrigation volumes can be controlled either by the nitrogen uptake rate or by the permeability of the soils.

The treatment plant was designed for a total nitrogen concentration in the effluent of 10.0 mg/l. During 2010, the total nitrogen concentration in the irrigation water averaged 9.19 mg/ and in 2011 the concentration averaged 7.4 mg/l TN.

The following two tables illustrate the allowable irrigation volume during a cool year and an average year with a total nitrogen concentration of 10 mg/l–N, an allowable load from irrigation of 108 pounds of nitrogen, and using 4% of the weighted average percolation rate of 1.58 inches/hour. The calculated allowable irrigations volumes for a wet/cool year and for an average year are summarized below.

It is important to note that potential groundwater mounding and course playability will limit the irrigation volumes below the calculated volumes from nutrient or hydraulic loading.

Wet/Cool Year **308.2 MG**

Average Year **317.3 MG**

Table 4-4
Average Year Irrigation

Constants:			Description:
1.58	Soil Permeability (in/hr)	--	Weighted average of soil permeability on the course
4%	Percolation Rate Factor	--	fraction of the soil permeability used for estimating the design percolation rate (typically 4-10%)
108	Agronomic Nitrogen Uptake Rate (lb/ac/yr)	--	based on kentucky bluegrass fairways of 150 pounds/year with 42 pounds supplied by grass clippings and applied fertilizer
10	Applied Effluent Nitrogen Concentration (mg/L	--	Total nitrogen concentration in irrigation water
20%	Nitrogen Removal from Chemical Reactions	--	fraction of applied nitrogen removed by denitification and volatilization (typically 15-25% for design)
176.5	Irrigated Area (ac)	--	calculated fairway and rough area, excluding required buffer areas for wetlands, roads, etc.
90%	Application Efficiency	--	ratio of volume collected at ground surface to volume delivered (estimate of sprinkler evaporation losses)

Land Application Disposal (LAD) Plan: **Average Year Scenario**

Month	Total Days	Growing Season Days	ET[1] (in)	ET (cm)	Total Precip[2] (in)	Total Precip (cm)	Perc Rate[7] (cm)	HLR - Soil Permeablilty (cm)	Nitrogen Uptake[3] (kg/ha)	HLR - Nitrogen[4] (cm)	Design HLR[5] (cm)	Controlling Factor	Design HLR (in)	Effective Irrigation Volume (MG)	Gross Delivery Volume (MG)
Jan	31	0	---	---	---	---	---	---	---	---	---	---	---	---	---
Feb	28	0	---	---	---	---	---	---	---	---	---	---	---	---	---
Mar	31	0	---	---	---	---	---	---	---	---	---	---	---	---	---
Apr	30	0	---	---	---	---	---	---	---	---	---	---	---	---	---
May	31	12	0.92	2.3	2.48	6.3	15.4	11.5	6.9	8.7	8.7	Nitrogen	3.41	16.4	18.2
Jun	30	30	3.82	9.7	2.84	7.2	38.5	41.0	28.8	36.0	36.0	Nitrogen	14.18	68.0	75.5
Jul	31	31	4.82	12.2	1.65	4.2	39.8	47.9	36.3	45.3	45.3	Nitrogen	17.85	85.6	95.1
Aug	31	31	4.16	10.6	1.58	4.0	39.8	46.4	31.3	39.1	39.1	Nitrogen	15.40	73.8	82.0
Sep	30	30	2.35	6.0	1.77	4.5	38.5	40.0	17.7	22.2	22.2	Nitrogen	8.72	41.8	46.5
Oct	31	3	0.00	0.0	1.29	3.3	3.9	0.6	0.0	0.0	0.0	Nitrogen	0.00	0.0	0.0
Nov	30	0	---	---	---	---	---	---	---	---	---	---	---	---	---
Dec	31	0	---	---	---	---	---	---	---	---	---	---	---	---	---
SEASON	365	137	16.07	40.8	11.61	29.5	175.9	187.3	121.0	151.3	151.3	---	59.57	285.5	317.3

Notes:

1. The ET used median monthly value from 35 years of data at Lake Yellowstone, WY from the Wyoming Irrigation Guide.
2. The precipitation used the average monthly precipitation based on 39 years of record at the Meadow Village Station 3S
3. The annual agronomic uptake rate has been proportioned to monthly ET.
4. The analysis assumes no deep percolation of nitrates.
5. The design hydraulic loading rate is based on the lesser of HLRs for soil permeability and nitrogen limit.
   This analysis does not account for groundwater mounding which may limit the water applied to the course.
6. This analysis is based on the procedures and recommendations included in EPA Process Design Manual for Land Treatment of Municipal Wastewater (EPA 625/1-81-013).
7. Perc rate based on 8 hours per day of irrigation

Table 4-5
Cool Year Irrigation

Constants:			Description:
1.58	Soil Permeability (in/hr)	--	Weighted average of soil permeability for various soils on golf course.
4%	Percolation Rate Factor	--	fraction of the soil permeability used for estimating the design percolation rate (typically 4-10%)
108	Agronomic Nitrogen Uptake Rate (lb/ac/yr)	--	based on Kentucky bluegrass fairys of 150 pound/year with 42 pounds supplied by grass clippings and applied fertilize
10	Applied Effluent Nitrogen Concentration (mg/L	--	Total nitrogen concentratin in irrigation water
20%	Nitrogen Removal from Chemical Reactions	--	fraction of applied nitrogen removed by denitification and volatilization (typically 15-25% for design)
176.5	Irrigated Area (ac)	--	calculated fairway and rough area, excluding required buffer areas for wetlands, roads, etc.
90%	Application Efficiency	--	ratio of volume collected at ground surface to volume delivered (estimate of sprinkler evaporation losses)

Land Application Disposal (LAD) Plan: **Coolest / Wettest Year in 10 Years Scenario**

Month	Total Days	Growing Season Days	ET[1] (in)	ET (cm)	Total Precip[2] (in)	Total Precip (cm)	Perc Rate[7] (cm)	HLR - Soil Permeablilty (cm)	Nitrogen Uptake[3] (kg/ha)	HLR - Nitrogen[4] (cm)	Design HLR[5] (cm)	Controlling Factor	Design HLR (in)	Effective Irrigation Volume (MG)	Gross Delivery Volume (MG)
Jan	31	0	---	---	---	---	---	---	---	---	---	---	---	0.0	0.0
Feb	28	0	---	---	---	---	---	---	---	---	---	---	---	0.0	0.0
Mar	31	0	---	---	---	---	---	---	---	---	---	---	---	0.0	0.0
Apr	30	0	---	---	---	---	---	---	---	---	---	---	---	0.0	0.0
May	31	12	0.74	1.9	3.46	8.8	15.4	8.5	6.9	8.7	8.5	Permeability	3.35	16.1	17.8
Jun	30	30	2.99	7.6	3.96	10.1	38.5	36.1	28.0	35.0	35.0	Nitrogen	13.76	66.0	73.3
Jul	31	31	4.17	10.6	2.30	5.8	39.8	44.6	39.0	48.8	44.6	Permeability	17.54	84.1	93.4
Aug	31	31	3.62	9.2	2.20	5.6	39.8	43.4	33.9	42.3	42.3	Nitrogen	16.66	79.9	88.8
Sep	30	30	1.42	3.6	2.47	6.3	38.5	35.9	13.3	16.6	16.6	Nitrogen	6.54	31.3	34.8
Oct	31	3	0.00	0.0	1.80	4.6	3.9	0.0	0.0	0.0	0.0	Nitrogen	0.00	0.0	0.0
Nov	30	0	---	---	---	---	---	---	---	---	---	---	---	0.0	0.0
Dec	31	0	---	---	---	---	---	---	---	---	---	---	---	0.0	0.0
SEASON	365	137	12.94	32.9	16.19	41.1	175.9	168.4	121.0	151.3	147.0	---	57.86	277.3	308.2

Notes:

1. The ET used is a 10% probability cool year value from 35 years of data at Lake Yellowstone, WY from the Wyoming Irrigation Guide. The ET in any month can be expected to equal or exceed the given values 9 out of every 10 years.
2. The precipitation used is a 10% probability wet year value from SCS TR-21. The precipitation in any month can be expected to be less than or equal to the given values 9 out of every 10 years.
3. The annual agronomic uptake rate has been proportioned to monthly ET.
4. The analysis assumes no deep percolation of nitrates.
5. The design hydraulic loading rate is based on the lesser of HLRs for soil permeability and nitrogen limit.
   This analysis does not account for groundwater mounding which may limit the water applied to the course
6. This analysis is based on the procedures and recommendations included in EPA Process Design Manual for Land Treatment of Municipal Wastewater (EPA 625/1-81-013).
7. Based on 8 hour day of irrigation

5 Best Management Practices

In addition to the careful application and monitoring of manmade fertilizers and reuse water, there are a variety of measure that should be taken to ensure that drainage from the golf course does not reach surface waters and that all nutrients applied to the course are taken up by the turf grass and plants along the course. Many of the practices outlined in this plan are outside of the control of the Water and Sewer District but the District is encourage to contact the golf course management and work to establish BMP's that are followed.

