UNDERWOOD
engineers

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To: David Ford UE File No: 1727.00
From: David J. Mercier, P.E.
cc: Tom Page, Keith Pratt
Date: December 14, 2012, Revised January 11, 2013
Re: WOLFEBORO – Project Status Meeting Summary – December 6, 2012

On Thursday, December 6, 2012 a meeting was held at the Town of Wolfeboro's Public Works Office from 9:00 AM to 12:30 PM. David Ford was in attendance representing the Town; David Mercier and Tom Page were in attendance for Underwood.

The key purpose of the meeting was to discuss the draft letter report recently issued by UE regarding potential effluent disposal capacities on the existing Town-owned wastewater treatment facility property. Later in the meeting, the other three Underwood wastewater scope items were also discussed and are covered later in these minutes.

FINAL EFFLUENT DISPOSAL

Underwood Engineers issued a Draft Letter Report on Monday, December 3, 2012 regarding potential wastewater effluent disposal capacities on the existing Town-owned wastewater treatment facility (WWTF) property. The draft letter evaluated three scenarios: 1) the potential cost to completely replace all of the existing spray area distribution, header, and spray nozzle piping, 2) the potential layout and effluent volumes that could be disposed of via drip dispersal on the existing site built around the existing effluent storage pond (ESP) and spray irrigation areas, and 3) the potential layout and effluent volumes that could be disposed of if new drip dispersal systems were built in the same footprint as the existing spray area.

Scenario #1 - Spray Irrigation

Dave Mercier explained that the cost opinion to replace all of the existing spray irrigation piping was $1.94M. Underwood does not feel that it is cost effective to replace the existing spray irrigation piping versus continuing to service and repair the existing spray irrigation piping over the next 20-year period. When one considers the ½ man year of labor to maintain and to start up and shut down the existing spray irrigation piping each season, as well as the money currently spent for replacement parts to replace broken or worn piping features, it is much less than the cost of a 20-year bond payment on $1.94M ($130K @ 3%). It is also believed that the existing pipe has 20 years left in it and the fact that the Town has a significant inventory of replacement piping due to the spray areas that were taken off-line to replace pipe is good.

Dave Mercier relayed that based on a meeting that was held recently with Mitch Locker of DES, Mitch discussed that the permitted capacity for the spray of 2 inches/week has now been adopted as a State standard but that it is possible to petition and have that number increased. Mitch did say that given the history of the existing spray site, it would take significant data to support an increase in the existing permitted flow but that it was not out of the question. Tom Page mentioned that based on past studies done, it would appear that some spray areas could be pushed to as much as 3 inches/week, where other areas may not be able to be pushed, but if it were assumed that overall the existing spray areas could be permitted at 2.5 inches/ week, it would increase the total annual effluent disposal capacity of the existing spray areas from 30 MG/Yr to 47 MG/Yr, assuming the current average rainfall of 28" per year during the 6-month spray period. Dave Mercier mentioned that it would require further study to determine if the existing spray area flows could be pushed to the 2.5 inches concurrently with new spray areas being constructed around and upstream of the existing spray areas as the new drip dispersal could affect the groundwater mounding in the existing spray areas.

Scenario #2 - Potential Effluent Disposal Through New Drip Disposal Zones

The next scenario discussed was the potential effluent that could be disposed of through new drip dispersal zones constructed around the existing ESP and spray areas. Underwood provided tabular data for a range of potential disposal rates for the new drip areas with loading rates ranging from 0.15 gpd/sf to 0.3 gpd/sf, which equate to low to moderate loadings rates for drip dispersal systems but which are considered appropriate for the types of soils and the high ground water table that exists across the existing site. Based on discussions with Town staff, the past history of spraying on the existing site, and to provide a reasonable factor of safety, Underwood and the Town agreed that it was appropriate to use the lower loading rate at 0.15 gpd/sf for long-term planning on the existing site until further site investigations were completed. Utilizing this loading rate, the new drip dispersal effluent disposal capacity around the existing ESP and spray areas is 43 MG/Yr at an estimated cost of $5.13M. This results in a maximum effluent disposal capacity for the site of 73 MG/Yr between existing spray and new drip dispersal. The higher loading rate of 0.3 gpd/sf may be valid in specific areas but would need a much more in-depth soil study and on-site engineering to be able to support the higher loading rate.

Scenario #3 - New Drip Dispersal Systems in Place of Existing Spray

Scenario #3 analyzed the benefit of constructing new drip dispersal systems within the existing footprint of the existing spray systems. The numbers show that is not cost effective at the lower loading rate (0.15 gpd/sf) to build new drip in place of the existing spray because the cost would be $3.9M and the capacity would only be increased by 8 MG/Yr above what the current spray can do. Much discussion ensued relative to the ultimate goal that the Town has which is to be able to not only dispose of its current annual wastewater effluent flows but also to provide additional capacity for future growth as well as provide a 20% buffer to stay under the State's requirements for facility planning. Currently wastewater effluent flows are 140 MG/Yr. It was agreed that if the existing WWTF disposal site could be built out as proposed with new drip systems to dispose of a maximum of 73 MG/Yr on the existing site between drip and spray, that the Town would need to be able to continue to dispose of at least 73 MG/Yr at the rapid infiltration basin (RIB) site to be able to comfortably handle current wastewater effluent production rates. If the RIB site is not able to be operated in the future at a rate equivalent to at least 73 MG/Yr, then the Town will be forced to go off-site to look for land to construct additional subsurface disposal just to handle current flows. The Town will definitely need to look off-site to develop the third 73 MG/Yr of subsurface disposal to get to the 219 MG/Yr or 0.6 MGD design capacity of the WWTF. Underwood presented the attached figure which identifies the different soil classes that exist on properties along the forcemain between the RIB pump station and the rapid infiltration basins themselves. While no additional study has been done, the concept discussed was that it may be possible to identify land along the RIB forcemain that could be purchased for construction of new drip dispersal fields at a lower cost per million gallons than on the existing site. This is due to the potential for a better site to be found with better soils that would accommodate a higher drip dispersal loading rate and allow more flow to be discharged to the ground in a smaller footprint, which would reduce capital costs for an equivalently sized system despite the fact that new land purchase costs would be factored in. For planning purposes, the cost of an additional 73 MG/Yr of subsurface disposal at a new off-site location along the existing transmission main will likely be similar to the $5.13M for Scenario #2 after land acquisition costs and transmission costs are added back in.

Summary

In closing on this topic, Underwood discussed that the effort involved in getting to this point on the existing site exceeded initial estimates and the fact that significant work outside of scope was performed in the area of investigation of fog nozzles for evaporation treatment of effluent at the ESP, the budget for this work item has been expended. As a result, no money exists to advance this area of study any further and it was agreed between Dave Ford and Underwood that the work will be put on hold with the letter remaining in draft stage until a later point when the Town has had time to assess the long-term capacity that exists at the RIB site and additional monies have been allocated for this purpose.

INFILTRATION AND INFLOW (I/I)

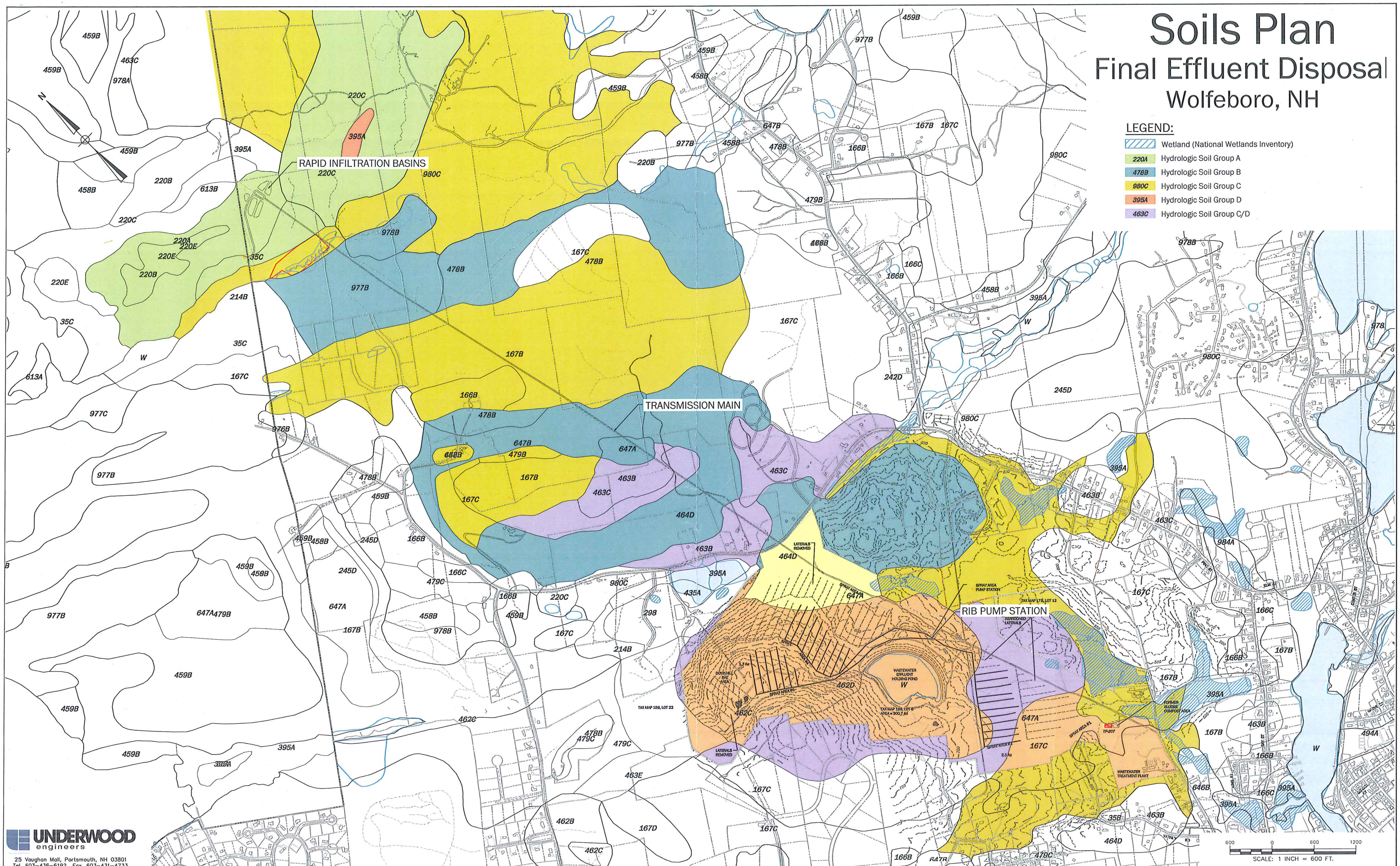
Final versions of the three letter reports on I/I have been delivered to the Town. With the delivery of these three final reports, the scope is considered complete. Dave Ford has requested that Underwood produce scopes and fees to match the recommended work for 2013 as outlined in the third I/I Letter Report. This will involve scopes for both a Study Phase and for a Design Phase for an I/I Rehabilitation Project. Dave Ford stated that it is his goal to perform the study and rehabilitation projects in a design/build-type fashion such that the Contractor utilized can work in conjunction with Underwood to first inspect areas and then immediately follow-up with the appropriate repairs such that engineering costs will be minimized and the maximum amount of rehabilitation work can be accomplished within the $400,000 budget that has been established. Dave Ford also stated that the Town will most likely not pursue SRF Funding for this work but that Underwood should still be sure to submit the information to the State as is required when work is being done on wastewater systems. Underwood agreed to look into I/I Rehabilitation Design Build possibilities and get back to the Town.

SCADA

Dave Mercier explained that with the issuance of the second draft version of the SCADA Letter Report that Underwood considers the SCADA scope complete with the exception of the need to add a paragraph at the end of the letter on how best to incorporate the remote pump stations into a new SCADA system located at the WWTF. Dave Ford stated that the recent e-mail by Dave Mercier discussing potential ways to gather the information from the pump stations to get it to SCADA was somewhat confusing since the majority of the existing pump stations already have Mission Cellular alarm units installed. Dave Mercier stated that that was new information and that Underwood would be sure to revise the recommendations for pump station SCADA improvements to coincide with the existing equipment. Dave Ford agreed that he would provide Underwood with the password to allow Underwood to access the Town's Mission website so that Underwood would have a full understanding of the existing systems and information being gathered from the pump stations. It was agreed that once Underwood had reviewed the Town's Mission site, that they would issue a final version of the SCADA Letter Report with the appropriate pump stations recommendations for SCADA at the end and that that would close out the SCADA scope. It was discussed that the SCADA and Building HVAC improvements budget still has approximately $10,000 left unspent as Underwood was not asked to participate in the Building HVAC Improvements work. Dave Ford stated that he will need to shift that remaining money to the Building HVAC Improvements budget and that Underwood should consider their work complete with the issuance of the final SCADA Letter Report.

WWTF Long Term Plan

Dave Ford asked about the status of the WWTF Long Term Plan work. Dave Mercier stated that this work item still requires a fair amount of effort to complete. A letter report would summarize the current status/condition of unit processes throughout the plant and provide recommendations for needed improvements to those areas over a 20-year planning period. Underwood also needs to produce a 10-year CIP Plan with recommended improvements, costs, and scheduling. The final goal of this work will be to deliver a letter report to the NHDES to show the change in course for Wolfeboro to undertake smaller upgrades over a 10-year period as opposed to undertaking one large, all-encompassing wastewater upgrade. This is mainly due to the fact that the changes that have been implemented in the operation of the plant over the last several years have resulted in an excellent wastewater effluent that negates the need for a large, comprehensive upgrade at this time. Dave Ford stated that this item had the least stringent schedule of the four wastewater tasks but that he would like to have a meeting in early to mid-January 2013 to discuss the draft letter report on this topic. Dave Mercier agreed to set up a meeting in early to mid-January to be held at Underwood's Concord office.



Soils Plan
Final Effluent Disposal
Wolfeboro, NH
LEGEND:
Wetland (National Wetlands Inventory)
220A Hydrologic Soil Group A
478B Hydrologic Soil Group B
980C Hydrologic Soil Group C
395A Hydrologic Soil Group D
463C Hydrologic Soil Group C/D
RAPID INFILTRATION BASINS
TRANSMISSION MAIN
RIB PUMP STATION
LATERALS REMOVED
SPRAY AREA PUMP STATION
ABANDONED LATERALS
WASTEWATER EFFLUENT HOLDING POND
WASTEWATER TREATMENT PLANT
FORMER SLUDGE COMPOST AREA
TAX MAP 159, LOT 22
SCALE: 1 INCH = 600 FT.
600 0 600 1200
N
UNDERWOOD engineers
25 Vaughan Mall, Portsmouth, NH 03801
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DRAFT

1729-01

December 3, 2012

Mr. David Ford, P.E.
Public Works Director – Town of Wolfeboro
84 South Main Street
PO Box 629
Wolfeboro, NH 03894

Re: ***Final Effluent Disposal Evaluation – Existing Spray Property - Letter Report #1***
Wastewater Evaluations
Wolfeboro, New Hampshire

Dear Mr. Ford:

The following letter report is the first of the memo deliverables required by Task 3 of our Scope of Services dated May 31, 2012. This letter specifically evaluates spray and drip dispersal scenarios on Town-owned land around the effluent storage pond, as directed by email correspondence with the Town on September 27, 2012. This letter presents a desktop analysis for the following three (3) effluent disposal scenarios:

1. Replace the existing spray irrigation system with a new shallowly buried spray system in the same footprint.

2. Construct new drip dispersal adjacent to existing active spray areas within the Town-owned land.

3. Replace the existing spray irrigation system with a new drip dispersal system in the same footprint.

Background

The Town of Wolfeboro owns and operates a municipal wastewater collection system, wastewater treatment facility (WWTF), and effluent disposal system. Treated WWTF effluent is pumped to an unlined effluent storage pond (ESP) for flow equalization, and effluent is pumped from the effluent storage pond to spray irrigation disposal fields and rapid infiltration basins (RIBs) for final disposal.

The Town owns a 300 +- acre parcel that includes the WWTF, ESP, and spray irrigation fields. Portions of this parcel are also used for outdoor recreational activities including hiking and cross-country skiing. This letter report focuses on effluent disposal capacity at this parcel only.

The spray irrigation facilities in use since the 1970's were intended to be retired when the rapid infiltration basins were brought online in March 2009 and expanded in 2010. However, due to performance issues with the RIBs, use of the spray system to dispose of a portion of flows was continued in 2009, 2011, and 2012.

Wastewater Flows and Storage Capacity

Wastewater flow projections and capacity needs will be evaluated under separate cover. Table 1 summarizes current wastewater flows and permitted effluent volumes. ***Both the existing RIB and spray irrigation systems are required to handle current flows, and the combined capacity is less than the WWTF design flow.***

Table 1. Permitted and Current Flows.

	Effluent Flow MGD, average	**Effluent Flow MGal/year**
WWTF design flow	0.6	219
RIB permitted application (Note 1)	0.34 (annual average)	124
Spray permitted application (Note 2)	0.166 (6 months only)	30.4
Total permitted application	**0.420 (annual average)**	**154.5**
WWTF effluent flow, 2010	0.349	127.4
WWTF effluent flow, 2011	0.393	143.8

Note 1. RIB loading based on 2012 Groundwater Discharge Permit.
Note 2. Spray loading based on 2011 Groundwater Discharge permit minus average precipitation (34.8 Mgal/year at 28 inches average precipitation 2009 - 2011 during spray season).

Existing Spray System

The original spray disposal system was installed approximately 35 years ago, covering an area of approximately 100 acres in five (5) zones. In recent years, the Town has abandoned portions of the spray system where there were issues with surface ponding and active runoff. Currently, only selected portions of Zone 2, Zone 4, and Zone 5 are operated (Figure 1, Appendix A).

The Town was issued a new, 5-year NHDES Groundwater Discharge Permit (GWP-198705015-W-003) on April 29, 2011 that allows discharge over this reduced area of approximately 46 acres. Spray discharge is limited to 2 inches in any 7-day period over the 46 acres (2,498,820 gallons per week) including effluent and precipitation. Spray area discharges are only permitted from May 1 to October 31 (6 months per year). No spray discharge is allowed when the groundwater table is within 12 inches of the surface or there is frozen ground.