BMP #1 Know the type and content of manmade fertilizers.

The application rate of fertilizer should be carefully recorded with the date applications are made and the pounds of nitrogen and phosphorous applied.

BMP #2 Keep accurate records of reuse water and nutrient concentrations

Keep a spreadsheet up to date that shows the volume of reuse water irrigated on a daily basis and the concentration of nitrogen and phosphorous in the reuse water.

BMP #3 Control the irrigation areas and irrigation during windy conditions

Keep all sprinkler heads directed away from the surface streams and maintain a 50-foot setback between irrigated areas and surface waters when possible. Install a weather station and control that will automatically shut the irrigation pumps down during windy conditions to avoid wind drift of reuse water.

BMP #4 Control surface runoff

Eliminate any surface drains that drain directly to surface waters. Create small wetland areas for surface drainage that cannot be eliminated.

BMP#5 Calibrate the application equipment

The only way to accurately know how much fertilizer is actually being applied is to calibrate your application equipment. Calibration should be done in accordance with the manufacturer's recommendation. For granular materials, it may be necessary to recalibrate whenever using a new material with different flow characteristics.

BMP#6 Maintain Water Quality Buffers

Maintain a vegetated strip of land along surface waters composed of bushes and un-mowed areas. Unfertilized rough, mowed no lower than three inches, should be maintained in areas around surface water where it is not possible to maintain a buffer of brush and woody vegetation. Control foot and cart traffic in buffer areas through signs and fencing. Denser, deep-rooted areas are effective at removing sediments, fertilizers, pesticides, and grass clipping in surface water runoff and have several advantages:

- Trunk, stems and leafy ground cover slow down runoff in areas prone to concentrated amounts from storms

- Decomposing woody roots help nitrate convert to less mobile forms of nitrogen
- Nutrients can be taken up by the woody biomass
- Forest litter forms a mat to filter runoff water

BMP #7 Mix and Handle Chemical Away from Water Resources

Pesticides, fertilizers and waste from equipment maintenance are all potential sources of surface and groundwater pollution. Small releases of concentrated pesticides or fertilizers can result in substantial contamination of water resources, especially groundwater.

BMP#8 Control Stormwater Runoff

The purpose of stormwater control is to slow water velocities and reduce peak discharges in order to reduce erosion, flooding, and pollutant runoff before it enters surface waters.

- Avoid the direct discharge of stormwater runoff from parking lots, service areas, buildings and roadways directly into watercourses. Use grassy swales, filter strips and constructed wetlands.
- Divert surface runoff onto wide, relatively flat vegetated areas.

APPENDIX A
NUTRIENT LOADING SPREADSHEET

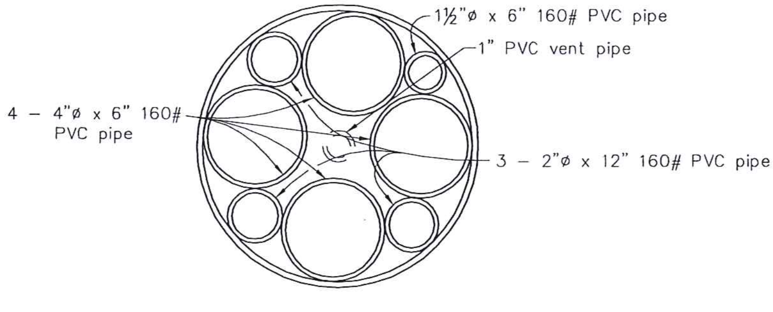
2011 Irrigation Flows Meadow Village Golf Course

	Flow							Nitrogen Applied					Phosphorous Applied					
Date	North Loop Pump 1	North or South Loop Pump 2	South Loop Pump 3	JP 4	JP 5	Fresh Water	Total WW	Lb/day applied total course	Flow to South Zone	Lb/day Applied South	Flow to North Zone	Lb/day Applied North	Lb/day Applied South	Lb/day Applied North	Collection Date	Client Sample ID	Nitrogen, Total mg/l	Total P mg/l
4/27/2011															04/05/11	Filter Effluent	20.0	3.6
4/28/2011																		
4/29/2011																		
4/30/2011																		
5/1/2011																		
5/2/2011																		
5/3/2011																		
5/4/2011																		
5/5/2011																		
5/6/2011																		
5/7/2011																		
5/8/2011																		
5/9/2011				120,000			120,000	11	60,000	6	60,000	6	1	1				
5/10/2011		575,000		134,000	24,000		733,000	67	79,000	7	654,000	60	1	11				
5/11/2011		887,000		28,000	0		915,000	84	14,000	1	901,000	83	0	15	05/11/11	Filter Effluent	11.0	1.9
5/12/2011		993,000		5,000	0		998,000	92	2,500	0	995,500	91	0	16				
5/13/2011	1,000	1,634,000		9,000	0		1,644,000	151	4,500	0	1,639,500	150	0	26				
5/14/2011	2,000	1,627,000		0	0		1,629,000	149	0	0	1,629,000	149	0	26				
5/15/2011	0	1,628,000		0	0		1,628,000	149	0	0	1,628,000	149	0	26				
5/16/2011	1,000	1,686,000		0	2,000		1,689,000	155	1,000	0	1,688,000	155	0	27				
5/17/2011	2,000	1,699,000		0	27,000		1,728,000	159	13,500	1	1,714,500	157	0	28				
5/18/2011	27,000	839,000		11,000	28,000		905,000	51	19,500	1	885,500	50	0	9	05/18/11	Filter Effluent	6.8	1.3
5/19/2011		914,000	15,000	35,000	0		964,000	55	32,500	2	931,500	53	0	10				
5/20/2011		843,000	0	10,000	0		853,000	48	5,000	0	848,000	48	0	9				
5/21/2011		0	1,000				1,000	0	1,000	0	0	0	0	0				
5/22/2011			5,000				5,000	0	5,000	0	0	0	0	0				
5/23/2011			1,000				1,000	0	1,000	0	0	0	0	0				
5/24/2011							0	0	0	0	0	0	0	0				
5/25/2011	1,000	717,000	1,000	2,000	8,000		729,000	41	6,000	0	723,000	41	0	8				
5/26/2011		1,444,000	6,000	38,000	1,000		1,489,000	114	25,500	2	1,463,500	112	0	14	05/26/11	Irrigation Water	9.2	1.1
5/27/2011		1,424,000	9,000	5,000			1,438,000	110	11,500	1	1,426,500	109	0	13				
5/28/2011		1,461,000					1,461,000	112	0	0	1,461,000	112	0	14				
5/29/2011	1,000	1,458,000					1,459,000	112	0	0	1,459,000	112	0	14				
5/30/2011		1,007,000					1,007,000	77	0	0	1,007,000	77	0	9				
5/31/2011	2,000	830,000			9,000		841,000	65	4,500	0	836,500	64	0	8				
6/1/2011		1,960,000					1,960,000	150	0	0	1,960,000	150	0	18				
6/2/2011		1,119,000					1,119,000	86	0	0	1,119,000	86	0	10				
6/3/2011		1,134,000	89,000		1,000	89,000	1,135,000	87	500	0	1,134,500	87	0	11				
6/4/2011		1,946,000	270,000			270,000	1,946,000	149	0	0	1,946,000	149	0	18				
6/5/2011		1,906,000	652,000			652,000	1,906,000	146	0	0	1,906,000	146	0	18				
6/6/2011		1,260,000	273,000		8,000	273,000	1,268,000	97	4,000	0	1,264,000	97	0	12				
6/7/2011		186,000	120,000		3,000	120,000	189,000	15	1,500	0	187,500	14	0	2				
6/8/2011			17,000		3,000	17,000	3,000	0	1,500	0	1,500	0	0	0				
6/9/2011			20,000		3,000	20,000	3,000	0	1,500	0	1,500	0	0	0	06/09/11	Irrigation Water	6.8	1.3
6/10/2011			20,000		3,000	20,000	3,000	0	1,500	0	1,500	0	0	0				
6/11/2011			20,000		3,000	20,000	3,000	0	1,500	0	1,500	0	0	0				
6/12/2011			19,000		3,000	19,000	3,000	0	1,500	0	1,500	0	0	0				
6/13/2011			19,000		3,000	19,000	3,000	0	1,500	0	1,500	0	0	0				
6/14/2011			19,000		3,000	19,000	3,000	0	1,500	0	1,500	0	0	0				
6/15/2011			19,000		3,000	19,000	3,000	0	1,500	0	1,500	0	0	0				
6/16/2011			18,000		3,000	18,000	3,000	0	1,500	0	1,500	0	0	0	06/16/11	Irrigation Water	4.9	
6/17/2011		1,001,000	18,000		4,000	18,000	1,005,000	41	2,000	0	1,003,000	41	0	11				
6/18/2011		1,656,000	16,000			16,000	1,656,000	68	0	0	1,656,000	68	0	18				
6/19/2011		1,648,000	16,000			16,000	1,648,000	67	0	0	1,648,000	67	0	18				
6/20/2011		1,655,000	16,000			16,000	1,655,000	68	0	0	1,655,000	68	0	18				
6/21/2011		958,000	17,000		1,000	17,000	959,000	39	500	0	958,500	39	0	11				
6/22/2011		197,000	140,000		7,000	140,000	204,000	8	3,500	0	200,500	8	0	2				
6/23/2011		316,000	307,000		10,000	307,000	326,000	12	5,000	0	321,000	12	0	0	06/23/11	Irrigation Water	4.4	0.1

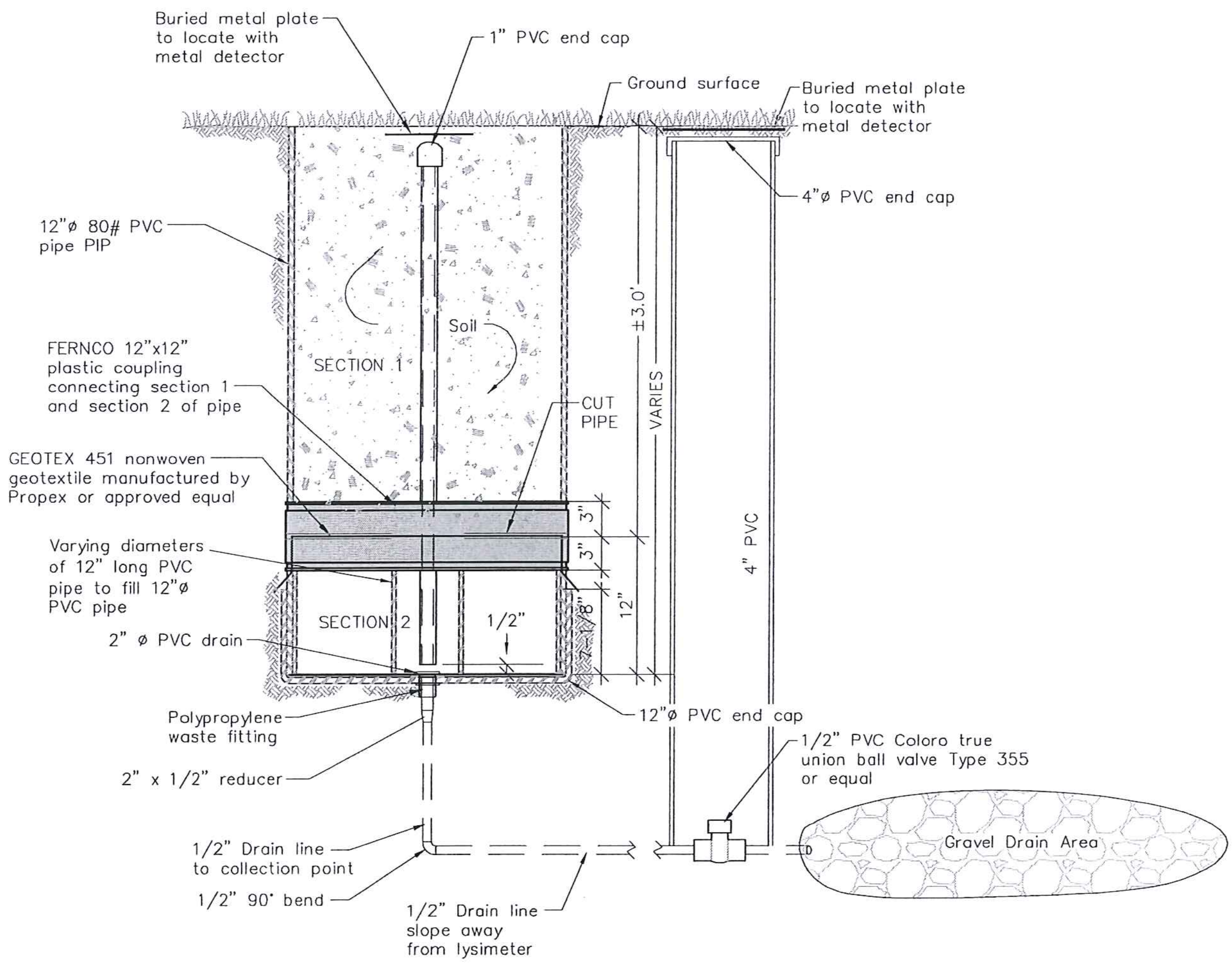
Date	North Loop Pump 1	North or South Loop Pump 2	South Loop Pump 3	JP 4	JP 5	Fresh Water	Total WW	Lb/day applied total course	Flow to South Zone	Lb/day Applied South	Flow to North Zone	Lb/day Applied North	Lb/day Applied South	Lb/day Applied North	Collection Date	Client Sample ID	Nitrogen, Total mg/l	Total P mg/l
6/24/2011		120,000	218,000		16,000	218,000	136,000	5	8,000	0	128,000	5	0	0				
6/25/2011			1,000	16,000	4,000	1,000	20,000	1	10,000	0	10,000	0	0	0				
6/26/2011		188,000	104,000	56,000	1,000	104,000	245,000	9	28,500	1	216,500	8	0	0				
6/27/2011		268,000	228,000	33,000		228,000	301,000	11	16,500	1	284,500	10	0	0				
6/28/2011		378,000	549,000			549,000	378,000	14	0	0	378,000	14	0	0				
6/29/2011		927,000	471,000	15,000		471,000	942,000	35	7,500	0	934,500	34	0	1				
6/30/2011		875,000	410,000			410,000	875,000	31	0	0	875,000	31	0	2	06/30/11	Irrigation Water	4.3	0.2
7/1/2011		498,000	402,000	30,000		402,000	528,000	19	15,000	1	513,000	18	0	1				
7/2/2011		983,000	383,000	32,000		383,000	1,015,000	36	16,000	1	999,000	36	0	2				
7/3/2011		1,345,000	383,000	23,000		383,000	1,368,000	49	11,500	0	1,356,500	49	0	2				
7/4/2011		2,588,000	418,000	24,000		418,000	2,612,000	94	12,000	0	2,600,000	93	0	5				
7/5/2011		2,266,000	332,000	30,000		332,000	2,296,000	82	15,000	1	2,281,000	82	0	4				
7/6/2011		2,132,000	358,000	31,000		358,000	2,163,000	78	15,500	1	2,147,500	77	0	4				
7/7/2011		1,889,000	861,000	8,000		861,000	1,897,000	71	4,000	0	1,893,000	71	0	5	07/07/11	Irrigation	4.5	0.3
7/8/2011		1,191,000	1,414,000	1,000		1,414,000	1,192,000	45	500	0	1,191,500	45	0	3				
7/9/2011		1,106,000	1,269,000			1,269,000	1,106,000	42	0	0	1,106,000	42	0	3				
7/10/2011		1,246,000	1,374,000			1,374,000	1,246,000	47	0	0	1,246,000	47	0	3				
7/11/2011		2,016,000				0	2,016,000	76	0	0	2,016,000	76	0	6				
7/12/2011		983,000		139,000		0	1,122,000	42	69,500	3	1,052,500	40	0	3				
7/13/2011		13,000	14,000	271,000		14,000	284,000	11	135,500	5	148,500	6	0	0				
7/14/2011		336,000	187,000	245,000		187,000	581,000	40	122,500	8	458,500	31	0	1	07/14/11	Irrigation	8.2	0.4
7/15/2011		722,000	806,000	14,000		806,000	736,000	50	7,000	0	729,000	50	0	2				
7/16/2011		1,045,000	412,000	16,000		412,000	1,061,000	73	8,000	1	1,053,000	72	0	3				
7/17/2011		720,000	492,000	18,000		492,000	738,000	50	9,000	1	729,000	50	0	2				
7/18/2011		951,000	483,000	71,000		483,000	1,022,000	70	35,500	2	986,500	67	0	3				
7/19/2011		1,045,000	573,000	75,000		573,000	1,120,000	77	37,500	3	1,082,500	74	0	3				
7/20/2011		852,000	521,000	77,000		521,000	929,000	64	38,500	3	890,500	61	0	3				
7/21/2011		731,000	491,000	56,000		491,000	787,000	51	28,000	2	759,000	49	0	3	07/21/11	Irrigation Water	7.7	0.5
7/22/2011		778,000	206,000	101,000		206,000	879,000	56	50,500	3	828,500	53	0	3				
7/23/2011		1,409,000	732,000	55,000		732,000	1,464,000	94	27,500	2	1,436,500	92	0	5				
7/24/2011		696,000	565,000	31,000		565,000	727,000	47	15,500	1	711,500	46	0	3				
7/25/2011		705,000	534,000	45,000		534,000	750,000	48	22,500	1	727,500	47	0	3				
7/26/2011		939,000	551,000	47,000		551,000	986,000	63	23,500	2	962,500	62	0	4				
7/27/2011		834,000	549,000	36,000		549,000	870,000	56	18,000	1	852,000	55	0	3				
7/28/2011		1,239,000	571,000	0		571,000	1,239,000	87	0	0	1,239,000	87	0	10	07/28/11	Irrigation Water	8.4	0.9
7/29/2011		*998,333*	432,000	0			1,430,333	100	432,000	30	998,333	70	3	8				
7/30/2011		*998,333*	432,000	0			1,430,333	100	432,000	30	998,333	70	3	8				
7/31/2011		*998,333*	432,000	0			1,430,333	100	432,000	30	998,333	70	3	8				
8/1/2011	2,000	*998,333*	432,000	164,000	0		1,596,333	112	514,000	36	1,082,333	76	4	8				
8/2/2011	36,000	922,000	176,000	47,000	106,000		1,287,000	90	252,500	18	1,034,500	72	2	8				
8/3/2011	159,000	0	405,000	56,000	190,000		810,000	57	528,000	37	282,000	20	4	2				
8/4/2011	578,000	0	634,000	218,000	139,000		1,569,000	47	812,500	24	756,500	23	3	3	08/04/11	Irrigation Water	3.6	0.5
8/5/2011	459,000	253,000	608,000	72,000	131,000		1,523,000	46	709,500	21	813,500	24	3	3				
8/6/2011	Pump Off	461,000	440,000	25,000	151,000		1,077,000	32	528,000	16	549,000	16	2	2				
8/7/2011		270,000	76,000	29,000	175,000		550,000	17	178,000	5	372,000	11	1	1				
8/8/2011		631,000	552,000	28,000	130,000		1,341,000	40	631,000	19	710,000	21	2	3				
8/9/2011		738,000	453,000	30,000	122,000		1,343,000	40	529,000	16	814,000	24	2	3				
8/10/2011		841,000	382,000	52,000	121,000		1,396,000	42	468,500	14	927,500	28	2	4				
8/11/2011		863,000	413,000	29,000	122,000		1,427,000	101	488,500	35	938,500	67	4	8	08/11/11	Irrigation Water	8.5	1.1
8/12/2011		858,000	406,000	50,000	123,000		1,437,000	102	492,500	35	944,500	67	4	9				
8/13/2011		829,000	417,000	58,000	123,000		1,427,000	101	507,500	36	919,500	65	5	8				
8/14/2011		829,000	398,000	55,000	120,000		1,402,000	99	485,500	34	916,500	65	4	8				
8/15/2011		886,000	403,000	48,000	95,000		1,432,000	102	474,500	34	957,500	68	4	9				
8/16/2011		668,000	384,000	82,000	95,000		1,229,000	87	472,500	33	756,500	54	4	7				
8/17/2011		1,553,000	393,000	37,000	0		1,983,000	141	411,500	29	1,571,500	111	4	14				
8/18/2011		1,364,000	387,000	69,000	0		1,820,000	138	421,500	32	1,398,500	106	3	11	08/18/11	Irrigation	9.1	1.0
8/19/2011		1,445,000	425,000	40,000	0		1,910,000	145	445,000	34	1,465,000	111	4	12				
8/20/2011		1,014,000	395,000	8,000	0		1,417,000	108	399,000	30	1,018,000	77	3	8				
8/21/2011		*1,284,333*	415,000	*19,000*	*0*		1,718,333	130	424,500	32	1,293,833	98	3	10				
8/22/2011		*1,284,333*	415,000	*19,000*	*0*		1,718,333	130	424,500	32	1,293,833	98	3	10				
8/23/2011		1,394,000	425,000	9,000	0		1,828,000	139	429,500	33	1,398,500	106	3	11				