The existing spray distribution piping system consists of aluminum, above-grade irrigation piping ranging from 10" headers to 3" laterals with ¾" brass impact sprinkler heads. The Town has salvaged some abandoned piping to repair active spray zones, and some abandoned piping has not yet been salvaged and remains in the field. Table 2 summarizes our understanding of the active, abandoned, and previously removed distribution piping:

Table 2. Existing Spray System Distribution Piping Summary

Area	3" (feet)	4" (feet)	6" (feet)	8" (feet)	10" (feet)	Total (feet)
Active	14,590	0	200	312	6,696	**21,798**
Abandoned in Place	6,311	0	195	203	1,874	**8,583**
Previously Removed	14,168	753	775	781	1,875	**18,352**
Total	**35,069**	**753**	**1,170**	**1,296**	**10,445**	

There are several issues with the existing spray distribution system that require significant ongoing maintenance and may limit the disposal capacity:

- Main lines and laterals are exposed above ground and can be damaged by falling trees and branches and by large wildlife.
- Pipes may shift, resulting in leakage at joints.
- Laterals do not have isolation valves.
- Laterals do not have flushing valves.
- Access is limited for inspection, repair, and maintenance.

- Mowing and herbacide application required to control plant growth is difficult due to rough terrain.

Effluent is pumped from the ESP to the spray areas using two 100 HP pumps with variable frequency drives (VFDs) installed in 2004. The VFDs are controlled by PLC based automatic controls at an operator interface terminal (OIT) installed in the adjacent RIB pumping station which have been in service since July 2012. Spray areas are sequentially dosed at a specific flow rate and pressure for multiple timed cycles until a preselected total volume is applied within a 24 hour period. The total volume that can be applied is determined daily by the operator based on recent rainfall. The automatic controls provide significantly improved control of spray application rates and duration compared to the previous manually operated system and have prevented active runoff.

Spray disposal totaled only 3.25 Mgal in 2011, with discharges in August through October. In 2012, spray disposal was initiated in mid May following installation of the automatic controls. Total effluent spray volume though October 2012 was 27.6 Mgal. The average loading was 1.98 inches/week, including 28.1 inches total of precipitation.

Existing Topography, Soils and Groundwater Levels

The topography at the existing spray site is moderately steep, with slopes of 15% to 30%. Groundwater flows are assumed to follow the surface, which slopes northerly in the northern portion of the site, easterly in the central portion, and southeasterly in the southern portion. Vegetation is primarily deciduous, ranging from young to mature trees.

Existing soils generally consist of a mixture of sand, silt, clay, and boulders referred to as glacial till. Test pits in and around the spray fields were documented in previous reports (Hydrogeological Evaluation of Spray Irrigation Facility Wolfeboro New Hampshire, S W Cole Engineering Inc, June 29 2006). Hand borings encountered refusal at depths of 0.6 ft to 3.2 ft, presumably due to boulders. There are visible bedrock outcroppings in certain areas, and numerous large boulders are present on the ground surface.

Existing observation wells (OWs) have reported depths of 4 ft to 13 ft to refusal, with one well in Spray Area 5 extending 21.6 ft below grade. Minimum water level depths below grade recorded during the 2012 spray season ranged from 1.7 feet in OW-2B to 11.2 feet in OW-5B.

The 2006 report delineated several locations in the spray areas with saturated surface soils or ponded water. This was apparently due to spray application of effluent at a significantly higher rate than is currently used.

Wetland areas and tributaries border the northern, eastern, and southeastern boundaries of the site. Runoff to the Mirror Lake watershed from the northern part of the spray site including Spray Area 5 is a concern that was addressed by discontinuing use of certain spray areas.

Scenario – Replace Spray Irrigation with New Spray System (Active Areas Only)

Description:
This scenario includes replacement of the existing active spray distribution piping and spray heads. The following was assumed as a basis for conceptual costs:

- New HDPE header piping for active spray areas
- New PVC lateral piping for active spray areas
- New piping to match existing pipe sizes
- New piping buried 2 ft to reduce maintenance and facilitate off-season recreation of spray areas
- New risers to extend sprinkler heads above grade
- New brass sprinkler heads
- Limited new gravel roads to improve access to active spray areas
- Reuse of existing pumps and controls (recently upgraded)

Basis of Design:
The allowable effluent disposal capacity by spray irrigation depends on precipitation. Based on the existing spray disposal permit, annual effective spray disposal is approximately 30 million gallons when average precipitation is deducted from the loading rate (Table 3). Note that spray season precipitation can vary widely (19" in 2009, 33" in 2011), affecting the actual seasonal volume of effluent that can be disposed of. Detailed calculations are included in Appendix B.

Table 3. Current Spray Disposal Capacity

	NHDES Discharge Permit
Discharge loading limit, inches/week	2.0
Loading limit, gpd/sf	0.18
Area, acres	46
Area, SF	2,003,760
Average daily loading limit, gpd	357,000
Annual loading limit (Spray Season), Mgal/year	65.1
Average precipitation (2009-2012 Spray Season), in	28
Spray volume lost to rain, Mgal/year	34.8
Effective Loading Limit (Spray Season), gpd	***166,000***
Effective Disposal Capacity (Spray Season), Mgal/year	***30.4***

Spray disposal totaled only 3.25 Mgal in 2011, with discharges in August through October. In 2012, spray disposal was initiated in mid May following installation of the automatic controls. Total effluent spray volume though October 2012 was 27.6 Mgal. The average loading was 1.98 inches/week, including 28.1 inches total of precipitation.

Spray Expansion and Loading Considerations:
Expansion of the existing active spray areas and/or increasing the permitted loading rate could possibly increase annual spray disposal capacity. Previous reports suggested reducing the existing 300' property line buffer to 100' and expanding the spray fields into other areas. However, since most of the original spray areas have been abandoned due to performance issues, expansion of the currently active spray areas was not considered in this report.

Previous reports also suggested that increased loading rates might be feasible in some areas of the site. For example, if the permitted loading rate were increased to 2.5"/week under the existing permit, effective annual spray disposal volume could increase up to about 47 million gallons (Table 4). Initial discussions with NHDES on November 9, 2012 suggested a loading rate greater than the state standard of 2 inches/week is not impossible but would require significant additional analysis and data to support. Note that this increased loading rate would be an operational modification and would not affect the capital cost estimates below.

Table 4. Spray Disposal Capacity with Increased Loading Rate

	Increased Loading Rate to 2.5 inches/week
Discharge loading limit, inches/week	2.5
Loading limit, gpd/sf	0.223
Area, acres	46
Area, SF	2,003,760
Average daily loading limit, gpd	446,000
Annual loading limit (Spray Season), Mgal/year	81.4
Average precipitation (2009-2011 Spray Season), in	28
Spray volume lost to rain, Mgal/year	34.8
Effective Loading Limit (Spray Season), gpd	***256,000***
Effective Disposal Capacity (Spray Season), Mgal/year	***46.6***

Cost:
The Engineer's Opinion of Probable Costs for Scenario 1 is **$1.94 million dollars**. A detailed breakdown is included in Appendix C.

Advantages and Disadvantages of Scenario 1
<u>Advantages</u>

- Uses existing pumps and controls
- Town has familiarity with the process
- Some evaporation occurs during spray (estimated 3%-5%)
- 2012 records support the current permitted disposal volume
- Some uptake of nutrients by plant life occurs before discharge reaches the groundwater table.

<u>Disadvantages</u>

- Spray disposal is limited to about half the year
- Disposal quantities are significantly reduced due to precipitation
- High maintenance costs to keep spray areas clear of growth, start-up/winterization of the system, and daily groundwater monitoring
- Existing active spray areas have capacity for only a portion of existing flows
- Higher loading rates may not be feasible.

Scenario 2 – Construct Drip Dispersal Adjacent to Active Spray Areas

Description:
This scenario is to install new drip dispersal zones on Town owned land adjacent to the existing spray zones to increase effluent disposal capacity. Drip dispersal uses shallow buried small diameter tubing that is pressurized to distribute effluent through emitters. This technology can be applied to sloped, forested sites with less impact to natural conditions than conventional subsurface disposal.

This scenario includes:

- 1/2" HDPE drip tubing along contours, arranged in zones.
- Drip line spacing 4' average, 2' minimum, to allow routing around interferences.
- Top feed manifold design to accommodate slopes and allow drainage during freezing conditions.
- PVC supply and return/flush piping to each zone, buried below frost line.
- New drip dosing station including pumps, filters, valves, and controls.

For the purposes of this preliminary evaluation, a conceptual layout of equally sized drip zones was prepared (Figure 2, Appendix A). The zones were located in the areas most likely to be feasible for subsurface disposal. Areas that may be potentially wet or contain ledge outcrops were avoided. The area above the ESP was not used to avoid potential recharge of the pond. Detailed subsurface investigations, field surveys, and hydrogeological evaluations would be needed to confirm the final location and design loading of the drip zones.

Most of the new drip zones are proposed to be located around the ESP and be dosed from a new dosing station located near the existing pumping stations. The former sludge composting site adjacent to the Wastewater Treatment Facility was also considered for drip dispersal. This site was assumed to have a separate dosing station supplied from the force main to the ESP.

Basis of Design:

Detailed preliminary design calculations are included in Appendix B and summarized in Table 5 below. The lower loading range or application rate indicated is based on drip manufacturer's recommendations for the existing soil conditions (fine sandy loams). The upper loading range indicated in Table 3 represents a potentially greater disposal capacity if confirmed through further study and performance monitoring. For the planning purposes of this study, the conservative lower application rate is recommended pending further study.

Table 5. New Drip Dispersal - Basis of Design

Parameter	Lower Loading Range	Upper Loading Range
General drip zone design		
Area per zone, sf	28,880	28,880
Zone area loading rate, gpd/sf	**0.15**	**0.3**
Total loading per zone, gpd	**4,320**	**8,640**
Drip zones around ESP		
Number of zones	24	24
Total drip capacity, gpd	103,700	207,400
Total drip capacity, Mgal/year	**37.8**	**75.7**
Drip zones near WWTF		
Number of zones	3	3
Total drip capacity, gpd	13,000	25,900
Total drip capacity, Mgal/year	**4.7**	**9.5**
Total drip capacity all zones, Mgal/year	**42.5**	**85.2**

Cost:

The Engineer's Opinion of Probable Cost for Scenario 2 is (Appendix C) :

Drip zones around ESP	$4.66 million
Drip zones near WWTF	$0.47 million
Total	**$5.13 million**

Advantages and Disadvantages of Alternative 2:

Advantages

- Year round application.
- Not limited by precipitation, leaf fall, or frozen ground surfaces.
- Avoids potential runoff and erosion issues of spray irrigation.
- Expandable in future with additional zones.
- Lower impact to existing terrain and forest.
- Can be designed around existing recreational uses.
- Plant uptake can contribute to disposal
- Proven operation elsewhere in New Hampshire in steep areas.

Disadvantages

- Careful planning and siting is needed to locate systems around existing site limitations such as ledge outcrops or shallow groundwater.
- Areas with abundant stones or boulders may be problematic to install drip.
- All new distribution piping and pumping controls required.
- No proven track record at Wolfeboro site.
- Existing site may not be expandable with drip to handle all existing flows.

Scenario 3 – Replace Existing Spray Disposal with Drip Dispersal

Description:

This scenario is to replace the existing spray irrigation system with new subsurface drip dispersal. The new drip zones would be sited in the existing spray areas around interferences such as large boulders, outcrops, shallow cover and depressions (Figure 3, Appendix A). For the purposes of this evaluation, approximately 50% of the existing spray area was assumed feasible for drip dispersal zones. A new or upgraded dosing station would serve the drip zones replacing spray disposal. The capacity of new drip zones in the existing spray area would be approximately 27 Mgal to 55 Mgal/year (Table 6).

Table 6. Drip Dispersal Replacing Spray - Basis of Design

Parameter	Lower Loading Range	Upper Loading Range
Area per zone, sf	28,880	28,880
Zone area loading rate, gpd/sf	**0.15**	**0.3**
Total loading rate per zone, gpd	**4,320**	**8,640**
Drip zones in existing spray areas		
Number of zones	24	24
Total drip capacity, gpd	103,700	207,400
Total drip capacity, Mgal/year	**37.8**	**75.7**

Cost:

The Engineer's Opinion of Probable Cost for Scenario 3 is (Appendix C) :

Drip zones replacing Spray	$3.86 million	
Dosing station	$0.30 million	(if not provided under Alternate 2)
Total	**$4.16 million**	

Advantages and Disadvantages of Scenario 3:

(see Scenario 2)

Summary of Alternatives

The potential disposal capacity and opinion of cost for each alterative are summarized in Table 7.

Table 7. Summary of Scenarios

Scenario	Annual Disposal, Lower Range (Mgal/year)	Annual Disposal, Upper Range (Mgal/year)	Engineer's Opinion of Probable Capital Cost
Scenario 1 - New Spray Disposal System			
Existing Spray Areas (Note 1)	**30**	**47**	**$1,940,000**
Scenario 2 - Existing Spray and New Drip			
Existing Spray Areas (Note 1)	30	47	-
New Drip Areas (Note 2)	43	85	$5,130,000
Subtotal	**73**	**132**	**$5,130,000**
Scenario 3 - Replace Spray with Drip			
Replace existing Spray with Drip (Note 2)	38	76	$3,860,000
New Drip Areas (Note 2)	43	85	$5,130,000
	81	**161**	**$8,990,000**
Subtotal			

Note 1. Spray loading rate range= 2"/week to 2.5"/week including precipitation, May - October only.
Note 2. Drip loading rate range = 0.1 to 0.2 gpd/SF, year round.

Conclusions

- Both existing systems (RIB and spray irrigation) are needed to meet current flows, and total permitted capacity does not meet WWTF design flow.
- Replacing the existing spray distribution piping with new spray piping reduces O&M requirements and increases reliability but is likely not cost effective and does not increase current disposal capacity.

- Spray capacity can be potentially increased by using a higher loading rate, but would need significant empirical data to support and would need approval by NHDES.
- Drip dispersal allows year round operation and reduces storage needs.
- Drip dispersal may or may not have a higher annual disposal capacity than existing spray, depending on the final design loading rate.
- The costs to implement drip dispersal compared to spray are higher due to new pumping facilities and long piping runs.
- The maximum potential capacity for effluent disposal on the existing Town owned parcel is less than current wastewater flows (144 MGal/year in 2011), except for the highest assumed loading rate in this report.
- The cost effectiveness of drip dispersal depends on the design flowrate and the configuration.
- Improvements can be phased.

Recommendations

- Perform additional study before proceeding with improvements at the existing spray site.
- Evaluate 20 year projected WWTF design flow capacity required.
- Evaluate additional properties adjacent to existing Town owned land and the RIB force main for possible drip dispersal.
- Identify if other areas with higher permissible loading rates can be used, which may be more cost effective for drip installations.
- Identify if other areas would support more cost effective drip system layouts (e.g. shorter supply and return piping between the dosing station and drip zones).

Please call if you have any questions.

Very truly yours,

UNDERWOOD ENGINEERS, INC.

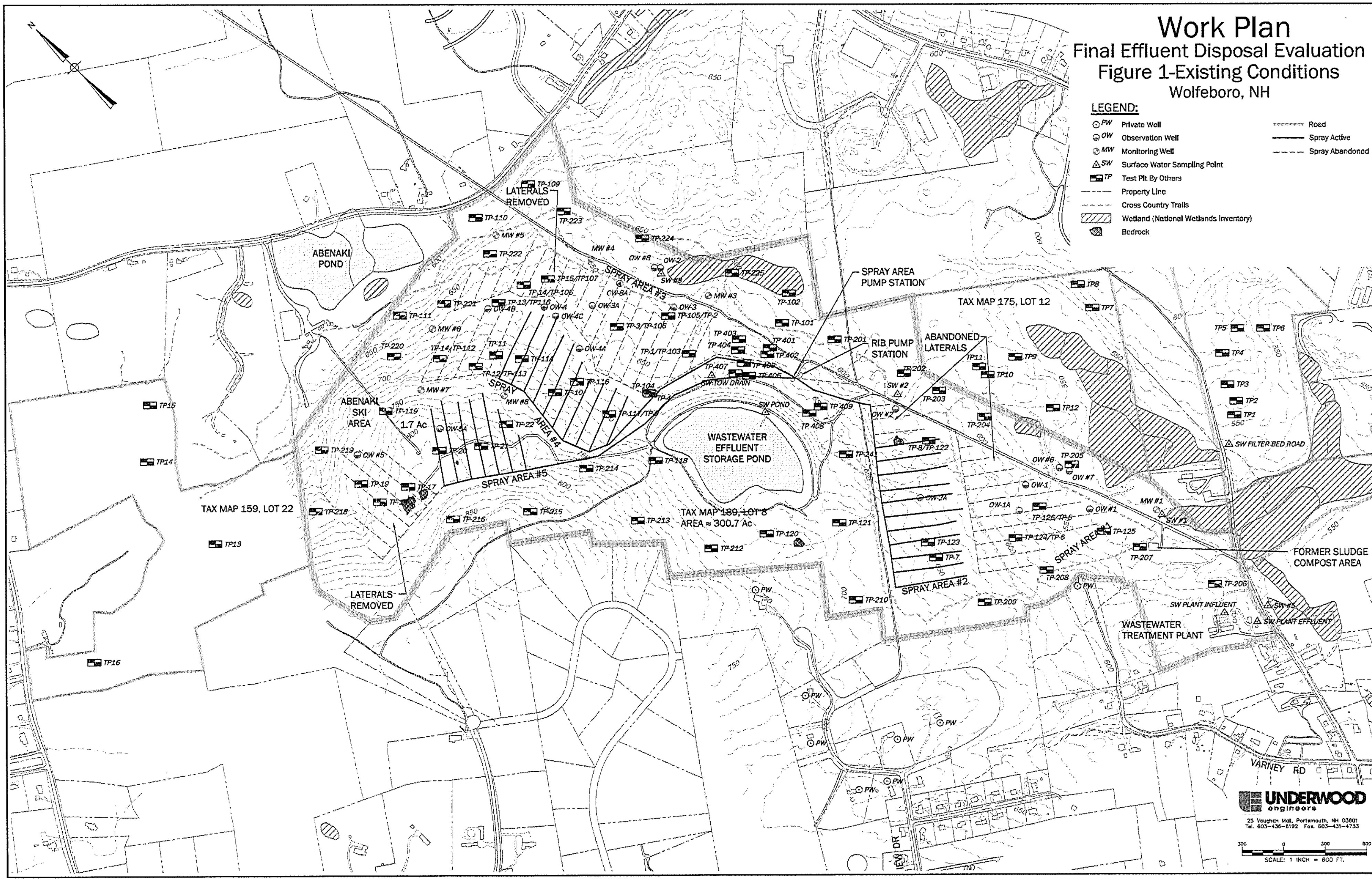
David J. Mercier, P.E.
Sr. Project Manager