Date	North Loop Pump 1	North or South Loop Pump 2	South Loop Pump 3	JP 4	JP 5	Fresh Water	Total WW	Lb/day applied total course	Flow to South Zone	Lb/day Applied South	Flow to North Zone	Lb/day Applied North	Lb/day Applied South	Lb/day Applied North	Collection Date	Client Sample ID	Nitrogen, Total mg/l	Total P mg/l
8/24/2011		1,361,000	423,000	8,000	0		1,792,000	136	427,000	32	1,365,000	104	3	11				
8/25/2011		1,234,000	404,000	16,000	0		1,654,000	119	412,000	30	1,242,000	89	3	9	08/25/11	Irrigation Water	8.6	0.9
8/26/2011		972,000	35,000	17,000	0		1,024,000	73	43,500	3	980,500	70	0	7				
8/27/2011		1,003,000	36,000	16,000	0		1,055,000	76	44,000	3	1,011,000	73	0	8				
8/28/2011		1,136,000	63,000	15,000	0		1,214,000	87	70,500	5	1,143,500	82	1	9				
8/29/2011		1,177,000	293,000	6,000	0		1,476,000	106	296,000	21	1,180,000	85	2	9				
8/30/2011		975,000	35,000	0	0		1,010,000	70	35,000	2	975,000	67	0	8	08/30/11	Irrigation Water	8.3	0.9
8/31/2011		1,037,000	40,000	0	0		1,077,000	75	40,000	3	1,037,000	72	0	8				
9/1/2011		1,162,000	120,000	0	0		1,282,000	89	120,000	8	1,162,000	80	1	9				
9/2/2011		1,292,000	340,000	0	0		1,632,000	113	340,000	24	1,292,000	89	3	10				
9/3/2011		1,348,000	277,000	0	0		1,625,000	112	277,000	19	1,348,000	93	2	10				
9/4/2011		1,381,000	276,000		0		1,657,000	115	276,000	19	1,381,000	96	2	11				
9/5/2011		1,416,000	315,000		0		1,731,000	120	315,000	22	1,416,000	98	2	11				
9/6/2011		1,479,000	306,000	0	0		1,785,000	124	306,000	21	1,479,000	102	2	11				
9/7/2011		1,132,000	517,000	14,000	51,000		1,714,000	119	549,500	38	1,164,500	81	4	9				
9/8/2011		1,437,000	552,000	45,000	1,000		2,035,000	141	575,000	40	1,460,000	101	4	11				
9/9/2011		1,419,000	495,000	47,000	0		1,961,000	136	518,500	36	1,442,500	100	4	11				
9/10/2011		1,399,000	352,000	8,000	0		1,759,000	122	356,000	25	1,403,000	97	3	11				
9/11/2011		1,432,000	446,000	8,000	0		1,886,000	131	450,000	31	1,436,000	99	3	11				
9/12/2011		1,370,000	452,000	20,000	0		1,842,000	128	462,000	32	1,380,000	96	4	11				
9/13/2011		1,453,000	396,000	6,000	0		1,855,000	128	399,000	28	1,456,000	101	3	11				
9/14/2011		1,383,000	470,000	5,000	0		1,858,000	129	472,500	33	1,385,500	96	4	11				
9/15/2011		1,395,000	420,000	18,000	0		1,833,000	121	429,000	28	1,404,000	93	0	11	09/15/11	Irrigation Water	7.9	
9/16/2011		1,222,000	358,000	6,000	0		1,586,000	104	361,000	24	1,225,000	81	0	10				
9/17/2011		981,000	0	7,000	0		988,000	65	3,500	0	984,500	65	0	8				
9/18/2011		991,000	0	7,000	0		998,000	66	3,500	0	994,500	66	0	8				
9/19/2011		1,122,000	63,000	11,000	0		1,196,000	79	68,500	5	1,127,500	74	0	9				
9/20/2011		1,482,000	39,000	23,000	0		1,544,000	102	50,500	3	1,493,500	98	0	12				
9/21/2011		1,451,000	66,000	19,000	0		1,536,000	101	75,500	5	1,460,500	96	0	11				
9/22/2011		1,615,000	337,000	7,000	0		1,959,000	108	340,500	19	1,618,500	89	7	33	09/22/11	Irrigation	6.6	2.4
9/23/2011		1,420,000	42,000	15,000	0		1,477,000	81	49,500	3	1,427,500	79	1	29				
9/24/2011		1,601,000	281,000	7,000	0		1,889,000	104	284,500	16	1,604,500	88	6	32				
9/25/2011		1,455,000	41,000	16,000	0		1,512,000	83	49,000	3	1,463,000	81	1	30				
9/26/2011		1,578,000	53,000	15,000	0		1,646,000	91	60,500	3	1,585,500	87	1	32				
9/27/2011		1,831,000	393,000	5,000	0		2,229,000	123	395,500	22	1,833,500	101	8	37				
9/28/2011		1,805,000	464,000	7,000	0		2,276,000	125	467,500	26	1,808,500	100	9	37				
9/29/2011		1,790,000	421,000	5,000	0		2,216,000	126	423,500	24	1,792,500	102	9	36	09/29/11	Irrigation Water	6.8	
9/30/2011		1,482,000	65,000	15,000	0		1,562,000	89	72,500	4	1,489,500	84	1	30				
10/1/2011		1,706,000	358,000	8,000	0		2,072,000	118	362,000	21	1,710,000	97	7	35				
10/2/2011		1,496,000	62,000	18,000	0		1,576,000	89	71,000	4	1,505,000	85	1	30				
10/3/2011		1,735,000	309,000	5,000	0		2,049,000	116	311,500	18	1,737,500	99	6	35				
10/4/2011		1,793,000	391,000	4,000	0		2,188,000	124	393,000	22	1,795,000	102	8	36				
10/5/2011		1,623,000	331,000	5,000	0		1,959,000	111	333,500	19	1,625,500	92	7	33				
10/6/2011		1,334,000	0	9,000	0		1,343,000	150	4,500	1	1,338,500	150	0	56	10/06/11	Irrigation	13.4	5.0
10/7/2011		767,000	0	10,000	31,000		808,000	90	20,500	2	787,500	88	1	33				
10/8/2011		0	0	11,000	106,000		117,000	13	58,500	7	58,500	7	2	2				
10/9/2011		0	0	11,000	107,000		118,000	13	59,000	7	59,000	7	2	2				
10/10/2011		0	0	14,000	106,000		120,000	13	60,000	7	60,000	7	3	3				
10/11/2011		0	0	6,000	108,000		114,000	13	57,000	6	57,000	6	2	2				
10/12/2011		0	0	0	107,000		107,000	12	53,500	6	53,500	6	2	2				
10/13/2011		0	0	0	108,000		108,000	13	54,000	6	54,000	6	0	2	10/13/11	Irrigation Water	14.4	
10/14/2011		0	15,000	2,000	169,000		186,000	22	100,500	12	85,500	10	0	4				
10/15/2011		0	0	6,000	255,000		261,000	31	130,500	16	130,500	16	0	5				
10/16/2011		0	0	5,000	123,000		128,000	15	64,000	8	64,000	8	0	3				
10/17/2011				Pumps Off				-	-	-								
					Pounds Total Nitrogen			11786	25,361,500	1,601	160,813,498	10185	228	1586				
					Acres Irrigated			176.5	Acres	106.5		70.0						
					Pounds/acre applied			66.8	Lbs/acre	15.0		145.5						