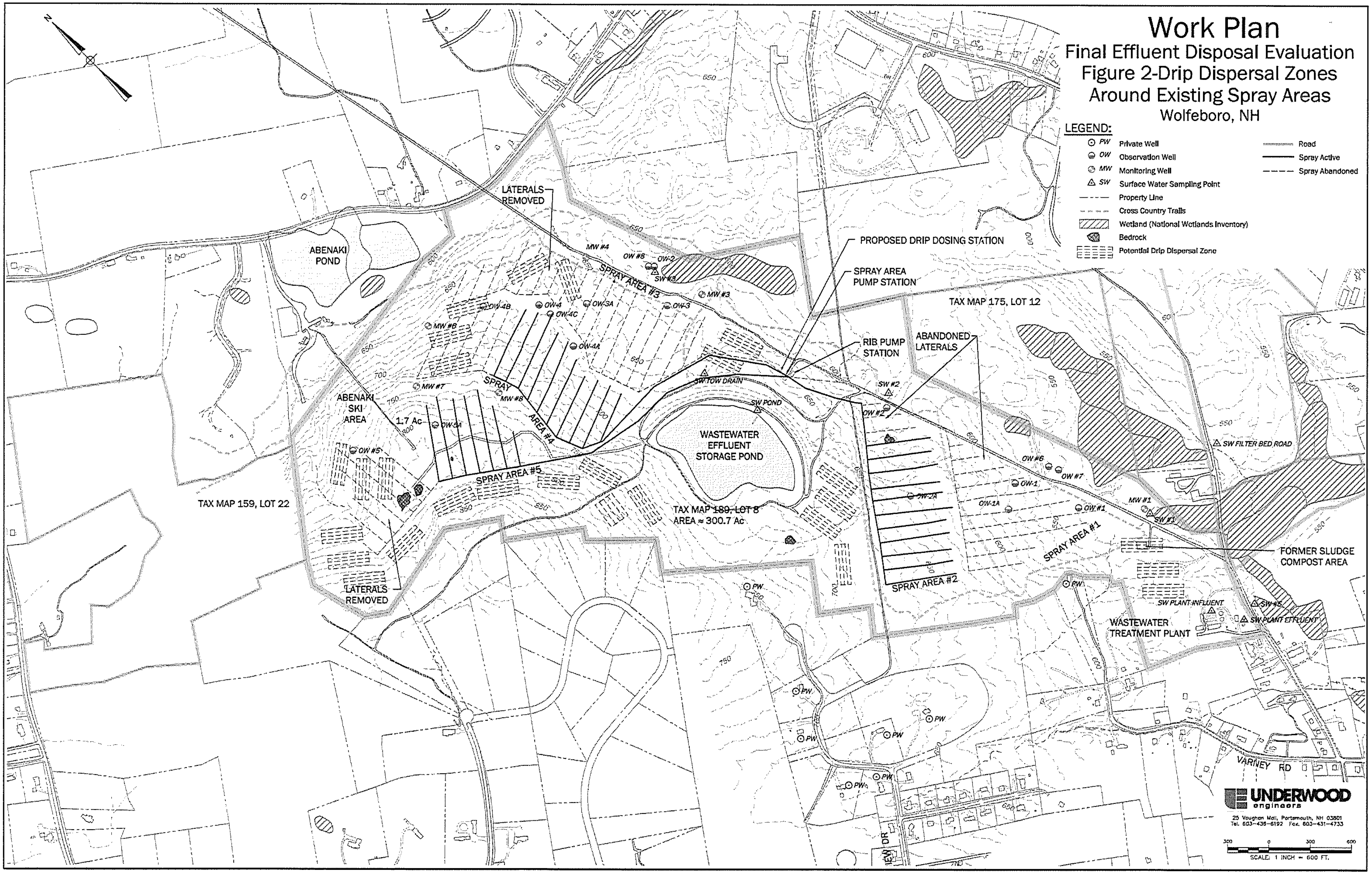
Thomas G. Page, P.E.
Project Manager

DJM/tgp

Enc.
Appendices:
Appendix A - Figures
Appendix B - Conceptual Design Computations
Appendix C - Opinion of Costs

Appendix A.
Figures


Work Plan
Final Effluent Disposal Evaluation
Figure 1-Existing Conditions
Wolfeboro, NH
LEGEND:
PW Private Well
OW Observation Well
MW Monitoring Well
SW Surface Water Sampling Point
TP Test Pit By Others
Property Line
Cross Country Trails
Wetland (National Wetlands Inventory)
Bedrock
Road
Spray Active
Spray Abandoned
ABENAKI POND
ABENAKI SKI AREA
1.7 Ac
LATERALS REMOVED
SPRAY AREA #3
SPRAY AREA #4
SPRAY AREA #5
SPRAY AREA #2
SPRAY AREA #1
SPRAY AREA PUMP STATION
RIB PUMP STATION
ABANDONED LATERALS
WASTEWATER EFFLUENT STORAGE POND
TAX MAP 175, LOT 12
TAX MAP 159, LOT 22
TAX MAP 189, LOT 8
AREA ≈ 300.7 Ac
FORMER SLUDGE COMPOST AREA
WASTEWATER TREATMENT PLANT
SW PLANT INFLUENT
SW PLANT EFFLUENT
SW FILTER BED ROAD
SW POND
SW TOW DRAIN
VARNEY RD
UNDERWOOD engineers
25 Vaughan Mall, Portsmouth, NH 03801
Tel. 603-436-6192 Fax. 603-431-4733
SCALE: 1 INCH = 600 FT.


Work Plan
Final Effluent Disposal Evaluation
Figure 2-Drip Dispersal Zones
Around Existing Spray Areas
Wolfeboro, NH
LEGEND:
PW Private Well
OW Observation Well
MW Monitoring Well
SW Surface Water Sampling Point
Property Line
Cross Country Trails
Wetland (National Wetlands Inventory)
Bedrock
Potential Drip Dispersal Zone
Road
Spray Active
Spray Abandoned
N
PROPOSED DRIP DOSING STATION
SPRAY AREA PUMP STATION
RIB PUMP STATION
ABANDONED LATERALS
TAX MAP 175, LOT 12
LATERALS REMOVED
ABENAKI POND
ABENAKI SKI AREA
1.7 Ac
TAX MAP 159, LOT 22
SPRAY AREA #3
SPRAY AREA #4
SPRAY AREA #5
SPRAY AREA #2
SPRAY AREA #1
WASTEWATER EFFLUENT STORAGE POND
TAX MAP 189, LOT 8
AREA ≈ 300.7 Ac
SW TOW DRAIN
SW POND
SW FILTER BED ROAD
FORMER SLUDGE COMPOST AREA
SW PLANT INFLUENT
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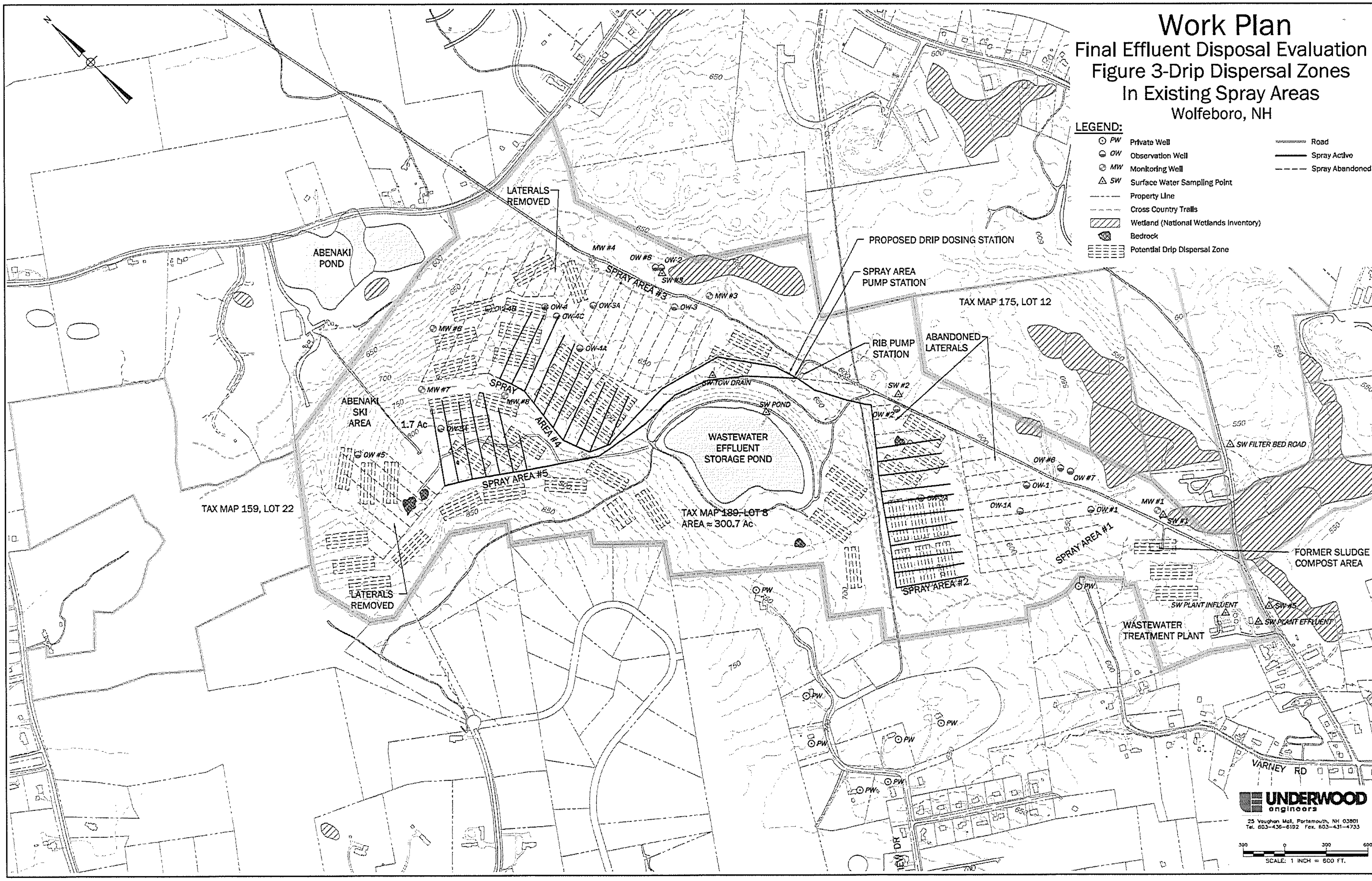
Work Plan
Final Effluent Disposal Evaluation
Figure 3-Drip Dispersal Zones
In Existing Spray Areas
Wolfeboro, NH
LEGEND:
PW Private Well
OW Observation Well
MW Monitoring Well
SW Surface Water Sampling Point
Property Line
Cross Country Trails
Wetland (National Wetlands Inventory)
Bedrock
Potential Drip Dispersal Zone
Road
Spray Active
Spray Abandoned
PROPOSED DRIP DOSING STATION
SPRAY AREA PUMP STATION
RIB PUMP STATION
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LATERALS REMOVED
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VARNEY RD
UNDERWOOD engineers
25 Vaughan Mall, Portsmouth, NH 03801
Tel. 603-436-6192 Fax. 603-431-4733
SCALE: 1 INCH = 600 FT.

Appendix B.
Conceptual Design Computations

Wolfeboro Effluent Disposal Evaluation
Effluent Loading at Existing Spray Areas
28-Nov-12

	NHDES Discharge Permit	Increased Loading at 2.5"/week
Effluent loading, inches/week	2	2.5
Effluent loading, gpd/sf	0.178	0.223
Area, acres	46	46
Area, SF	2,003,760	2,003,760
Loading limit, gpd	356,860	446,075
Annual Loading Limit (Spray Season), gal	65,126,971	81,408,714
Average Precip (2009-2011 Spray Season), in	28	28
Spray Volume Lost to Rain, gal	34,764,123	34,764,123
Effective Loading Limit (Spray Season), gal/week	***1,164,666***	***1,789,206***
Effective Loading Limit (Spray Season), gpd	***166,372***	***255,587***
Effective Disposal Volume (Spray Season), mgy	***30.4***	***46.6***

Notes:

1. Spray allowed May 1 to October 31 each year.
2. Precipitation (non WWTF effluent) that enters the holding pond also contributes to loading
3. Average annual precip based on 2009-2011 WWTF records during spray season
4. Increased loading would require modified permit
5. Current permit states spray site is approximately 46 acres and maximum spray irrigation is 2,498,820 gal per week

Year	Annual Precipitation (in)	Precip During Spray Season (in)	% during spray season
2009	52.23	30.9	59%
2010	44.56	19.41	44%
2011	58.23	33.19	57%
Ave	**51.7**	**27.8**	**54%**

Wolfeboro Effluent Disposal Evaluation
Conceptual Drip Dispersal Design

28-Nov-12

Parameter	Lower Loading Range	Higher Loading Range	Remarks
General Drip Zone Design			
Lateral length, ft	300	300	300' max lateral length
Lateral spacing, ft	4	4	4' average, 2' minimum, to allow routing around trees, interferences
Number of laterals, ft	24	24	Use even number for equal subzones
Zone width, ft	96	96	
Total drip line length, ft	7200	7200	
Zone area, sf	28,800	28,800	
Number of sub zones per zone	2	2	
Subzone width, ft	48	48	50' max lines from top manifold to lateral
Zone loading overall average, gpd/sf	0.15	0.30	Average loading over entire zone area
Zone loading overall average, in/week	1.7	3.4	
Zone loading, gpd per zone	4320	8640	
Drip line area, SF per LF	2.0	2.0	
Drip line loading rate, gpd/sf	0.3	0.6	loading rate over 1 SF each side of drip line
Emitter flowrate, gph	0.61	0.61	based on Perc-Rite emitters
Emitter spacing, ft	2	2	
Number of emitters per zone	3600	3600	
Total emitter flowrate per zone, gpm	36.6	36.6	
Drip Zones near Effluent Storage Pond			
Number of Zones	24	24	Assumed number of feasible zones
Capacity per zone, gpd	4320	8640	
Total capacity, gpd	103,680	207,360	
Total capacity, Mgal/yr	37.8	75.7	
Number of dosing pump stations	2	2	
Total capacity per station, gpd	51,840	103,680	
Number of zones dosed at a time per station	4	4	Flush 2 zones at a time to get high enough flushing rate
Flowrate per zone, gpm	36.6	36.6	
Total dosing pump rate, gpm	146.4	146.4	largest std Perc-rite unit is 250 gpm
Dosing pump run time per day, hours	5.9	11.8	total run time all doses (keep less than 50% of day)
Number of doses per day per zone	6	8	
Number of doses per day total	18	24	
Time per dose, min	19.7	29.5	15 minutes minimum for even distution, but limited to avoid instantaneous overloading.
Drip Zones near WWTF			
Number of Zones	3	3	
Capacity per zone, gpd	4320	8640	
Total capacity, gpd	12960	25920	
Number of zones dosed at a time	1	1	
Flowrate per zone, gpm	36.6	36.6	
Total dosing pump rate, gpm	36.6	36.6	
Dosing pump run time per day, hours	5.9	11.8	
Number of doses per day per zone	6	6	
Number of doses per day total	18	18	
Time per dose, min	19.7	39.3	
Total capacity, Mgal/yr	4.7	9.5	
Total Drip Dispersal capacity, gpd	116,640	233,280	
Total Drip Dispersal capacity, Mgal/year	42.6	85.1	

Notes
Consider higher flow emitters or more dripline per zone if need to reduce pump runtime.
Consider larger custom pumps instead of multiple skid mounted pump systems.

Wolfeboro Effluent Disposal Evaluation
Conceptual Drip Dispersal Design
Drip Zones in Existing Spray Areas
28-Nov-12

Parameter	Lower Loading Range	Higher Loading Range	Remarks
Estimate # of zones if convert to Drip			
Spray Area 2 area, acres	12.8	12.8	assume 9+- drip zones
Spray Area 4 area, acres	14.3	14.3	assume 9+- drip zones
Spray Area 5 area, acres	9.9	9.9	assume 6+- drip zones
Total spray area, acres	37.0	37.0	
Total spray area, SF	1,611,720	1,611,720	
Percent assumed feasible for drip	50%	50%	
Drip zone total area, SF	805,860	805,860	
Area per drip zone, SF	28,800	28,800	assume same size as new drip zones; layout may vary
Number of drip zones possible	28.0	28.0	
Number of drip zones used	**24**	**24**	to limit stacking of zones to about 3 max
Loading rate, gpd/SF	**0.15**	**0.30**	Average loading over entire zone area
Number of Zones	**24**	**24**	Assumed number of feasible zones
Capacity per zone, gpd	4320	8640	
Total capacity, gpd	103,680	207,360	
Total capacity, Mgal/yr	**37.8**	**75.7**	
Number of dosing pump stations	2	2	
Total capacity per station, gpd	51,840	103,680	
Number of zones dosed at a time per station	4	4	Flush 2 zones at a time to get high enough flushing rate
Flowrate per zone, gpm	36.6	36.6	
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Number of doses per day per zone	6	8	
Number of doses per day total	18	24	
Time per dose, min	19.7	29.5	15 minutes minimum for even distution, but limited to avoid instantaneous overloading.