APPENDIX B
ALTERNATIVE LYSIMETERS



PLAN VIEW
BUCKET LYSIMETER



SECTION VIEW
BUCKET LYSIMETER

BIG SKY GOLF COURSE

NUTRIENT MANAGEMENT PLAN
DETAIL OF BUCKET LYSIMETER

DOWL HKM

06M3.57115.01	APRIL 2012

Plant Nutrition

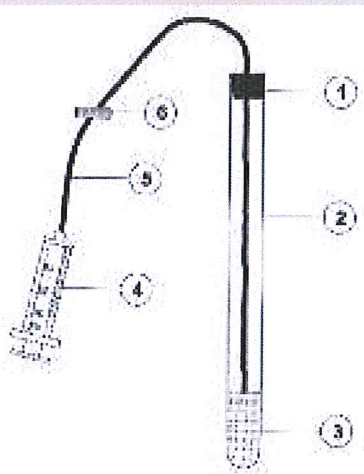
The three elements that are most needed by plants are nitrogen (N), phosphorous (P) and potassium (K). This is the reason why they are called macronutrients and should be given to plants.

Nitrogen is indispensable for the plant's life and is a key factor in fertilization. Nitrogen allows the development of the vegetative activity of the plant, in particular, causes lengthening of trunks and sprouts and increases the production of foliage and fruits. An excess of nitrogen weakens the plants' structure creating an unbalanced relationship between the leaves and the stalks. In addition, the plant becomes less resistant to diseases.

Phosphorous is an important element in the composition of DNA and RNA, the regulators of the energetic exchange (ATP & ADP), as well as the reserve substances in seeds and bulbs. It contributes to the formation of buds, roots, blooming, and lignification.

A lack of phosphorous results in: stifling of plant, slow growth, a reduction of production, smaller fruits and a lower expansion of the roots.

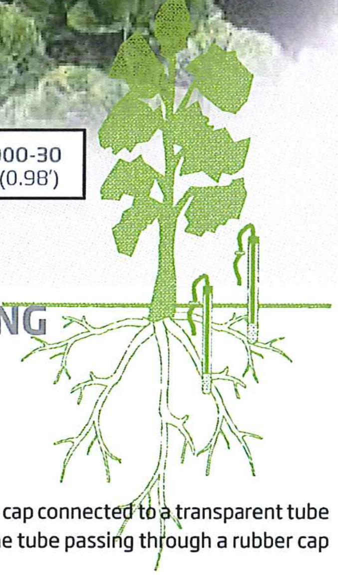
Even if **Potassium** is not a constituent of important compounds, it plays a remarkable role in many physiological activities like the control of cellular turgor and the accumulation of carbohydrates. It increases the size of fruits, their flavor, as well as yielding a positive effect on the color and fragrance of flowers. Potassium also makes plants more resistant to disease.



1. Rubber cap
2. Soil solution sampler tube
3. Porous ceramic tip
4. 30 mL syringe (pump)
5. Rubber suction capillary
6. Finger clamp

Available in 3 Lengths

HI 83900-90	HI 83900-60	HI 83900-30
90 cm (2.95')	60 cm (1.97')	30 cm (0.98')



HI 83900

SUCTION LYSIMETER FOR ROOT LEVEL SOIL MONITORING

- **Perfect companion to the HI 83200**
- **Monitor soil composition right at the roots**
- **Easy to use**

The HI 83900 suction lysimeter is built with a porous ceramic cap connected to a transparent tube for soil solution extraction. A rubber capillary is inserted in the tube passing through a rubber cap and reaching the ceramic tip.

The HI 83900 series lysimeter is an ideal tool for collecting soil solution samples and then perform quantitative chemical analysis. In this way the operator can easily monitor the level of nutrients, such as ammonia, nitrate, phosphorous and potassium, sulfate, calcium, magnesium.

The ceramic tip of the lysimeter can be used in all types of soil, and it is made of sinterized material that does not react with nutrient elements. The soil solution, therefore, is not affected by the chemical composition of the ceramic cap and the test results are always precise and reliable.

The HI 83900 allows the extraction of a solution from the soil by creating a vacuum (negative pressure or suction) inside the sampler tube, that exceeds the soil water tension. This will establish an hydraulic gradient for the solution to flow through the porous ceramic cap and into the lysimeter tube. Typically, a vacuum of about -60 cb (centibar) should be drawn.

For better monitoring of soil solution composition throughout an entire growth period of crops, at least two lysimeters should be installed in the root zone of a representative plant–one at the upper part and the other in the lower part of the root zone.

For better accuracy and repeatability of results, it is recommended to replicate the above described installation in at least two more locations.

ORDERING INFORMATION

HI 83900-30 is comprised of 30 cm (0.98') tube sampler tube ending with porous ceramic tip, capillary rubber tube with rubber cap and finger clamp, cleaning solution stater kit, 30 mL syringe and instructions.

HI 83900-60 is comprised of 60 cm (1.97') tube sampler tube ending with porous ceramic tip, capillary rubber tube with rubber cap and finger clamp, cleaning solution stater kit, 30 mL syringe and instructions.

HI 83900-90 is comprised of 90 cm (2.95') tube sampler tube ending with porous ceramic tip, capillary rubber tube with rubber cap and finger clamp, cleaning solution stater kit, 30 mL syringe and instructions.

ACCESSORIES

HI 83900-25 Cleaning solution kit, 500 mL

Instruction Manual

HI 83900

Suction Lysimeter

HANNA instruments
www.hannainst.com

Dear Customer,

Thank you for choosing a HANNA instruments® product.

Please read this instruction manual carefully before using the equipment. It will provide you with the necessary information for a correct use.

For additional technical information, do not hesitate to e-mail us at tech@hannainst.com or see the back cover for our worldwide contact list.

TABLE OF CONTENTS

PRELIMINARY EXAMINATION

Remove the equipment from the packing material and examine it carefully to make sure that no damage has occurred during shipping. If there is any noticeable damage, immediately notify your dealer.

Each kit includes:

- 1 x sampler tube ending with porous ceramic tip
- 1 x capillary rubber tube with rubber cap and finger clamp
- 1 x cleaning solution starter kit (120 mL bottle)
- 1 x 30 mL syringe
- instruction manual

Note Save all packing materials until you are sure that the equipment functions correctly. Any damaged or defective items must be returned in their original packing materials together with the supplied accessories.

ORDERING INFORMATION

HI 83900-30: Suction lysimeter, 30 cm (0.98') tube
HI 83900-60: Suction lysimeter, 60 cm (1.97') tube
HI 83900-90: Suction lysimeter, 90 cm (2.95') tube
HI 83900-25: Cleaning solution replacement kit, 500 mL bottle

WARRANTY

This equipment is guaranteed for two years against defects in workmanship and materials when used for their intended purpose and maintained according to instructions.