Wolfeboro Effluent Disposal Evaluation
Summary of Effluent Disposal Options -Capacity and Costs **30-Nov-12**

Scenario	Annual Disposal, Lower Range (Mgal/year)	Annual Disposal, Upper Range (Mgal/year)	Engineer's Opinion of Probable Capital Cost	Capital Costs per Mgal, lower loading	Capital Costs per Mgal, upper loading
Scenario 1 - New Spray Disposal System					
Replace Existing Spray	**30.4**	**46.6**	$1,936,000	$63,762	$41,505
Scenario 2 - Existing Spray and New Drip					
Maintain Existing Spray	30.4	46.6	$0		
New Drip Areas	42.6	85.1	$5,130,000	$120,497	$60,249
Subtotal	**72.9**	**131.8**	**$5,130,000**		
Scenario 3 - Replace Spray with Drip and New Drip					
Replace Spray with Drip	37.8	75.7	$3,856,000	$101,894	$50,947
New Drip Areas	42.6	85.1	$5,130,000	$120,497	$60,249
Subtotal	**80.4**	**160.8**	**$8,986,000**	**$111,743**	**$55,871**

Notes
1. Spray disposal loading rate range= 2"/week to 2.5"/week including precipitation, May - October only
2. Drip dispersal loading rate range = 0.15 to 0.30 GPD/SF, year round

Wolfeboro Effluent Disposal Evaluation

WWTF Design Capacity	600,000	gpd	219	Mgal/year
Existing Flow (2011)	390,000	gpd	142.4	Mgal/year

These Tables below show RIB capacity needed to meet existing effluent flow of 140 Mgal/year

Lower Range for Spray and Drip

	RIB Mgal/year	**Spray** Mgal/year	**Drip** Mgal/year	**Total** Mgal/year	**RIB** gpd	**Spray** gpd	**Drip** gpd	**Total** gpd
Scenario 1	124	30.4	0.0	**154.4**	339726	83,186	-	**422,912**
Scenario 2	67.0	30.4	42.6	140.0	183736	83,186	116,640	**383,562**
Scenario 3	59.6	0	80.4	**140.0**	163242	-	220,320	**383,562**

Upper Range for Spray and Drip

	RIB Mgal/year	**Spray** Mgal/year	**Drip** Mgal/year	**Total** Mgal/year	**RIB** gpd	**Spray** gpd	**Drip** gpd	**Total** gpd
Scenario 1	124	46.6	0.0	**170.6**	339726	127,793	-	**467,519**
Scenario 2	8.2	46.6	85.1	**140.0**	22488	127,793	233,280	**383,562**
Scenario 3	0.0	0	160.8	**160.8**	0	-	440,640	**440,640**

Appendix C.
Opinions of Costs

TABLE A.
WOLFEBORO, NH - WASTEWATER EVALUATIONS
NEW SPRAY DISPOSAL SYSTEM OPTION - CURRENTLY ACTIVE SPRAY AREAS ONLY
CONCEPTUAL COST OPINION

10/1/2012

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
General Requirements	1	LS	$ 122,854.50	$122,900
Restoration Allowance	1	LS	$ 20,000.00	$20,000
Gravel Road/path, 15' wide, 6" deep	6,000	LF	$ 10.00	$60,000
Clearing and Grubbing (Along Active Headers 15' wide)	6,000	LF	$ 1.75	$10,500
10" SDR 11 HDPE installed 2' deep	6,700	LF	$ 60.00	$402,000
8" SDR 11 HDPE installed 2' deep	320	LF	$ 55.00	$17,600
6" SDR 11 HDPE installed 2' deep	200	LF	$ 40.00	$8,000
4" SDR 11 HDPE installed 2' deep	0	LF	$ 30.00	$0
3" SDR 21 PVC installed 2' deep	14,600	LF	$ 20.00	$292,000
HDPE Fittings (10"x3")	30	EA	$ 300.00	$9,000
HDPE Fittings (Misc.)	10	EA	$ 300.00	$3,000
Trench Ledge/Boulder Removal, allowance	1,212	CY	$ 100.00	$121,200
Sprinkler head and aluminium riser (Zone 2)	66	EA	$ 200.00	$13,200
Sprinkler head and aluminium riser (Zone 4)	63	EA	$ 200.00	$12,600
Sprinkler head and aluminium riser (Zone 5)	46	EA	$ 200.00	$9,200
Improvements to existing PS, allowance	1	LS	$ 50,000.00	$50,000
Valve allowance	1	LS	$ 20,000.00	$20,000
Electrical Allowance	1	LS	$ 10,000.00	$10,000
Instrumentation Allowance	1	LS	$ 10,000.00	$10,000
SUBTOTAL				***$1,191,000***
Contractor OH&P - 15%				$179,000
Contingency - 15%				$179,000
TOTAL PROBABLE CONSTRUCTION COST				***$1,549,000***
Admin, Engineering and Construction Services - 25%				$387,000
TOTAL PROJECT COSTS YEAR 2012				***$1,936,000***

Notes:

TABLE B.
WOLFEBORO, NH - WASTEWATER EVALUATIONS
NEW DRIP DISPOSAL SYSTEM OPTION - ADJACENT TO EXISTING SPRAY AREAS AT ESP
CONCEPTUAL COST OPINION

10/1/2012

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
General Requirements	1	LS	$ 295,550.00	$295,600
Restoration Allowance	1	LS	$ 20,000.00	$20,000
Gravel Road/path, 15' wide, 6" deep	6,000	LF	$ 10.00	$60,000
Site Work Allowance	1	LS	$ 50,000.00	$50,000
Monitoring wells	10	EA	$ 1,000.00	$10,000
PVC piping - supply/return	60,000	LF	$ 20.00	$1,200,000
Drip Zone cost each (see breakdown)	24	LS	$ 35,000.00	$840,000
Drip filtration unit, 150 gpm	2	LS	$ 20,000.00	$40,000
Pumps, duplex	2	LS	$ 20,000.00	$40,000
Piping and valves allowance	1	LS	$ 20,000.00	$20,000
Mechanical Work (HV) Allowance	1	LS	$ 10,000.00	$10,000
Building, 20' x 30' approx.	600	SF	$ 300.00	$180,000
Electrical Allowance	1	LS	$ 50,000.00	$50,000
Instrumentation and Controls Allowance	1	LS	$ 50,000.00	$50,000
SUBTOTAL				***$2,866,000***
Contractor OH&P - 15%				$430,000
Contingency - 15%				$430,000
TOTAL PROBABLE CONSTRUCTION COST				***$3,726,000***
Admin, Engineering and Construction Services - 25%				$932,000
TOTAL PROJECT COSTS YEAR 2012				***$4,658,000***
Notes:				

TABLE C.
WOLFEBORO, NH - WASTEWATER EVALUATIONS
NEW DRIP DISPOSAL SYSTEM OPTION - ADJACENT TO WWTF
CONCEPTUAL COST OPINION

10/1/2012

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
General Requirements	1	LS	$ 29,854.00	$29,900
Restoration Allowance	1	LS	$ 5,000.00	$5,000
Site Work Allowance	1	LS	$ 5,000.00	$5,000
Monitoring wells	2	EA	$ 1,000.00	$2,000
PVC piping - supply/return	2,000	LF	$ 20.00	$40,000
Drip Zone cost each (see breakdown)	3	LS	$ 35,000.00	$105,000
Drip filtration unit	1	LS	$ 10,000.00	$10,000
Pumps, duplex	1	LS	$ 5,000.00	$5,000
Piping and valves allowance	1	LS	$ 5,000.00	$5,000
Mechanical Work (HV) Allowance	1	LS	$ 5,000.00	$5,000
Building, 12' x 16' approx.	192	SF	$ 300.00	$57,600
Electrical Allowance	1	LS	$ 10,000.00	$10,000
Instrumentation and Controls Allowance	1	LS	$ 10,000.00	$10,000
SUBTOTAL				***$290,000***
Contractor OH&P - 15%				$44,000
Contingency - 15%				$44,000
TOTAL PROBABLE CONSTRUCTION COST				***$378,000***
Admin, Engineering and Construction Services - 25%				$95,000
TOTAL PROJECT COSTS YEAR 2012				***$473,000***
Notes:				

TABLE D.
WOLFEBORO, NH - WASTEWATER EVALUATIONS
NEW DRIP DISPOSAL SYSTEM OPTION - REPLACING EXISTING SPRAY AREAS
CONCEPTUAL COST OPINION

10/1/2012

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
General Requirements	1	LS	$ 244,720.00	$244,700
Restoration Allowance	1	LS	$ 10,000.00	$10,000
Gravel Road/path, 15' wide, 6" deep	6,000	LF	$ 10.00	$60,000
Site Work Allowance	1	LS	$ 50,000.00	$50,000
Demolition Allowance	1	LS	$ 20,000.00	$20,000
Monitoring wells	8	EA	$ 1,000.00	$8,000
PVC piping - supply/return	50,000	LF	$ 20.00	$1,000,000
Drip Zone cost each (see breakdown)	24	LS	$ 35,000.00	$840,000
Drip filtration unit, 150 gpm	2	LS	$ 20,000.00	$40,000
Pumps, duplex	2	LS	$ 20,000.00	$40,000
Piping and valves allowance	1	LS	$ 20,000.00	$20,000
Mechanical Work (HV) Allowance	0	LS	$ 10,000.00	$0
Building, 16' x 24' approx.	0	SF	$ 300.00	$0
Electrical Allowance	1	LS	$ 20,000.00	$20,000
Instrumentation and Controls Allowance	1	LS	$ 20,000.00	$20,000
SUBTOTAL				***$2,373,000***
Contractor OH&P - 15%				$356,000
Contingency - 15%				$356,000
TOTAL PROBABLE CONSTRUCTION COST				***$3,085,000***
Admin, Engineering and Construction Services - 25%				$771,000
TOTAL PROJECT COSTS YEAR 2012				***$3,856,000***

Notes:
Assume station building included in Alt. 2 expanded drip zone costs

TABLE E.
WOLFEBORO, NH - WASTEWATER EVALUATIONS
DRIP DISPERSAL OPTION - ZONE COST
CONCEPTUAL COST OPINION

9/18/2012

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
Clearing	1	AC	$ 5,000.00	$5,000
Drip Emitter Tubing and fittings	7,200	LF	$ 1.00	$7,200
Manifolds and lateral feeds, 3/4" PVC	1,400	LF	$ 1.00	$1,400
Trenching (for drip tube and lateral feeds)	7,500	LF	$ 1.00	$7,500
Drip zone installation allowance	1	LS	$ 5,000.00	$5,000
Mulch, furnish and install	250	CY	$ 25.00	$6,300
Piezometers	2	EA	$ 300.00	$600
Drip zone valves allowance	1	LS	$ 2,000.00	$2,000
SUBTOTAL				***$35,000***
Notes:				

DRAFT

1729-01

December 5, 2012

Mr. David Ford, P.E.
Public Works Director – Town of Wolfeboro
84 South Main Street
PO Box 629
Wolfeboro, NH 03894

Re: ***Evaporation Disposal Pilot Conceptual Feasibility Evaluation***
Wastewater Evaluations
Wolfeboro, New Hampshire

Dear Mr. Ford:

The following letter report summarizes our findings regarding the feasibility of performing a pilot study to install fog diffusers in the vicinity of the WWTF effluent storage pond (ESP) using a tap off the existing force mains located in the vicinity of the ESP. The intent is to encourage WWTF effluent evaporation to reduce the quantity of effluent that must be disposed of in the spray irrigation disposal fields or the rapid infiltration basins (RIBs). We have assumed that effluent pumped through the fog nozzles that is not evaporated would return into the ESP. We looked at the following fog/misting systems:

- *BETE TFXP Fog Nozzle* (Attachment A) since this system operates using hydraulic pressures only to create the mist and does not require an outside power source.

- *New Waste Concepts Proposal, Typhoon Evaporative Misting* (Attachment B) however this system requires additional electric supply for operation which is not consistent with the Town's goal of operating the mist solely from a tap off existing force mains.

WWTF effluent pumping station pump curves used in this evaluation were acquired from the pump manufacturer.

Evaporation Estimates from Fog Nozzles

A literature review of scientific papers revealed that there is disagreement about how to calculate and measure evaporation rate during spray procedures. We used a procedure described in a paper entitled *Sprinkler Evaporation Losses* from Agricultural Engineer by K.R. Frost and H.C. Schwalen, 1955, to estimate percent evaporation loss using the factors of relative humidity, air temperature, nozzle diameter, wind velocity, and nozzle pressure. We used this procedure because it was referenced by most of the other papers included in our literature review and the procedure utilized meteorological factors that could be adjusted for NH climates. Using meteoritic averages for Wolfeboro and/or Concord, NH found in various sources, we found that evaporation rates during the 6 month spray season in Wolfeboro range from approximately 3% to 5% of the pumped fog volume (Attachment E).

Conversations with BETE engineers confirmed that 3% to 5% evaporation rates are reasonable to assume for climates similar to Wolfeboro using BETE fog nozzles. Twelve percent (12%) to 15% evaporation rates are typical for climates similar to Phoenix, AZ.

Assuming a BETE TF 32 XP fog head with the largest opening to minimize clogging which creates the largest droplet size, (approximately 480 micron Sauter Mean Diameter), and a flow rate of 42 gpm @ 40psi, and 24 hours a day operation; average evaporation estimates range from 1,800 to 3,000 gallons per day per fog nozzle during the right weather. This means that approximately 4 to 6 fog heads would be needed to evaporate an average of 10,000 gallons per day if operated 24 hours a day, or 16 to 24 heads to evaporate an average of 10,000 gallons per day if operated for 6 hours per day (equates to 1.8 MG evaporation per year based on 6 month operation).

Conversely, New Waste Concepts are claiming 60% to 80% evaporation rates from their Typhoon rotary head. However, New Waste Concepts has not provided documentation supporting these high evaporative rate claims other than marketing videos.

Each Typhoon rotary head requires a flow rate of 8 gpm and requires 2 HP to operate it. If one can really achieve a 60% evaporation rate from these heads, 2 units operating 24 hours a day would be required to achieve 10,000 gpd of evaporation. Unfortunately, there is no good way to measure/confirm the actual evaporation rate achieved short of collecting and measuring all flow that makes it to the ground which is unrealistic.

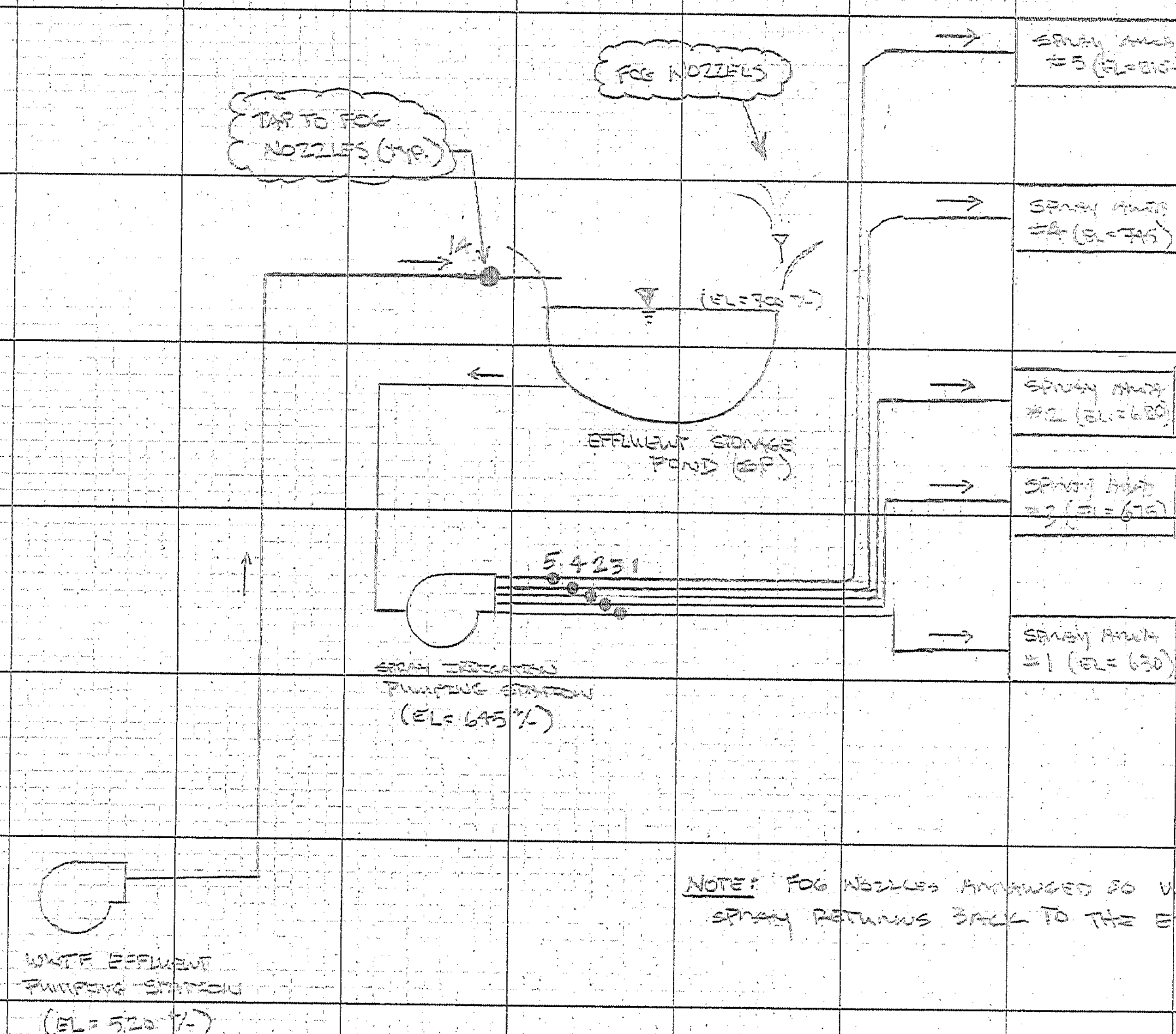
Operating Pressure at Fog Nozzle Considerations - Hydraulics

For the purposes of this evaluation we evaluated fog nozzle taps off the existing forcemains located in the vicinity of the ESP (Sketch #1) including:

- WWTF effluent forcemain prior to discharge to ESP (1A)
- Spray Area #2 Header while dosing spray area (2)
- Spray Area #4 Header while dosing spray area (4)
- Spray Area #5 Header while dosing spray area (5)

Note, no survey was performed as part of this evaluation. Elevations cited in this letter were based on information provided in *Spray Irrigation Facility "As Built", Hoyle Tanner & Associates, Inc., October 1975* (Attachment C). Conceptual forcemain pressures are based on

SKETCH #1: FOG NOZZLE TAP SCHEMATIC



NOTE: FOG NOZZLES ARRANGED SO UN-EVAPORATED SPRAY RETURNS BACK TO THE ESP.

elevation, neglecting friction losses, and the Town must compare the conceptual forcemain pressures to actual working pressures observed in the system prior to implementation (Table 1).

Table 1 – Conceptual Fog Nozzle Hydraulics

Location		Assumed High Point Elevation (ft)	Residual Pressure at High Point (psi)	Residual Pressure at Fog Nozzles (ft)	Available Pressure at Fog Nozzles (psi)
	ESP (Fog Nozzles)	700			
1A	WWTF F.M.	700	0	0	0
1	Spray Area #1 Header	630	35	11	5
2	Spray Area #2 Header	680	35	61	26
3	Spray Area #3 Header	675	35	56	24
4	Spray Area #4 Header	745	35	126	54
5	Spray Area #5 Header	810	35	191	83

- BETE TF 32 XP Fog Nozzles require operating pressures of 40-60 psi (92 to 139 ft of water)

- <u>WWTF Force Main Tap:</u> The existing WWTF pumping station force main discharge to the ESP discharges at atmospheric pressure at approximate el. = 700' (see photo). This means that there is not sufficient residual pressure to operate hydraulic misting heads at the pond. Fog nozzles would have to be installed at elevations below the pond around approximately el. = 560' to 600' to have sufficient residual forcemain pressure for misting. These elevations occur around Sta. 15+00 to 20+50 on the existing service road between the WWTF and the holding pond. Alternatively, we considered throttling the ESP discharge to induce additional pressure upstream of the throttling valve. Unfortunately, the performance curve of the existing WWTF effluent pumps do not provide sufficient pressure (>40 psi) necessary to operate fog nozzles located at the ESP (Attachment D).

- Spray Area #2 Supply Header is below el. = 700', so would likely not provide sufficient residual pressure to operate fog nozzles around the ESP unless existing zone sprinkler disposal heads are operating at significantly higher pressure than the assumed 35 psi.

- Spray Area #4 Supply Header reaches elevations of approximately el. = 745' and might produce sufficient residual pressure to operate fog nozzles installed around the ESP.

- Spray Area #5 Supply Header reaches elevations of approximately el. = 810' and might produce sufficient residual pressure to operate fog nozzles installed around the ESP.

Although it appears that there is sufficient residual pressure for Spray Areas #4 and #5 to operate fog nozzles around the ESP at the same time spray irrigation is occurring, it is not believed that the existing spray irrigation pumps can provide sufficient flow to simultaneously operate the spray irrigation fields (300-500 gpm) and sufficient flow to the fog nozzles around the ESP to achieve any significant evaporation from the fog nozzles. However, this would need to be confirmed with hydraulic modeling outside the scope of this evaluation.

Alternatively, it is likely that the existing spray irrigation pumps could independently operate an array of 12 fog nozzles (approximately 500 gpm total) if not simultaneously operated with the spray irrigation fields. If 12 fog nozzles are operated for 12 hours during the day when most advantageous for evaporation, an estimated 11,000 to 18,000 gpd evaporation could occur under good conditions. However, this fog evaporation approach would require that the regular spray irrigation disposal occur during the night, which we understand is not preferred by the operators and would reduce the evaporation that currently occurs during existing spray irrigation. Also, it is estimated that only 2 to 3 million gallons of effluent would be disposed of annually through fog nozzle evaporation.

Cost
UE performed an electrical consumption cost comparison between the existing spray irrigation disposal system and the conceptual fog disposal system. We calculated the horsepower requirements, converted to kilowatts, for 2012 disposal of 27.6 million gallons (152,000 gpd) apportioned to each of the spray fields accounting for the elevation differences and annual volume differences discharged to each field (Appendix E). This was compared to the horsepower requirements of fog disposal of 2 to 3 million gallons around the ESP. For this relative evaluation we assumed a uniform 60% pumping efficiency and uniform $0.14 per kW-hr for both scenarios and found the electrical cost for fog disposal would be around $3,000/MG while spray irrigation disposal is around $135/MG. We recognize that these are gross estimations for comparison purposes only with assumptions that should be confirmed by the Town. Regardless, the electrical costs for fog disposal appear to be over 20 times more expensive than the existing spray irrigation disposal system. This differential in energy costs is consistent with the low reported 3%-5% evaporation rates in northeast climates requiring effluent

recirculation pumping under the fog scenarios versus 'pumping it once' for disposal under the existing spray irrigation disposal system.

Conclusions

- The climate of Wolfeboro, NH is not conducive to disposing of significant volumes of wastewater through evaporation.

- Of the 2 systems evaluated, only the BETE fog nozzle system does not require an outside electrical source and can be operated solely off hydraulic pressure, if available.

- Spray Areas #4 and #5 appear to generate sufficient residual pressure to operate BETE fog nozzles at the ESP, but the existing spray irrigation pumps do not appear to provide sufficient flow to simultaneously operate fog nozzles and spray irrigation.

- Three percent (3%) to 5% evaporation rates appear reasonable to assume based on Wolfeboro meteorological conditions and hydraulically driven fog nozzles. <u>At 3% to 5% assumed evaporation rates, the Town would need to pump a total of approximately 0.2 to 0.33 mgd @40 psi through the fog nozzles to achieve an estimated 10,000 gpd evaporation volume.</u>

- Additional hydraulic analysis and modeling is needed to evaluate the flow and pressure that might be available to operate a fog nozzle "tap" using the existing pumps without adversely affecting the performance of the spray disposal fields.

- The BETE system has no moving parts, electrical requirements or screens so appears to be a lower maintenance alternative than the Typhoon rotary head.

- The Town appears to need an array of 12 BETE TF 32 XP fog heads, operating 12 hours a day, to evaporate an average of 2 to 3 million gallons of effluent annually during the 6-month spray season.

- Electrical consumption costs for fog disposal appears to be 20 times greater than the existing spray irrigation system primarily due to recirculation of effluent and low reported evaporation rates.

- While the Typhoon rotary head claims to produce a smaller droplet size than the BETE nozzle system, additional information is required, but has not been forthcoming from the manufacturer to support the 60% to 80% evaporation rates claimed by the Typhoon rotary head under Wolfeboro's climatological conditions.

- It is unclear whether permitting authorities would give the Town credit for "evaporation disposal" under any Town WWTF permit.

Recommendation
Underwood does not recommend pursuing evaporation disposal at this time. The climate of Wolfeboro, NH is not conducive to evaporation as a community in the southwestern United States might be. Based on our preliminary evaluation and reported 3% to 5% evaporation rates, it appears that the Town would need to pump hundreds of thousands of gallons of effluent each day through fog nozzles at 40 psi to achieve 10,000 gallons of evaporation per day. The capital cost and energy costs are too high for the benefit. In addition, the estimated potential 1 to 3 million gallons of annual effluent evaporation represents only 1% to 2% of annual disposal needs for the Town and would therefore have limited benefit for overall effluent disposal management.

If the New Waste Concepts Typhoon rotary head can truly achieve 60% to 80% average daily evaporation rates in Wolfeboro's climate, it might be an option worth pursuing or investigating further. However, the manufacturer could not or was unwilling to provide any scientific documentation to support this claim and we could not find any scientific literature that cited evaporation rates anywhere near the 60% to 80% evaporation rates even in arid climates. In addition, we are concerned about potential long term maintenance issues ("slime growth") that might be associated with pumping WWTF effluent/ESP water through the Typhoon rotary head screen. New Waste Concepts has provided a proposal (Attachment B) for approximately $12,500 for a 2-month trial or $14,400 for purchase of 1 unit. Note that the $14,400 purchase option only includes 2-months rental of the VFD, centrifugal pump and generator after which time rental of those items would be $600/month.

Please call if you have any questions.

Very truly yours,

UNDERWOOD ENGINEERS, INC.

David J. Mercier, P.E.
Project Manager

Cole S. Melendy, P.E.
Project Engineer

CSM/csm

Enc.

Attachment A

BETE Fog Nozzle Information

BETE®

BETE Fog Nozzle Inc.
Applications Engineering Department

BETE ISO 9001:2008 QUALITY SYSTEMS

Phone: 413-772-0846
Fax: 413-772-6729
Web: www.bete.com

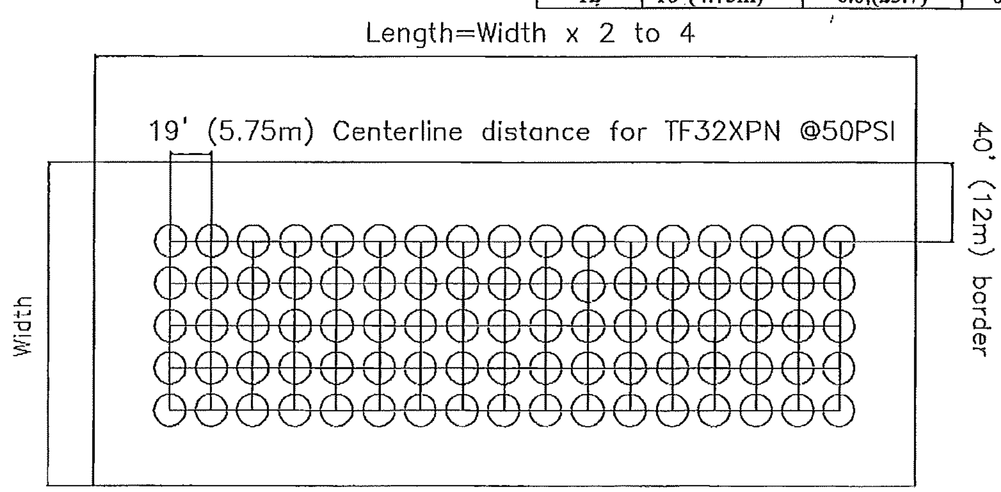
EVAPORATIVE DISPOSAL SPRAY POND DESIGN

- **RECOMMENDED NOZZLE:**
¾ TF 32 XPN in 316 SS or Brass.
- The **TF32XPN** provides 42 gpm (159 L/m) at 40 PSI (2.7 bar) and a ½" (12.7mm) free passage equal to orifice diameter. Smaller TF- XPN nozzles can be used to produce a smaller droplet size for more evaporation. With a tradeoff of a smaller free passage and lower flow rate requiring more nozzles.
- Pressures should be between 40 and 60 PSI (3-4 bar). Higher pressures will produce smaller droplet sizes and improve evaporation.
- The nozzle should be orientated to spray vertically upward. The 90-degree spray pattern achieves maximum residence time to increase evaporation
- The nozzles should be installed 4' (1.25m) above the pond to increase residence time. Drift and wind speed should be taken into consideration
- The typical border width is 40' (12m). The minimum border to surround the pond should be 25' (7.5m). The border is to account for drift.
- Pond layout should be rectangular. The length of the pond should equal to 2 to 4 widths. The long side should face prevailing wind.
- Spacing between nozzle centerlines should be 19' (5.75m) for the TF32XPN.

The BETE Difference

- The **BETE TF-XP** high-efficiency spiral nozzle design brings significant improvements to evaporative disposal applications over the performance possible with traditional whirl nozzles
- The **BETE TF-XP** series spiral nozzle produces sprays composed of droplets thirty to fifty percent smaller than conventional whirl nozzle designs at equivalent pressures. This finely atomized spray creates a large amount of droplet surface area to maximize evaporation. The nozzles are a compact, rugged, one-piece design having no internal plates or disks.
- In many spray pond applications the liquid being sprayed contains large solid particles that may plug the nozzle. The **BETE TF-XP** is a low-maintenance nozzle resistant to clogging, due to the absence of internals and a free-passage diameter equal to the orifice diameter.

Nozzle Rating	Center line distance between nozzles	Flow rate per nozzle **40 PSI (3 bar)**	Maximum nozzle free passage
		gpm (L/m)	in. (mm)
32	**19' (5.75m)**	**42.0 (166)**	**0.50 (12.7)**
28	19' (5.75m)	33.0 (130)	0.44 (11.1)
24	19' (5.75m)	24.1 (95.1)	0.38 (9.53)
20	19' (5.75m)	16.5 (65.1)	0.31 (7.94)
16	19' (5.75m)	10.6 (41.8)	0.25 (6.35)
14	16' (4.75m)	8.1 (32.0)	0.22 (5.56)
12	16' (4.75m)	6.0,(23.7)	0.19 (4.76)



Recommended Layout

SPIRAL

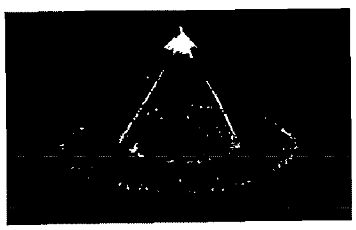
TFXP

Largest Free Passage

DESIGN FEATURES
- Largest free passage in the original spiral nozzle invented by BETE and continuously improved!
- Passes particles equal to orifice size
- Clog-resistant
- One-piece, extra heavy construction
- High energy efficiency
- Male connection

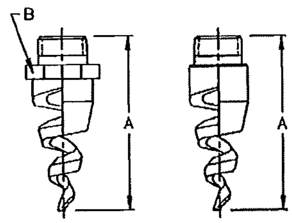
SPRAY CHARACTERISTICS
- Wide range of flow rates
- Fine atomization

Spray pattern: Full Cone
(Hollow Cone available by special order)
Spray angles: 90° and 120°
Flow rates: 3.0 to 3320 gpm



Full Cone 90° (XPN)

Full Cone 120° (XP)



Metal Plastic

Dimensions are approximate. Check with BETE for critical dimension applications.

TFXP Flow Rates and Dimensions
Full Cone, 90° (XPN) and 120° (XP) Spray Angles, 3/8" to 4" Pipe Sizes

Male Pipe Size	Nozzle Number	K Factor	GALLONS PER MINUTE @ PSI 10 PSI	20 PSI	30 PSI	40 PSI	50 PSI	60 PSI	Operation above 60 PSI not recom. for PTFE 80 PSI	100 PSI	High PSI Operation recom. for Metal Only 200 PSI	400 PSI	Approx. Free Pass. & Orifice Dia. (in.)	Approximate Dimensions (in.) for Metal Only A	B	Wt. (lbs.) Metal	Plas.
3/8	TF12	0.949	3.00	4.24	5.20	6.00	6.71	7.35	8.49	9.49	13.4	19.0	0.19	2.88	0.88	0.20	0.04
	TF14	1.28	4.05	5.73	7.01	8.10	9.06	9.92	11.5	12.8	18.1	25.6	0.22	2.88	0.88		
	TF16	1.68	5.30	7.50	9.2	10.6	11.9	13.0	15.0	16.8	23.7	33.5	0.25	2.75	0.88		
	TF20	2.61	8.25	11.7	14.3	16.5	18.4	20.2	23.3	26.1	36.9	52.2	0.31	3.12	0.88		
1/2	TF24	3.81	12.1	17.0	20.9	24.1	26.9	29.5	34.1	38.1	53.9	76.2	0.38	3.47	1.13	0.41	0.06
	TF28	5.22	16.5	23.3	28.6	33.0	36.9	40.4	46.7	52.2	73.8	104	0.44	3.50	1.13		
3/4	TF32	6.64	21.0	29.7	36.4	42.0	47.0	51.4	59.4	66.4	93.9	133	0.50	5.38	1.75	1.56	0.22
1	TF40	10.6	33.5	47.4	58.0	67.0	74.9	82.1	94.8	106	150	212	0.63	5.25	2.00	1.56	0.25
	TF48	15.0	47.5	67.2	82.3	95.0	106	116	134	150	212	300	0.75	6.63	2.00	2.06	0.47
1 1/2	TF56	20.4	64.5	91.2	112	129	144	158	182	204	288	408	0.88	6.97	2.50	4.00	0.59
	TF64	28.7	84.5	120	146	169	189	207	239	287	378	530	1.00	6.94	2.50	2.44	0.53
	TF72	30.4	96.0	136	166	192	215	235	272	304	429	607	1.13	7.41	2.50	2.81	0.53
2	TF88	44.3	140	198	242	280	313	343	398	443	628	885	1.38	10.5	2.63	5.12	1.25
	TF96	55.9	177	250	306	354	395	433	500	559	791	1120	1.50	11.0	2.63	6.31	1.25
3	TF112	81.0	256	362	443	512	572	627	724	810	1150	1620	1.75**	12.0	3.50	8.37	1.37
	TF128	107	339	480	586	679	759	829	960	1070	1510	2140	2.00**	11.7	3.50	9.75	1.50
4	TF160	166	525	742	909	1050	1170	1290	1480	1660	2350	3320	2.50**	12.0	4.50	15.6	1.87

Flow Rate (GPM) $= K\sqrt{PSI}$ **Free passage is 1.5"

Standard Materials: Brass, 316 Stainless Steel, PVC, Polypropylene and PTFE.

TO ORDER: specify pipe size, connection type, nozzle number, spray angle, and material.

Spray angle performance varies with pressure. Contact BETE for specific data on critical applications.

Attachment B

New Waste Concepts – Typhoon System Information

NWC
New Waste Concepts

NEW WASTE CONCEPTS PROPOSAL

Milton F. Knight
26624 Glenwood Rd
Perrysburg, Ohio 43551
419-872-2190 419-872-2602 Fax 1-800-359-2783

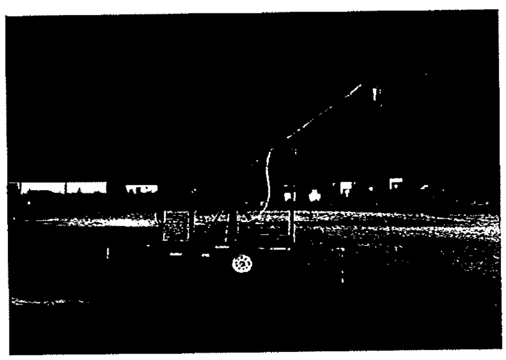
December 5, 2012

To: Wolfeboro WWT, Wolfeboro, NH
Underwood Engineers, Concorde, NH

Re: Proposal for Typhoon Evaporation System
With Praying Mantis Platform (mobile and fixed)

Gentlemen,

New Waste Concepts would like to thank you for the opportunity to submit a proposal for the trial installation of the 'Typhoon Evaporation System' using the Praying Mantis Mobile Platform. This proposal will offer you the opportunity to either purchase the trial unit at the end of two months, or continue to lease the unit for 3 more additional months, at the end of which after payment of all rent, delivery costs, etc. the unit ownership will be transferred by bill of sale to the Wolfeboro WWT. This proposal will also provide pricing on expanding the number of Typhoon Evaporation Units using either the fixed or mobile Praying Mantis platform.



Typhoon Evaporation System - Mobile Praying Mantis Platform:
The Mobile Praying Mantis platform includes all that is shown in the photo to the right with the exception that the gray electric NEMA 4 box, and the variable frequency drive which is inside the box in the photo is not included in the base pricing. If this unit were to be installed at a site permanently, the mobile 'Praying Mantis' platform would be tied to a source of supply for the leachate or other liquid, and a source of power, with a proper circuit breaker (voltage of the motor will determine amperage draw) to allow for the turning on and off of the Typhoon misting motor and a centrifugal pump or a submersible trash pump whose purpose would be to supply the liquid to the Typhoon misting motor.

NWC
New Waste Concepts

NEW WASTE CONCEPTS PROPOSAL

For the trial, we would suggest the following:

Trial Option 1: Enter into a 5 month lease with NWC:

a. Monthly Rental (*1):	$2,000.00
b. Monthly rental on VFD, centrifugal pump & generator:	$ 600.00
b. Security Deposit:	$1,000.00
c. Transportation (mobilization - 850 miles):	$3,500.00
d. Training on operation:	$ 300.00

Payment: prior to delivery

First two months of rent:	$4,000.00
First two months of rent (VFD,CP, & Gen)	$1,200.00
Security Deposit:	$1,000.00
Transportation:	$3,500.00
Training:	$ 300.00
Total:	$10,000.00

Monthly payment in months 3 through 5:

monthly of rental:	$2,000.00
monthly rent for (VFD,CP, & Gen)	$ 600.00

At the end of two months, Wolfeboro WWT would have the option under the lease to terminate, and return the Typhoon misting unit mounted on the mobile Praying Mantis platform, along with the VFD, Generator and Pump to New Waste Concepts. Wolfeboro WWT will pay $3,500 for the cost of returning the Typhoon Misting Unit.