This warranty is limited to repair or replacement free of charge. Damages due to accident, misuse, tampering or lack of prescribed maintenance are not covered.

If service is required, contact the dealer from whom you purchased the instrument. If under warranty, report the model number, date of purchase, serial number and the nature of the failure. If the repair is not covered by the warranty, you will be notified of the charges incurred.

If the instrument is to be returned to Hanna Instruments, first obtain a Returned Goods Authorization number from the Customer Service department and then send it with shipping costs prepaid.

When shipping any instrument, make sure it is properly packaged for complete protection.

GENERAL USE / OPERATING PRINCIPLES

The **HI 83900** suction lysimeter is built with a porous ceramic cap connected to a transparent tube for soil solution extraction. A rubber capillary is inserted in the tube passing through a rubber cap and reaching the ceramic tip.

The lysimeter is an ideal tool for collecting soil solution samples and then perform quantitative chemical analysis. In this way the operator can easily monitor the level of fertilization nutrients, such as ammonia, nitrate, phosphorous and potassium.

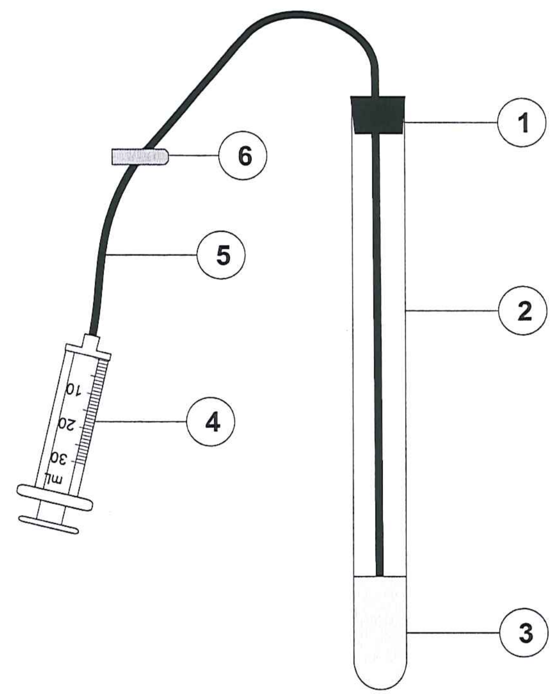
The ceramic tip of the lysimeter can be used in all types of soil, and it is made of sinterized material that does not react with nutrient elements. The soil solution, therefore, is not affected by the chemical composition of the ceramic cap, and the test results are always precise and reliable.

Use our chemical test kits or photometers for accurate analysis (see the HANNA instruments® general catalog or visit our web site at **www.hannainst.com** for a complete list of equipments, reagents and accessories).

The **HI 83900** allows to extract a solution from the soil by creating a vacuum (negative pressure or suction) inside the sampler tube, that exceeds the soil water tension. This will establish an hydraulic gradient for the solution to flow through the porous ceramic cap and into the lysimeter tube. Typically, a vacuum of about -60 cb (centibar) should be drawn.

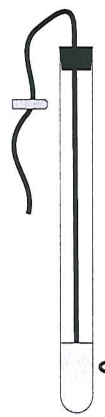
For better monitoring the soil solution composition throughout an entire growth period of crops, at least two lysimeters should be installed in the root zone of a representative plant, one at the upper part and the other in the lower part of the root zone.
For better accuracy and repeatability of results, it is recommended to replicate the above described installation in at least two more locations.

FUNCTIONAL DESCRIPTION

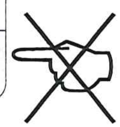


1. Rubber cap
2. Soil solution sampler tube
3. Porous ceramic tip
4. 30 mL syringe (pump)
5. Rubber suction capillary
6. Finger clamp

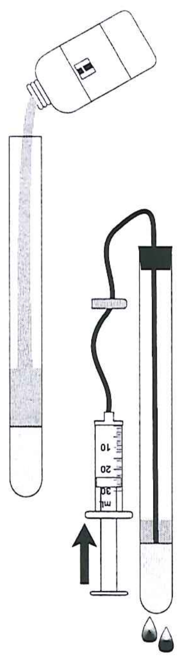
OPERATIONAL GUIDE



Assemble the unit by inserting the rubber capillary in the sampler tube and closing with the rubber cap. Check that the rubber capillary is into the ceramic tip, then remove the plastic bag from the ceramic part and follow the activation procedure explained below.



Important: NEVER TOUCH THE CERAMIC SENSITIVE PART WITH YOUR FINGER BEFORE AND DURING THE ACTIVATION PROCESS.



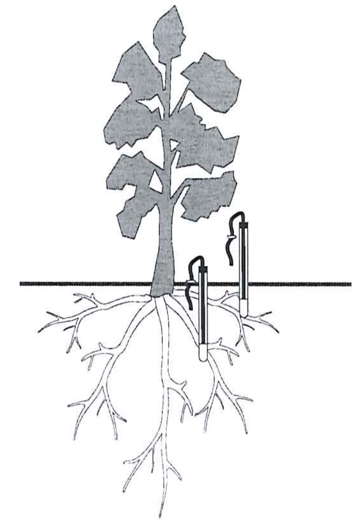
ACTIVATION

- Fill approximately 1/3 of the lysimeter tube with the supplied cleaning solution.
- Draw the syringe piston all the way back and attach the syringe to the rubber capillary.
- Close the tube with the rubber cap, open the finger clamp and push the syringe piston.
- Pinch the finger clamp and wait until the solution seeps through the porous ceramic tip. Draw the rest of the solution from the sampler tube and dispose of it.
- The lysimeter is now sterile, free of air bubbles and ready for insertion into the ground.
- Keep the ceramic tip moist until the lysimeter is inserted into the soil. Protect it with a plastic bag.

INSTALLATION

Location

- The selected location/plant for installing the lysimeter should be representative of the entire field.
- For better accuracy and repeatability of results, install at list 3 couples of lysimeters (see below) per each area to be monitored.



Operation

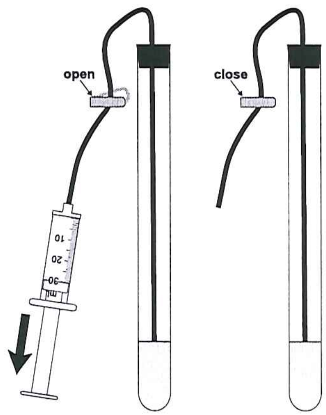
- Place the lysimeter inside the root zone. It is suggested to install at least two lysimeters, one at the upper and the other in the lower layer of the root zone.
- The recommended distance from the drip source depends on the soil type:
  sandy soil: 5 cm; medium soil: 10 cm; heavy soil: 15 cm.
- Drill a hole in the ground at the selected location and insert the **HI 83900**, while pushing and rotating it around its axis.
  After the proper depth is reached, compress the surrounding soil, while paying attention that the soil is tightly in contact with the ceramic tip.

Sample Extraction

Warning! Never operate the lysimeter in the following conditions:
- immediately after irrigation, otherwise the extracted solution will be the irrigation water and not the soil solution.
- before the irrigation water reaches the depth of the ceramic tip, because necessary tension can never be obtained if the sensitive tip is dry.

- Sample extraction needs a vacuum of approximately -60 cb (centibar) to be created inside the sampler tube. Connect the syringe to the rubber capillary, open the finger clamp and draw the syringe piston all the way back (30 mL). Pinch the finger clamp and disconnect the syringe.

  To obtain a vacuum of about -60 cb (centibar), perform these operations once with the **HI 83900-30** model, twice with **HI 83900-60** and 3 times with **HI 83900-90**.



- Before drawing out the soil solution, allow a time interval which depends on the soil type.

Tuff or sandy soil:	30 minutes
Light soil:	1 hour
Medium soil:	2 to 4 hours
Heavy soil:	3 to 12 hours

- To collect the soil solution, connect the syringe to the rubber capillary, open the finger clamp and the rubber cap, then draw the syringe piston all the way back (30 mL).
- Hold the piston until all the solution is sucked into the syringe, then disconnect the syringe from the capillary and leave the finger clamp open.
- Transfer the soil solution into the sampling vessel and immediately perform tests.

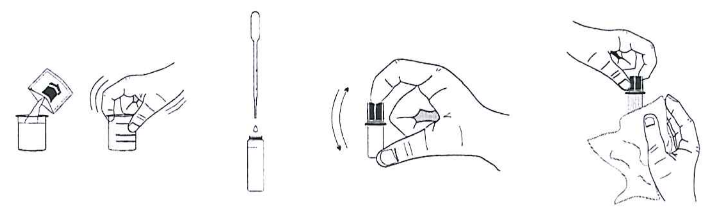
- Never draw the syringe piston more than specified times, otherwise the soil moisture tension will be broken. In addition, when a very high vacuum is created at the soil solution, the test results will be unreliable, due to a non-aerobic process.
- After drawing out the solution, the lysimeter should not remain at vacuum conditions until the next time of operation.