If Wolfeboro WWT decides to continue the lease for the additional 3 months, which will allow Wolfeboro WWT to own the Typhoon evaporation and aeration unit at the end of the 5th month of the lease, Wolfeboro will return the VFD, CP and Generator to New Waste Concepts, and will provide their own power source (220V, three phase) as well as the appropriate circuit breakers and NEMA four box for the Typhoon Misting Unit. Wolfeboro WWT shall have the option of purchasing the 110V, single phase, electrically powered centrifugal pump from NWC for $450 which is a 35% discount off NWC cost, which takes into account some rent has been received on this unit.

26624 Glenwood Rd. Perrysburg, OH 43551
www.nwci.com

NWC
New Waste Concepts

NEW WASTE CONCEPTS PROPOSAL

Trial Option 2: Purchase the Typhoon Misting Unit from NWC:

a. Purchase of Typhoon Misting unit on mobile platform:	$8,900.00
b. Monthly rental on VFD, centrifugal pump & generator:	$ 600.00
b. Security Deposit of VFD, CP and Gen):	$ 500.00
c. Transportation (mobilization - 850 miles):	$3,500.00
d. Training on operation:	$ 300.00

Payment: prior to delivery

Payment of Purchase Price:	$8,900.00
First two months of rent (VFD,CP, & Gen)	$1,200.00
Security Deposit:	$ 500.00
Transportation:	$3,500.00
Training:	$ 300.00
Total:	$14,400.00

Monthly payment for 5 months:

monthly rent for (VFD,CP, & Gen)	$ 600.00

At the end of two months, Wolfeboro WWT would have the option under the lease of the VFD, Centrifugal Pump and Generator to terminate the lease and use of these units, and bring the appropriate power (220-240V, three phase power) to the area where the mobile misting platform is located. Wolfeboro WWT will pay the cost of returning the generator, VFD, and centrifugal pump to NWC should they not purchase additional Typhoon misting units from NWC. To the extent that additional Typhoon misting units are purchased, NWC shall arrange to bring the generator, centrifugal pump, and VFD back to Perrysburg on a return trip following delivery of a Typhoon Misting Unit (s).

Interchangeability between Fixed Position and Mobile Praying Mantis Platform: All of the above numbers and costs are applicable across the board with the fixed position Praying Mantis Platform shown in the photo to the right as well as on the vimeo.com/nwci video.

SWANA

We've Got You Covered

DHL Think Global 2011 Exporter of the Year

WASTEC MEMBER

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NWC
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NEW WASTE CONCEPTS PROPOSAL

The only major difference between the mobile and the fix position Praying Mantis platforms is that the transportation cost per platform is likely to be less for the fixed position platform because I can get more platforms on a delivery trailer than I can on the trailer mounted units. Thus, the per unit delivery cost for a multiple unit order of the mobile platform is likely to be $1,200 per unit, while the per unit delivery cost for the fixed position platform will be about $600.00 per unit.

What is delivered?

Typhoon Evaporation and Aeration System - Mobile Platform:

1 - 2hp all stainless Steel electric motor, 220-240V, three phase, 60hz motor with special monel steel shaft
1- initial stage droplet creator - hi-flow hub
1 - second stage mist creator - no clog SS coarse mesh 12 inch basket
1 - hi-flow quad feed - 3/8" tube
1 - 4 way steel splitter for quad feed
1 - flow manifold providing feed of four tubes to 4 way steel splitter
1 - normally open electric solenoid switch and valve that allows drainage of system when power is shut down.
1 - single axle trailer with 4 wide support arms to provide stability on uneven ground and crank up or down supports
1 - extendable tube Typhoon Mounting pole and bracket which is balanced using weight and Gorilla lift mechanism.

Typhoon Evaporation and Aeration System - Fixed Position Platform:

1 - 2hp all stainless Steel electric motor, 220-240V, three phase, 60hz motor with special monel steel shaft
1- initial stage droplet creator - hi-flow hub
1 - second stage mist creator - no clog SS coarse mesh 12 inch basket
1 - hi-flow quad feed - 3/8" tube
1 - 4 way steel splitter for quad feed
1 - flow manifold providing feed of four tubes to 4 way steel splitter
1 - normally open electric solenoid switch and valve that allows drainage of system when power is shut down.
1 - single axle trailer with 4 wide support arms to provide stability on uneven ground and crank up or down supports
1 - extendable tube Typhoon Mounting pole and bracket which is balanced using weight and Gorilla lift mechanism

NWC
New Waste Concepts

NEW WASTE CONCEPTS PROPOSAL

Includes a 3 inch x 12 ft schedule 40 pipe for pressing into the ground, 4 inch x 4 ft schedule 40 pipe which fits over 3 inch pipe. Adjustable mount to keep Electric motor vertical and basket horizontal. 15 ft adjustable mast to keep misting head high in air. Cap to go over 3 inch pipe with attachment for bolting on the misting fan support mast and bracket allowing support mast to be located along a range of elevations. Cap to have electrical box for connecting power to fan unit attached to cap. CAP to have prepositioned bolt on piping which holds the T bracket for supplying leachate to misting head, and which holds banana filter, and SS needle valve.

Training will occur upon delivery of the unit and last for a period of two days.

Respectfully,

Tony

Milton "Tony" Knight
CEO

We, Wolfeboro WWT of Wolfboro, NH, on this, the ____ day of December, 201_, hereby wish to enter into an agreement of purchase ___ (check one) or an agreement to lease for a period of five months ___(check one) a TYPHOON EVAPORATION AND AERATION SYSTEM mounted on a mobile Praying Mantis platform.

Name: ______________________ Signature: ___________________ date: ______ 2013

NWC
New Waste Concepts

NEW WASTE CONCEPTS PROPOSAL

Milton F. Knight
26624 Glenwood Rd
Perrysburg, Ohio 43551
419-872-2190 419-872-2602 Fax 1-800-359-2783

Typhoon Evaporative Misting and Lily Pad Flotation System

New Waste Concepts (hereinafter NWC) has designed a flotation platform called the **Lily Pad** for 4 of its 230V three phase, **TYPHOON LINK** rotary misting and evaporation heads with dual tube feed, high feed evaporation hub, and 12 inch misting basket with course 12 mesh screen. NWC has also designed and fabricated a support pole network on which the **Typhoon Link** can be mounted and which is attached to the **Lily Pad** flotation platform

New Waste Concepts will provide the following:

- An 8ft by 8ft raft using empty plastic 55 gallon drums which are water tight, and which are to be attached to the underside of the raft. Mounting platforms or plates to which NWC's support pole mounting plates can be securely attached using bolts of sufficient size. Four drums shall be placed at each of the corners of the unit by NWC. In addition, NWC shall provide four points on the side of the raft where three poly ropes can be secured of sufficient length that will make sure that the raft stays in one place in the pond in which it is going to be placed. One such point must secure that the raft does not stretch out the power supply cords to the raft, causing them to disconnect from the raft.
- NWC shall also provide for a 250 ft long 6/4 electric cable of such casing as shall not to become destroyed in the pond water over which it floats. The cable shall be incased in foam insulation of sufficient size and design to assure that the cable does not sink. The 6/4 cable from the misting heads shall be attached to a 30 amp circuit with its own circuit breaker. The 6/4 cable shall feed a junction box where the four Typhoon electrical cords shall be led and then connected to the shore power.
- NWC shall also provide for 250 ft of 6/3 wire for the trash pump which pumps the water, as well as 250 ft of 12/3 wire for the heat tape. Each of these wires shall have a separate circuit and circuit breaker with the 6/3 wire having a 15 amp service & breaker and a junction box on the raft so that both the pump and the normally open valve for the manifold drain when powered off can drain the entire system. The 12/3 wire shall have a 10 amp service and breaker that will allow the heat tape to be turned on and off.
- Four support poles and mounting plates which will allow the support poles to rotate 180 degrees for ease of maintenance and removal of misting baskets and evaporative hubs.
- four Typhoon Link, 2 hp, Stainless Steel, 230 V, three phase motors with baskets, hubs, will be wired into the main power supply junction box.
- NWC will provide a four valve manifold assembly with a drain valve using a normally open control valve which is to be wired to power for the trash pump. This will allow the system

to completely drain down when the power is shut off to the trash pump. Above each valve will be a splitter to feed the dual tubes going to the misting head.

- 100 ft of 3/8 in tubing for use between the misting heads and the four valve manifold will be attached by NWC
- NWC will provide a 90 gallon per minute trash pump and 1 ½ inch feed line to the 4 valve manifold.
- The Lily Pad and the four Typhoon Links when it arrives will require minor construction to attach the 4 Typhoon Links, electrical power on the raft and preparing the raft for lifting into the pond
- NWCI shall provide its own employee to handle all final adjustments at the site.

Purchaser will provide and construct the following:

- Purchaser shall provide an excavator and an operator to lift and place the Lily Pad and its four Typhoon Links in the pond
- Puruchaser shall provide a 200 AMP service of three phase 230 V, with at least 55 amps available and three circuit breakers.
- Purchaser shall provide an electrician to handle final hook up and testing.

Pricing on the **Lily Pad** and 4 **Typhoon Links** from NWC is:

Four 230V three phase **Typhoon Links** & brackets	$15,407.00
Electric cords, insulation, motor, labor, etc	$14,354.00
Raft construction (labor and materials)	$ 5,715.00
Total Cost:	$35,476.00
Freight (estimated)	$ 3,500.00
Total Cost:	$38,976.00

Respectfully,

Tony

Milton "Tony" Knight
CEO

Accepted by:

name: ______________ Date: ___________ 2012

	no of units	gallons Mist per min	gallons Mist per hr	gallons Mist per 24 hr day		Efficiency percentage	True Gallons per day

Evaporation Efficiency at 80%

2.5 hp Monsoon Evaporator	1	6	360	8640		80%	6912
2.5 hp Monsoon Evaporator	4	24	1440	34560		80%	27648
2.5 hp Monsoon Evaporator	8	48	2880	69120		80%	55296

Evaporation Efficiency at 60%

2.5 hp Monsoon Evaporator	1	6	360	8640		60%	5184
2.5 hp Monsoon Evaporator	4	24	1440	34560		60%	20736
2.5 hp Monsoon Evaporator	8	48	2880	69120		60%	41472

Attachment C

Spray Field Record Drawing Information

TOWN OF WOLFEBORO
NEW HAMPSHIRE

SPRAY IRRIGATION FACILITY

PROJECT NO. C-330098-02

BOARD OF SELECTMEN
DR. LAWRENCE S. TOMS, CHAIRMAN
RAYMOND F. POLLINI
PAUL A. CROTEAU

TOWN MANAGER
GUY L. KRAPP

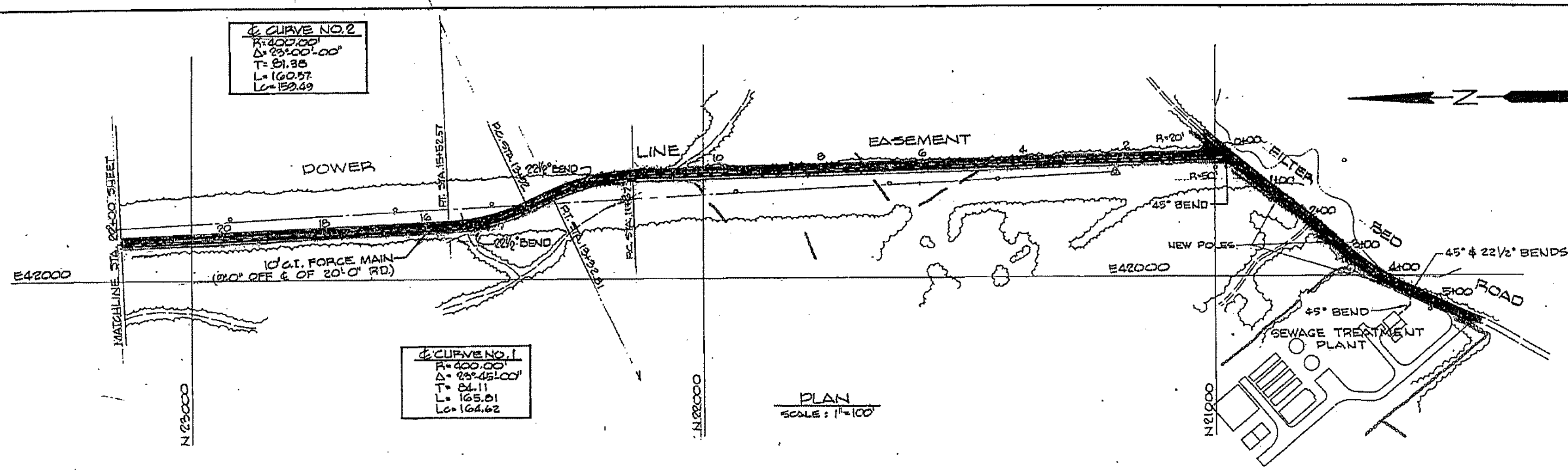
OCTOBER 1975

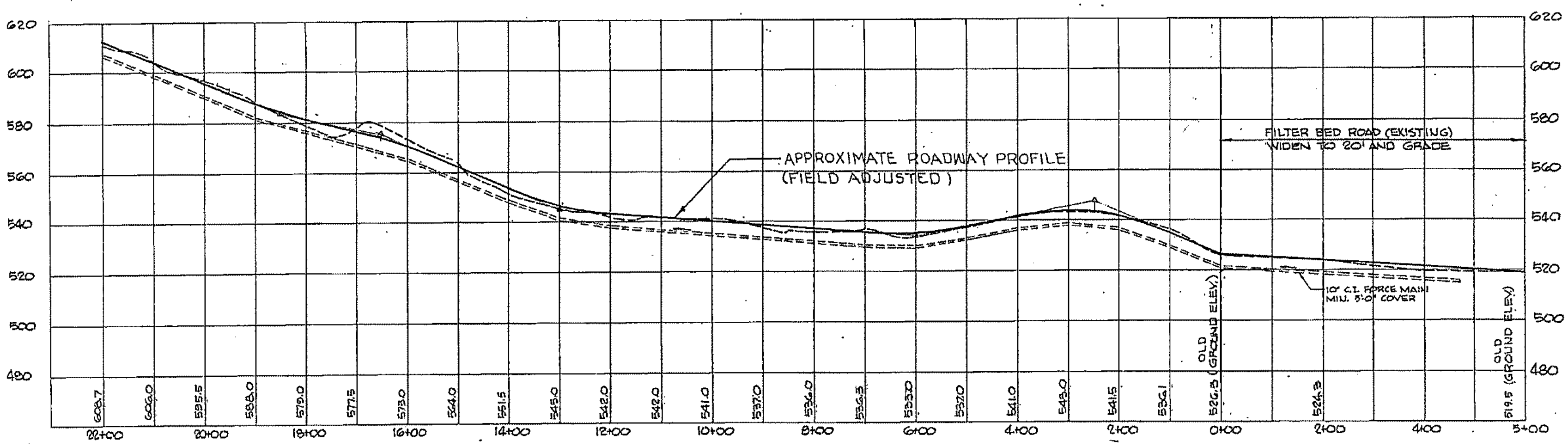
HOYLE TANNER & ASSOCIATES, INC.
CONSULTING ENGINEERS
MANCHESTER, NEW HAMPSHIRE

"AS BUILT"

1.4

100,000





PROFILE
SCALE: 1"=100' HORIZ.
1"=20' VERT.

"AS BUILT"

I HEREBY CERTIFY THAT ALL WORK INDICATED ON THIS DRAWING HAS BEEN COMPLETED AS SHOWN.

SIGNED *Charles I. Hinkley* P.E.