SUGGESTIONS FOR SAMPLE ANALYSIS

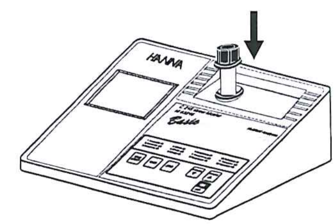
HANNA instruments® offers a wide variety of instrumentation, chemical test kits and reagents (ask your dealer for details) to analyze soil solution samples.

Use the **HI 83215** (or **HI 83225**) *Grow Master* bench photometer for testing the presence and strength of **ammonia, nitrate, phosphorus and potassium** on the spot (**low, medium and high ranges**). This advanced instrument is very simple to operate even for non-technical users, and provides lab results.

1. Add the proper reagent (see photometer instruction manual) to the sample solution and shake gently.
2. Fill two measuring cuvets, one with the solution without reagent (blank) and the other with the reacted sample. Screw the cap onto the cuvets and shake.
3. Wipe the cuvets with a soft tissue to remove any dirt or fingerprint.



4. Select the desired program and insert the "blank" cuvet into the photometer cell. Press "ZERO".
5. Now insert the cuvet with the solution to be analyzed and press "READ".



For **pH/EC/TDS measurements**, you can use these portable meters, housed in a water-resistant casing ideal for field applications:

HI 9811-5	0 to 14 pH, 6000 µS/cm, 3000 ppm, 0 to 70°C
HI 9813-6	0 to 14 pH, 4.00 mS/cm, 1999 ppm, 0 to 60°C, with HANNA F.S.T. system
HI 991300	0 to 14 pH, 3999 µS/cm, 2000 ppm, 0 to 60°C, with advanced features

Chemical Test Kits for Agriculture:

HI 38078	kit for SAR (Sodium Absorption Ratio) test
HI 3896	professional kit for testing traces, low, medium and high ranges of nitrogen, phosphorus and potassium, and pH from 4 to 9.

MAINTENANCE AND STORAGE

The lysimeter should remain installed for all the crop season, and the ceramic cap must be sterilized against fungi and algae at least every two months, without removing it from the ground.

- Fill the syringe with the supplied cleaning solution (approximately 10 mL).
- With the finger clamp open, inject the solution into the lysimeter tube for about 10 seconds. Draw up the rest of the solution and dispose of it.

Do not perform soil solution tests immediately after sterilization.

In seasonal cropping and during winter, remove the lysimeter from its installation before the first frost.

- Immediately after removing the lysimeter, immerse the tip in the cleaning solution over night.
- Let the solution drain through the porous ceramic cap, gravity flow.
- Air dry the lysimeter and store it.

Warning!

- Do not let the ceramic cap dry while dirty.
- Do not store at temperatures below freezing because some water may remain trapped inside the porous ceramic.

TROUBLESHOOTING

If the lysimeter is unable to extract soil solution, first check that:

- The soil is tightly in contact with the porous ceramic cap.
  >>> Compress the surrounding soil if necessary.
- The suction capillary reaches the ceramic tip.
  >>> Otherwise push it downwards through the rubber cap.

Moreover, the following conditions can cause inability to extract soil solution:

- The water has not reached the ceramic tip. This can occurs when the lysimeter is positioned at a depth of 40-50 cm.
  >>> Delay time of operation.
- Water reaches the depth of the ceramic tip very slowly, also measured in days for very heavy or compact soils. In this case, the lysimeter should not be installed in low depths such as 50-60 cm.
  >>> Use the lysimeter in depths of only 15-30 cm.
  >>> Install the lysimeter in a different location, where the soil is not too compact.
- Fully developed plants can compete with the lysimeter for water, and may be not possible to extract the solution. It can also happen that the solution not collected in time will be extracted back from the lysimeter by the plant.
  >>> Operate earlier.
- The water distribution is not uniform.
  >>> Check the irrigation water flow.
- The soil is dry, due to an irrigation with insufficient amount of water.
  >>> Irrigate again increasing the amount of water.

SALES AND TECHNICAL SERVICE CONTACTS

Australia:	Tel. (03) 9769.0666 • Fax (03) 9769.0699
China:	Tel. (10) 88570068 • Fax (10) 88570060
Egypt:	Tel. & Fax (02) 2758.683
Germany:	Tel. (07851) 9129-0 • Fax (07851) 9129-99
Greece:	Tel. (210) 823.5192 • Fax (210) 884.0210
Indonesia:	Tel. (21) 4584.2941 • Fax (21) 4584.2942
Japan:	Tel. (03) 3258.9565 • Fax (03) 3258.9567
Korea:	Tel. (02) 2278.5147 • Fax (02) 2264.1729
Malaysia:	Tel. (603) 5638.9940 • Fax (603) 5638.9829
Singapore:	Tel. 6296.7118 • Fax 6291.6906
South Africa:	Tel. (011) 615.6076 • Fax (011) 615.8582
Taiwan:	Tel. 886.2.2739.3014 • Fax 886.2.2739.2983
Thailand:	Tel. 66.2619.0708 • Fax 66.2619.0061
United Kingdom:	Tel. (01525) 850.855 • Fax (01525) 853.668
USA:	Tel. (401) 765.7500 • Fax (401) 765.7575

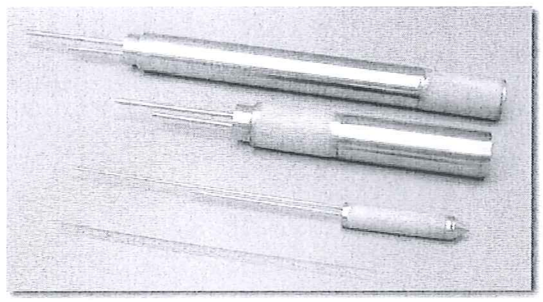
For e-mail contacts and complete list of Sales and Technical offices, please see ***www.hannainst.com***

MAN83900 09/05

SOIL MEASUREMENT SYSTEMS SMS

Suction Lysimeters

Description:



Suction lysimeters collect pore water from unsaturated soil. After installation below ground level, vacuum is applied to the lysimeter through tubing leading from the lysimeter to the ground surface. The negative air pressure created inside the lysimeter draws pore water into the lysimeter through the porous, stainless steel section of the lysimeter. The pore water is transported to the surface by applying positive pressure to the lysimeter through a second tube. At the surface the pore water is collected in a collection bottle. Suction lysimeters perform best in moist soil and below the water table. Pore water collection from relatively dry formations (pressure potential less than -500 mbar) is difficult.

Models:

SW-070	Dual Chamber
SW-070A	Dual Chamber
SW-071	Single Chamber
SW-074	Small Single Camber

Click on models above for setup details.

Features:

- All welded 304 stainless steel construction
- No glue or plastics
- Suitable for organics and most inorganics
- Separate upper chamber for sample storage (models SW-070 and SW-070A)
- One way stainless steel valve prevents back flow from storage chamber to sample chamber (models SW-070 and SW-070A)
- Strong and durable.
- Suitable for installation at great depths (models SW-070 and SW-070A)
- 600 mbar bubbling pressure
- Optional battery powered vacuum pump (SW-073)

Dual chamber models only:

- Separate upper chamber for sample storage
- One-way stainless steel valve prevents back flow from upper storage chamber to sample chamber
- Suitable for installation at great depths

Specifications:

	SW-070	SW-070A	SW-071	SW-074
Total length (in)	18.0	36.0	10.7	4.5

Porous steel length (in)	3.7	3.7	3.7	3.7
Outside diameter (in)	2.0	2.0	2.0	.875
OD SS outlet tubing (in)	.250	.250	.250	.125
Length SS outlets (in)	4 and 6.5	4 and 6.5	4 and 6.5	6 and 11
Storage volume (ml)	575	1000	260	NA

Frequently asked questions:

Question 1: How deep can I install the lysimeters?

Answer:

The dual chamber models can be installed at depths of up to several hundred meters (500 feet or more). The single chamber models should be installed no deeper than six meters (about 20 feet).

Question 2: Should I use a contact material to ensure good contact between the porous section of the lysimeter and the surrounding soil or sediment?

Answer:

Many researchers use sifted fine sand removed from the depth of lysimeter installation as contact material. If such sand is not available, silica flour may be used as contact material. It is best to add water to the contact material first, resulting in a slurry that can be poured down a plastic pipe temporarily placed in the access hole.

Question 3: Are vacuum and pressure sources required for operation of the lysimeters?

Answer:

Model SW-074 requires a vacuum source (i.e. a vacuum pump) to draw pore water from the surrounding medium into the lysimeter, and from there up into a collection bottle, located on the soil surface.