DATE 3/14/80

REV.	DESCRIPTION	DR BY	CHD BY	APPD BY	DATE
	REVISED "AS BUILT"	R.B.	N.T.	N.T.	7/82

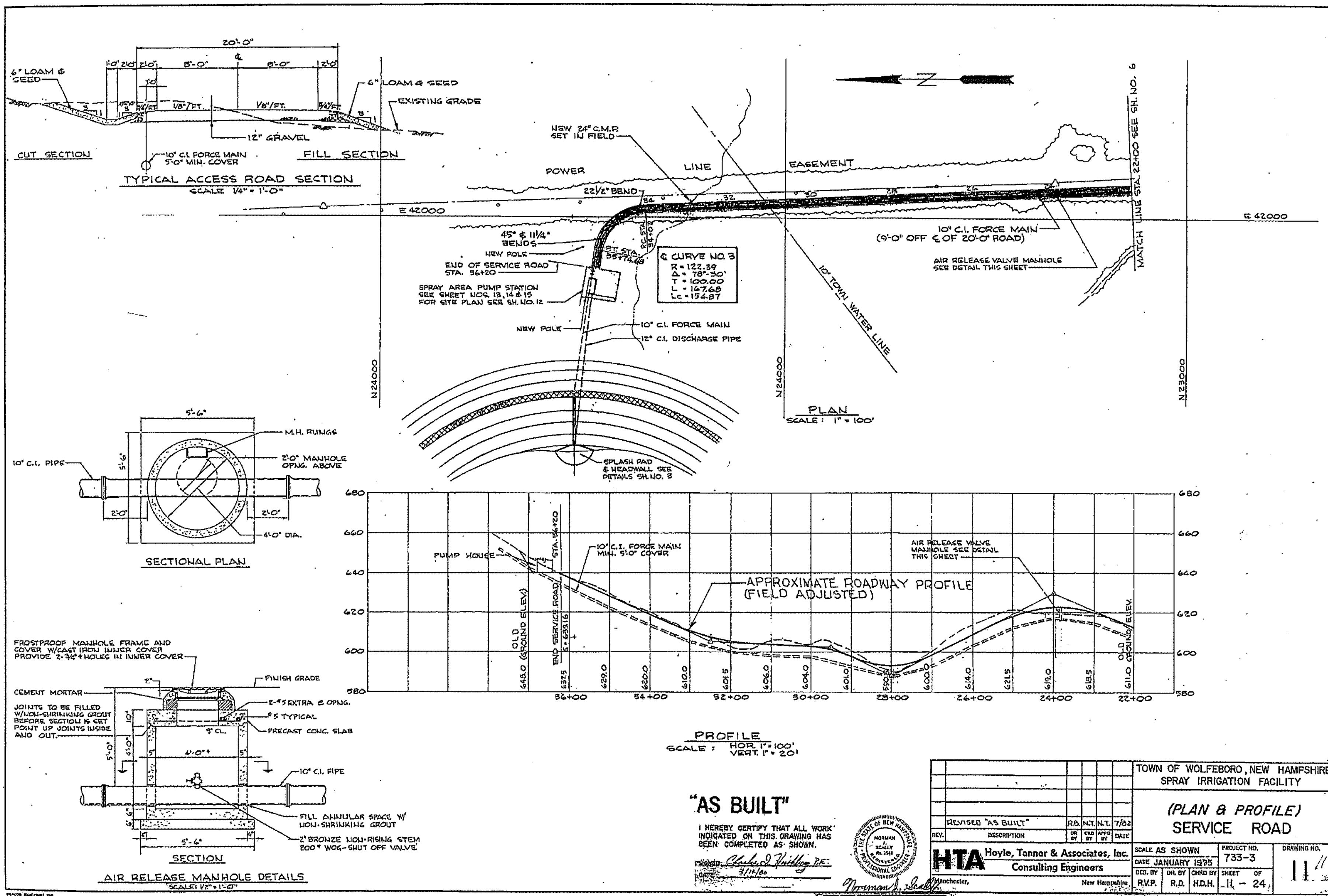
TOWN OF WOLFEBORO, NEW HAMPSHIRE
SPRAY IRRIGATION FACILITY

(PLAN & PROFILE)
SERVICE ROAD

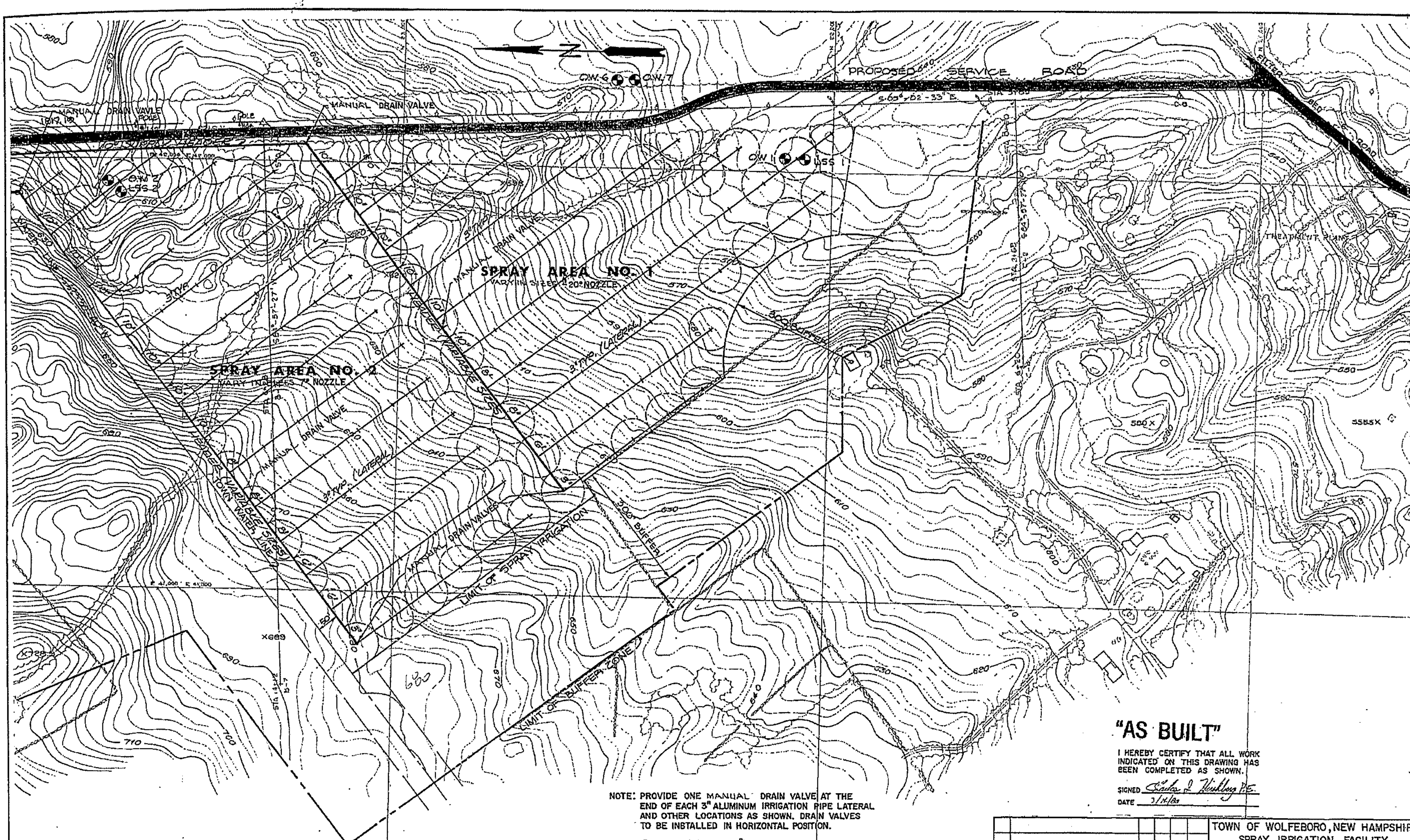
HTA Hoyle, Tanner & Associates, Inc.
Consulting Engineers
Manchester, New Hampshire

SCALE AS SHOWN			PROJECT NO. 733-3	DRAWING NO. 10
DATE JANUARY 1975				
DES. BY R.V.R.	DR. BY S.A.M.	CHKD BY H.D.H.	SHEET 10 OF 24	

DO NOT SCALE DRAWING



TYPICAL ACCESS ROAD SECTION
SCALE 1/4" = 1'-0"
CUT SECTION
FILL SECTION
6" LOAM & SEED
EXISTING GRADE
12" GRAVEL
10" C.I. FORCE MAIN 5'-0" MIN. COVER
PLAN
SCALE: 1" = 100'
POWER LINE EASEMENT
NEW 24" C.M.P. SET IN FIELD
22 1/2° BEND
45° & 11 1/4° BENDS
NEW POLE
END OF SERVICE ROAD STA. 36+20
SPRAY AREA PUMP STATION SEE SHEET NOS. 13, 14 & 15 FOR SITE PLAN SEE SH. NO. 12
10" C.I. FORCE MAIN
12" C.I. DISCHARGE PIPE
SPLASH PAD & HEADWALL SEE DETAILS SH. NO. 8
℄ CURVE NO. 3
R = 122.39
Δ = 78°-30'
T = 100.00
L = 167.68
Lc = 154.87
10" TOWN WATER LINE
10" C.I. FORCE MAIN (9'-0" OFF ℄ OF 20'-0" ROAD)
AIR RELEASE VALVE MANHOLE SEE DETAIL THIS SHEET
MATCH LINE STA. 22+00 SEE SH. NO. 6
E 42000
N 24000
N 23000
PROFILE
SCALE: HOR. 1" = 100' VERT. 1" = 20'
PUMP HOUSE
10" C.I. FORCE MAIN MIN. 5'-0" COVER
APPROXIMATE ROADWAY PROFILE (FIELD ADJUSTED)
AIR RELEASE VALVE MANHOLE SEE DETAIL THIS SHEET
OLD (GROUND ELEV.)
END SERVICE ROAD STA. 36+20
36+00
34+00
32+00
30+00
28+00
26+00
24+00
22+00
AIR RELEASE MANHOLE DETAILS
SCALE: 1/2" = 1'-0"
SECTIONAL PLAN
SECTION
10" C.I. PIPE
M.H. RUNGS
2'-0" MANHOLE OPNG. ABOVE
4'-0" DIA.
FROSTPROOF MANHOLE FRAME AND COVER W/CAST IRON INNER COVER PROVIDE 2-3/4" HOLES IN INNER COVER
FINISH GRADE
CEMENT MORTAR
JOINTS TO BE FILLED W/NON-SHRINKING GROUT BEFORE SECTION IS SET POINT UP JOINTS INSIDE AND OUT.
2-#5 EXTRA @ OPNG.
#5 TYPICAL
PRECAST CONC. SLAB
FILL ANNULAR SPACE W/ NON-SHRINKING GROUT
2" BRONZE NON-RISING STEM 200# WOG-SHUT OFF VALVE
"AS BUILT"
I HEREBY CERTIFY THAT ALL WORK INDICATED ON THIS DRAWING HAS BEEN COMPLETED AS SHOWN.
TOWN OF WOLFEBORO, NEW HAMPSHIRE
SPRAY IRRIGATION FACILITY
(PLAN & PROFILE)
SERVICE ROAD
REVISED "AS BUILT" R.B. N.T. N.T. 7/82
HTA Hoyle, Tanner & Associates, Inc. Consulting Engineers
Manchester, New Hampshire
SCALE AS SHOWN
DATE JANUARY 1975
PROJECT NO. 733-3
SHEET 11 OF 24
DRAWING NO. 11
DES. BY R.V.P. DR. BY R.D. CHKD BY H.D.H.
DO NOT SCALE DRAWING



"AS BUILT"

I HEREBY CERTIFY THAT ALL WORK INDICATED ON THIS DRAWING HAS BEEN COMPLETED AS SHOWN.

SIGNED *[signature]* P.E.

DATE 3/14/83

NOTE: PROVIDE ONE MANUAL DRAIN VALVE AT THE END OF EACH 3" ALUMINUM IRRIGATION PIPE LATERAL AND OTHER LOCATIONS AS SHOWN. DRAIN VALVES TO BE INSTALLED IN HORIZONTAL POSITION.

SPRAY LATERALS 3" TYP. NOT LAID IN STRAIGHT ALIGNMENT
SPRAY NOZZLES VARY IN SIZES AS REQUIRED.

LEGEND

- LSS1 LYSEMETER PAN SAMPLING STATION
- OW 1 OBSERVATION WELL

REV.	DESCRIPTION	DR BY	CKD BY	APPD BY	DATE
	REVISED "AS BUILT"	R.B.	N.T.	N.T.	7/82

TOWN OF WOLFEBORO, NEW HAMPSHIRE
SPRAY IRRIGATION FACILITY

(PLAN)

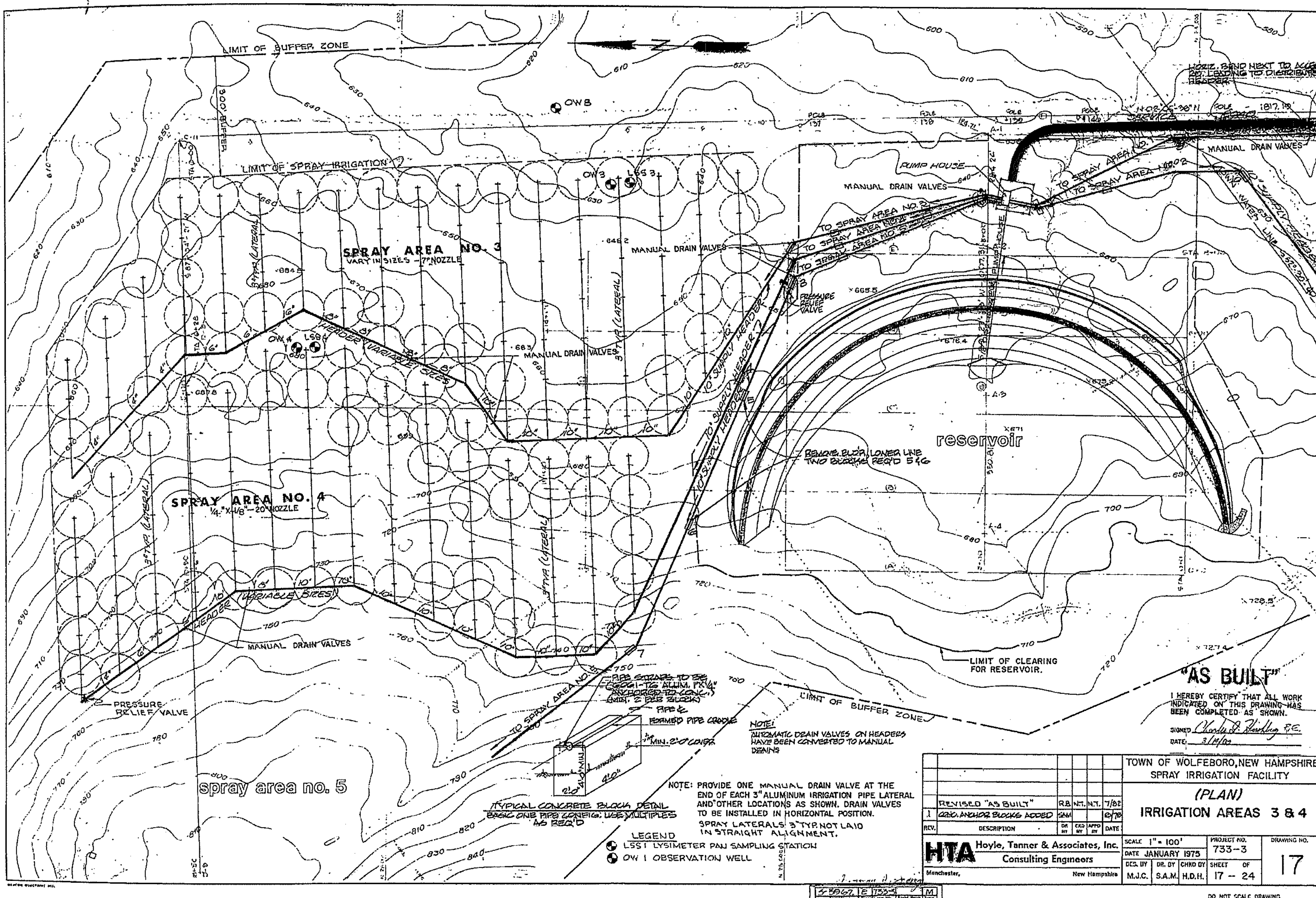
IRRIGATION AREAS 1 & 2

HTA Hoyle, Tanner & Associates, Inc.
Consulting Engineers
Manchester, New Hampshire

SCALE 1" = 100'	PROJECT NO.	DRAWING NO.
DATE JANUARY 1975	733-3	16
DES. BY M.J.C. / DR. BY S.A.M. / CHKD BY H.D.H	SHEET 16 OF 24	

DO NOT SCALE DRAWING

FINAL O A S P M E



NOTE: PROVIDE ONE MANUAL DRAIN VALVE AT THE END OF EACH 3" ALUMINUM IRRIGATION PIPE LATERAL AND OTHER LOCATIONS AS SHOWN. DRAIN VALVES TO BE INSTALLED IN HORIZONTAL POSITION.
SPRAY LATERALS 3" TYP NOT LAID IN STRAIGHT ALIGNMENT.

LEGEND
LSS 1 LYSIMETER PAN SAMPLING STATION
OW 1 OBSERVATION WELL

"AS BUILT"
I HEREBY CERTIFY THAT ALL WORK INDICATED ON THIS DRAWING HAS BEEN COMPLETED AS SHOWN.
SIGNED [signature] P.E.
DATE 3/14/80

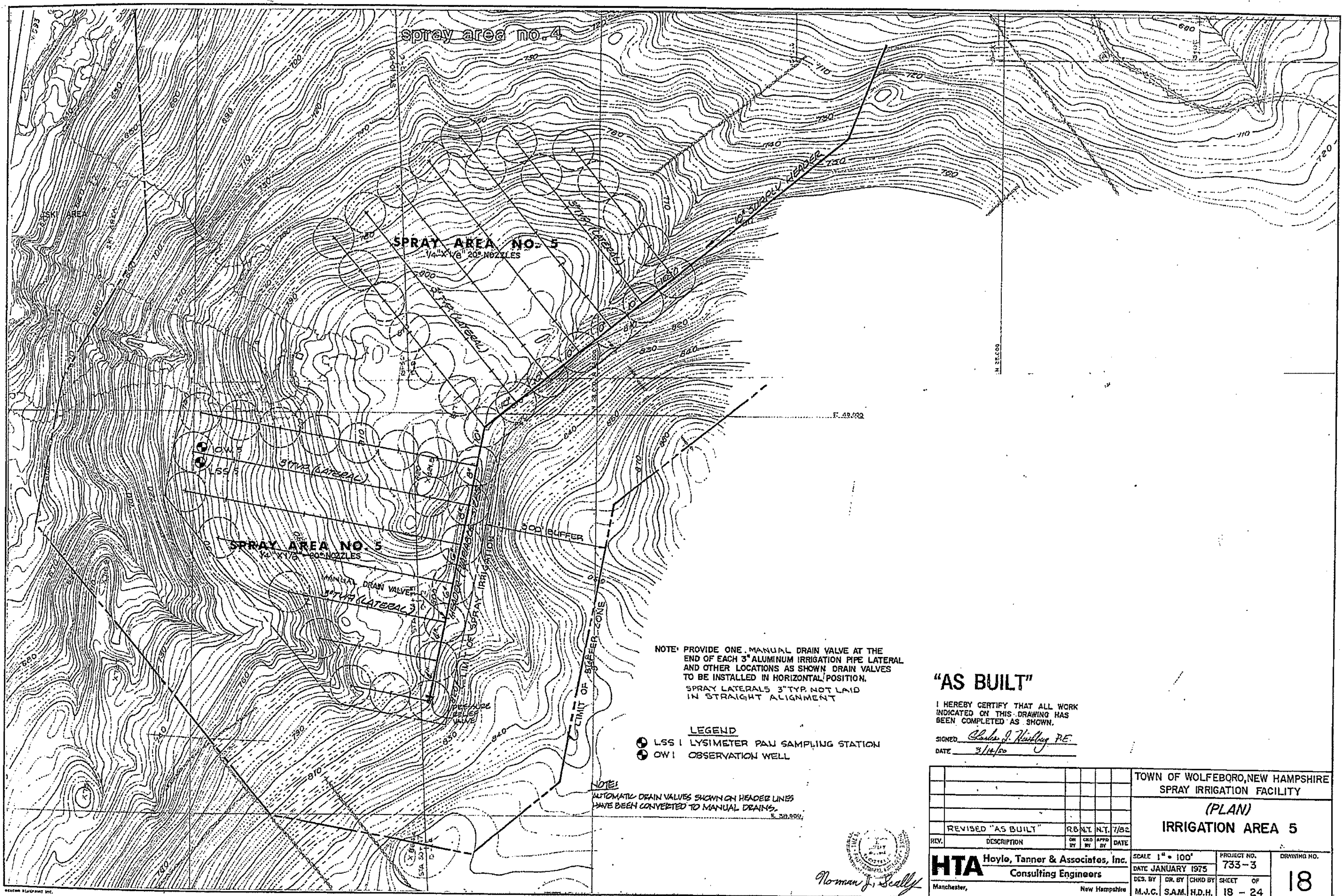
REV.	DESCRIPTION	DR BY	CKD BY	APPD BY	DATE
	REVISED "AS BUILT"	R.B.	N.T.	N.T.	7/82
1	CONC. ANCHOR BLOCKS ADDED	SAM			6/78