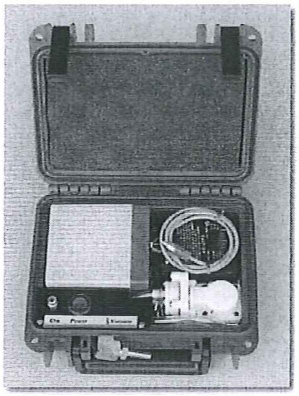
Model SW-071 can also be operated with just a vacuum source, if it is placed at a relatively shallow depth (i.e. less than 3 to 4 meter), and if a collection bottle is located on the soil surface, as for model SW-074.

However, SW-071 models are usually operated such that the pore water is collected in the lysimeter itself. In that case a pressure pump (hand pump or electric pump) is needed to apply pressure to the vacuum/pressure tube of the lysimeter. This forces the water from the lysimeter up into the collection bottle. A good bicycle can be used for this purpose.

The dual chamber models SW-070 and SW-070A need both vacuum (to draw the pore water into the lysimeter and into the upper chamber of the lysimeter), and pressure. Pressure is needed to force the pore water sample up through the fluid return tube to the collection bottle at the soil surface. For a lysimeter placed at a depth of 30 meters (98 feet) one needs an air pump that can deliver a pressure of at least 30 meters, equivalent to 3 bars or about 45 psi. Note that most bicycle pumps can deliver at least 100 psi or 6.6 bars.

SOIL MEASUREMENT SYSTEMS SMS

Vacuum Pump



The battery-operated vacuum pump is designed to provide vacuum to suction lysimeters installed in the field. Suction lysimeters are frequently installed at locations where line power is not available. This small vacuum pump will draw enough vacuum (maximum vacuum 340 mbar) to extract pore water into suction lysimeters when the soil or porous matrix are relatively moist (matrix potential greater than -200 mbar). In reality if the soil or porous material is dryer than a water content equivalent to –200 mbar matrix potential, the hydraulic conductivity of the soil immediately around the lysimeter is so low as to make extraction of soil pore water very difficult. This is especially true for sandy soils, and coarse textured materials.

The battery and vacuum pump are enclosed in a strong container. It measures 23 x 20 x 10 cm and weighs 2.7 kg. On a fully charged battery the pump can run continuously and draw vacuum for 3 to 4 days.

Frequently Asked Questions

How many lysimeters can I connect to one vacuum pump?

Answer:

If all tubing to the lysimeters is airtight and if all connections are airtight, one pump can maintain an approximate negative pressure of 300 mbar in many lysimeters. However, even small leaks can severely reduce the efficiency of the system. Thus great care is required in installing lysimeters in the field. Leak testing is done by applying positive pressure to the tubing and connectors, and by holding all connections under water. Appearance of air bubbles in the water is proof of leaks.

How quick can the pump create partial vacuum?

Answer:

This pump can reduce the pressure in a 1 liter bottle to -100 mbar in 11 seconds. It takes approximately 30 seconds to reduce the air pressure in a 1 liter bottle to -200 mbar.

Are there any precautions one should take when using this pump?

Answer:

One should always place an overflow bottle in the fluid return tube right before the vacuum pump. This ensures that no water from the lysimeters can enter the pump. Water will damage the pump.

Are these pumps suitable for permanent installations?

Answer:

For permanent installations line powered pumps (110V or 220V) are preferable. The portable, battery powered pump is particularly suitable for intermittent pore water collection, and/or where suction lysimeters are widely dispersed in the field.

WIL-GRO®
PROFESSIONAL FERTILIZER

FIVE IRON
25-3-10

Wil-Cote Premium

GUARANTEED ANALYSIS:

Total Nitrogen (N)	25.00%
5.30% Ammoniacal Nitrogen	
19.70% Urea Nitrogen*	
Available Phosphate (P_2O_5)	3.00%
Soluble Potash (K_2O)	10.00%
Sulfur (S)	5.00%
Iron (Fe)	5.00%

Plant Nutrients Derived From: Monoammonium Phosphate, Urea, Polymer Coated Urea, Ammonium Sulfate, Muriate of Potash, and Iron Sucrate.

*17.50% Slow Release Nitrogen from Polymer Coated Urea.

DIRECTIONS FOR USE:

	Lbs. of Actual Nitrogen to apply per 1,000 sq. ft.	Lbs. of Actual 25-3-10 to apply per 1,000 sq. ft.	Lbs. of Actual 25-3-10 to apply per acre
Turfgrass:	1.00	4.0	175

Apply to dry turf or foliage and irrigate thoroughly immediately after application. Plant nutrients may cause staining of sidewalks. Sweep walkways prior to irrigation. Walkways should be dry at time of application. Keep away from pools, ponds, etc. Do not contaminate potable water.

PRODUCT COVERAGE: Based on the recommended rate, one 50-lb. bag covers 12,500 sq. ft.
3.5 - 50 LB. BAGS COVER ONE ACRE

SPREADER SETTINGS:
(4 lbs./1,000 sq. ft.)

Scotts Accupro 2000	M½	*(12 ft. spread width)*
Lesco Commercial	15	*(10 ft. spread width)*
CBR II	5½	*(10 ft. spread width)*
Earthway	15	*(12 ft. spread width)*
Spyker 7622	4.9	*(12 ft. spread width)*

Note: Spreader settings are guidelines only. Spreaders should be checked for accuracy.

Information regarding the contents and levels of metals in this product is available on the internet at http://www.regulatory-info-we.com/

STORAGE AND DISPOSAL:
Do not contaminate water, food or feed by storage, disposal or cleaning of equipment.

Store in a safe manner. Store in original container only and keep tightly sealed when not in use. Dispose of unused product and empty containers in accordance with Federal, State and local regulations.

For chemical spills, leaks, fire or exposure, call CHEMTREC: (800) 424-9300.

FIRST AID:
In all cases, call a poison control center or doctor for further treatment advice.

IF SWALLOWED, call a poison control center or doctor immediately. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to by a poison control center or doctor. Do not give anything to an unconscious person. **IF ON SKIN**, take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. **IF INHALED**, move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration. **IF IN EYES**, hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing.

ADVANTAGES AND BENEFITS:
- Long term feeding - 70% of the nitrogen in this product is from polymer coated urea.
- Formulated for turfgrass areas with high performance needs.
- Delivers consistently high color ratings and reduced clippings.

CAUTION
KEEP OUT OF REACH OF CHILDREN
PRECAUTIONARY STATEMENT
HAZARDS TO HUMANS AND DOMESTIC ANIMALS

Do not ingest. Avoid contact with skin, eyes or clothing. Avoid breathing dust, vapor or mist.

Manufactured by: Wilbur-Ellis Company, 7 E. Washington Ave., Yakima, WA 98903

K-032309

FIVE IRON
25-3-10

Conditions of Sale and Limitation of Warranty and Liability:

NOTICE: Read the entire Directions for Use and Conditions of Sale and Limitation of Warranty and Liability before buying or using the product. If the terms are not acceptable, return the product at once, unopened, and the purchase price will be refunded.

The Directions for Use of the product should be followed carefully. It is impossible to eliminate all risks inherently associated with the use of this product. Crop injury, ineffectiveness, or other unintended consequences may result because of many different factors including, without limitation, manner of use or application, weather, combination with other products, or crop conditions. All such risks shall be assumed by Buyer and User, and Buyer and User agree to hold Manufacturer and Seller harmless from any claims relating to such factors.

Seller warrants that this product conforms to the chemical description on the label. EXCEPT FOR THIS WARRANTY, THE PRODUCT IS FURNISHED "AS-IS," AND NEITHER SELLER NOR MANUFACTURER MAKES ANY OTHER WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THE SELECTION, PURCHASE OR USE OF THIS PRODUCT; SELLER AND MANUFACTURER SPECIFICALLY DISCLAIM ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Buyer and User accept all risks arising from any use of this product, including without limitation uses contrary to label instructions, under abnormal conditions, or under conditions not reasonably foreseeable to (or beyond the control of) Seller or Manufacturer.

To the extent permitted by law, neither Manufacturer nor Seller shall be liable for any incidental, consequential or special damages resulting from the use or handling of this product. THE EXCLUSIVE REMEDY OF THE BUYER OR USER, AND THE EXCLUSIVE LIABILITY OF MANUFACTURER AND SELLER, FOR ANY AND ALL CLAIMS, LOSSES, INJURIES OR DAMAGES (INCLUDING CLAIMS BASED ON BREACH OF WARRANTY, CONTRACT, NEGLIGENCE, TORT, STRICT LIABILITY OR OTHERWISE) RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT, SHALL BE THE RETURN OF THE PURCHASE PRICE OF THIS PRODUCT, OR, AT THE ELECTION OF MANUFACTURER OR SELLER, THE REPLACEMENT OF THE PRODUCT.

These Conditions of Sale and Limitation of Warranty and Liability shall be interpreted in accordance with the laws of the State of California, excluding its conflicts of laws rules, and may not be amended by any oral or written agreement.

NET WEIGHT 50 POUNDS (22.68 kg)

WIL-GRO®
PROFESSIONAL FERTILIZER