TOWN OF WOLFEBORO, NEW HAMPSHIRE
SPRAY IRRIGATION FACILITY
(PLAN)
IRRIGATION AREAS 3 & 4

HTA Hoyle, Tanner & Associates, Inc.
Consulting Engineers
Manchester, New Hampshire

SCALE	DATE	DES. BY	DR. BY	CHKD BY	PROJECT NO.	SHEET OF	DRAWING NO.
1" = 100'	JANUARY 1975	M.J.C.	S.A.M.	H.D.H.	733-3	17 - 24	17

DO NOT SCALE DRAWING


spray area no. 4
SPRAY AREA NO. 5
1/4" X 1/8" 20° NOZZLES
SPRAY AREA NO. 5
1/4" X 1/8" 20° NOZZLES
10" SUPPLY HEADER
3" TYP. (LATERAL)
MANUAL DRAIN VALVE
300' BUFFER
LIMIT OF BUFFER ZONE
LIMIT OF SPRAY IRRIGATION
SKI AREA
OW 5
LSS 5
NOTE: PROVIDE ONE MANUAL DRAIN VALVE AT THE END OF EACH 3" ALUMINUM IRRIGATION PIPE LATERAL AND OTHER LOCATIONS AS SHOWN. DRAIN VALVES TO BE INSTALLED IN HORIZONTAL POSITION.
SPRAY LATERALS 3" TYP. NOT LAID IN STRAIGHT ALIGNMENT
LEGEND
LSS 1 LYSIMETER PAN SAMPLING STATION
OW 1 OBSERVATION WELL
NOTE:
AUTOMATIC DRAIN VALVES SHOWN ON HEADER LINES HAVE BEEN CONVERTED TO MANUAL DRAINS.
"AS BUILT"
I HEREBY CERTIFY THAT ALL WORK INDICATED ON THIS DRAWING HAS BEEN COMPLETED AS SHOWN.
SIGNED Charles J. Hirtling P.E.
DATE 3/14/80
REVISED "AS BUILT" RB N.T. N.T. 7/82
REV. DESCRIPTION DR BY CKD BY APPD BY DATE
TOWN OF WOLFEBORO, NEW HAMPSHIRE
SPRAY IRRIGATION FACILITY
(PLAN)
IRRIGATION AREA 5
HTA Hoyle, Tanner & Associates, Inc.
Consulting Engineers
Manchester, New Hampshire
SCALE 1" = 100'
DATE JANUARY 1975
PROJECT NO. 733-3
DES. BY M.J.C.
DR. BY S.A.M.
CHKD BY H.D.H.
SHEET 18 OF 24
DRAWING NO. 18
DO NOT SCALE DRAWING
FINAL O A S P M E

Attachment D

WWTF Effluent Pump Curve

Pump Data Sheet - AURORA PUMPS

Company: HAYES PUMP
Name: PETER GILDAY
Date: 9/11/2012

Wolfboro, NH

AURORA Pentair

Pump:

Size: 3x4x10B
Type: 410 1 STG SPLIT CASE
Synch speed: 3600 rpm
Curve: 2PC-124752A
Specific Speeds:

Dimensions:

Speed: 3550 rpm
Dia: 8.5 in
Impeller: 444A131
Ns: 824
Nss: 7106
Suction: 4 in
Discharge: 3 in

Pump Limits:

Temperature: 275 °F
Pressure: 250 psi g
Sphere size: 0.5 in

Power: ---
Eye area: ---

Search Criteria:

Flow: 475 US gpm
Head: 265 ft

Fluid:

Water
SG: 1
Viscosity: 1.105 cP
NPSHa: ---

Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

Motor:

Standard: NEMA
Enclosure: ODP
Size: 100 hp
Speed: 3600
Frame: 365T
Sizing criteria: Max Power on Design Curve

---- Data Point ----

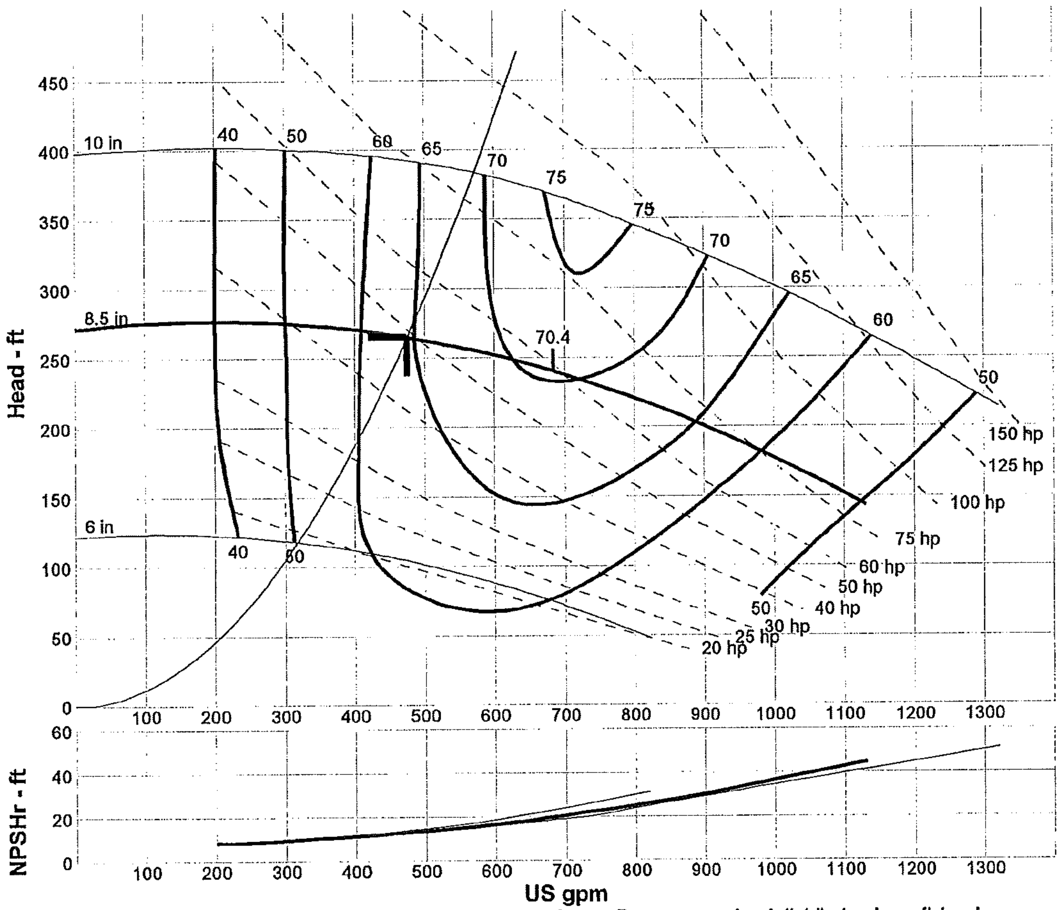
Flow:	475 US gpm
Head:	265 ft
Eff:	64%
Power:	49.4 hp
NPSHr:	13.2 ft

---- Design Curve ----

Shutoff head:	272 ft
Shutoff dP:	117 psi
Min flow:	---
BEP:	70% @ 684 US gpm
NOL power:	82.8 hp @ 1131 US gpm

-- Max Curve --

Max power: 149 hp @ 1320 US gpm



Curve efficiencies are typical. For guaranteed values, contact Aurora Pump or your local distributor. Las eficiencias en curvas son tipicas. Para valores garantizados contacte a Aurora Pump o a su distribuidor local.

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
570	3550	255	68	53.6	15.9
475	3550	265	64	49.4	13.2
380	3550	272	57	45.3	11.2
285	3550	276	48	40.7	9.4
190	3550	277	39	34.3	8.19

Selected from catalog: Aurora Pumps.60 Vers: 4.3

Attachment E

Evaporation Estimate Calculations

3. Draw a straight line from the mark for 40 psi nozzle pressure in column 7 to the point representing 5 mph wind speed in column 9. Locate point B where this line

Long-term daily maximum, average, and minimum daily temperatures are shown for each month and as annual averages. Daily average temperatures range from 56°F in winter to 81°F in summer. Daily maximum temperatures range from 68°F in winter to 92°F in summer. Table 1 also lists

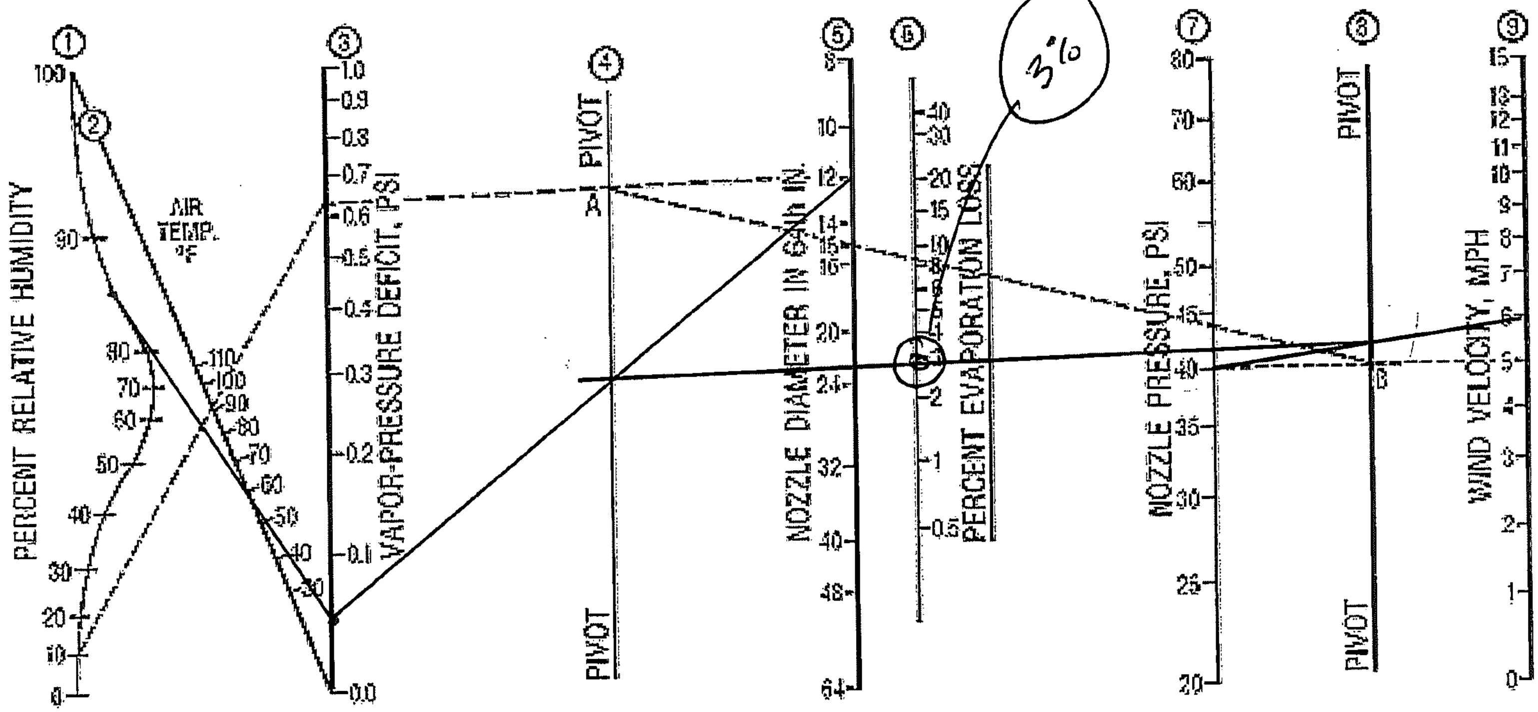


Figure 1. Sprinkler evaporation nomograph (from Frost and Schwalen, 1955).

WORST CASE

TEMP = 51°

HUMIDITY = 85%

WIND = 6 mph

OPERATING PRESSURE = 40 PSF

3% EVAPORATION

3. Draw a straight line from the mark for 40 psi nozzle pressure in column 7 to the point representing 5 mph wind speed in column 9. Locate point B where this line

Long-term daily maximum, average, and minimum daily temperatures are shown for each month and as annual averages. Daily average temperatures range from 56°F in winter to 81°F in summer. Daily maximum temperatures range from 68°F in winter to 92°F in summer. Table 1 also lists

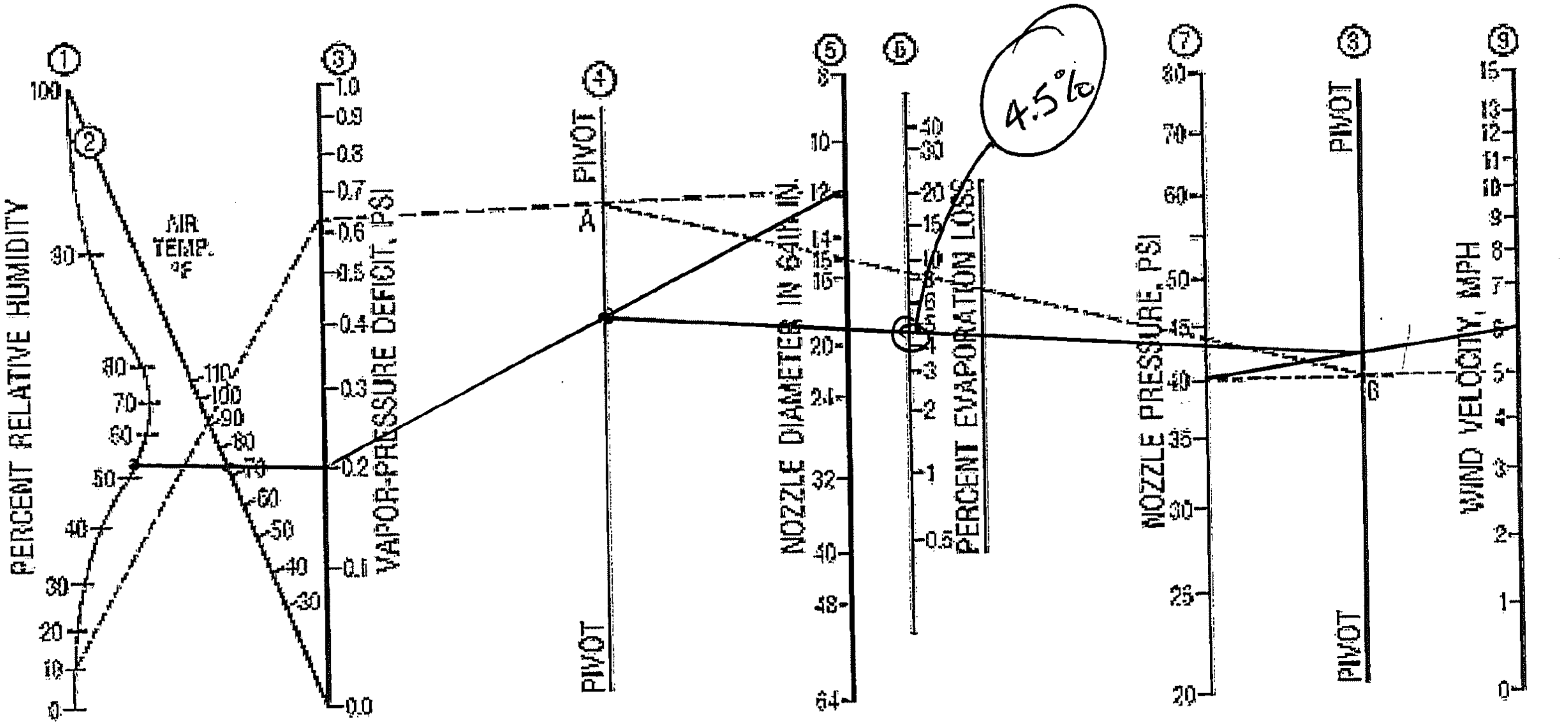


Figure 1. Sprinkler evaporation nomograph (from Frost and Schwalen, 1955).

BEST CASE

TEMP = 73°

HUMIDITY = 52%

WIND = 6 MPH

OPERATING PRESSURE = 40 PSI

NOZZLE = 3/16"

4.5% EVAPORATION

Universal Time: Thursday, 18 Oct 2012, 19:54

Historic Average

Home » Local » Historic Averages

Wolfeboro, New Hampshire

Monthly Averages & Records - °F | °C

Date	Average Low	Average High	Record Low	Record High	Average Precipitation	Average Snow
January	9°	29°	-24° (1994)	64° (2007)	3.27"	NA
February	11°	34°	-17° (1988)	63° (1997)	2.52"	NA
March	22°	42°	-11° (2003)	78° (1977)	2.98"	NA
April	33°	54°	12° (1995)	92° (2002)	3.42"	NA
May	45°	67°	29° (1997)	95° (1987)	3.5"	NA
June	54°	76°	38° (1986)	96° (1994)	3.61"	NA
July	60°	82°	45° (1988)	98° (1991)	4.18"	NA
August	58°	80°	40° (1988)	100° (1987)	3.63"	NA
September	50°	71°	30° (2000)	95° (2002)	3.31"	NA
October	38°	59°	24° (2002)	83° (1990)	3.78"	NA
November	30°	46°	7° (1989)	75° (1990)	3.62"	NA
December	18°	34°	-13° (1989)	69° (1998)	3.08"	NA

AVE = 50.8   AVE = 72.5°

Daily Averages & Records - °F | °C

Date	Average Low	Average High	Record Low	Record High	Average Precipitation	Average Snow
Sep 1	55°	76°	42° (1976)	88° (2000)	0.11"	NA
Sep 2	55°	76°	44° (1991)	89° (2000)	0.11"	NA
Sep 3	54°	75°	43° (1987)	91° (1999)	0.11"	NA
Sep 4	54°	75°	41° (1987)	92° (1999)	0.11"	NA
Sep 5	54°	75°	41° (2000)	91° (1999)	0.11"	NA
Sep 6	53°	75°	41° (2000)	87° (1983)	0.11"	NA
Sep 7	53°	74°	40° (1984)	87° (1983)	0.11"	NA
Sep 8	53°	74°	42° (1990)	90° (2007)	0.11"	NA
Sep 9	52°	73°	42° (1979)	91° (2002)	0.11"	NA
Sep 10	52°	73°	43° (1979)	95° (2002)	0.11"	NA
Sep 11	52°	73°	41° (1995)	93° (2002)	0.11"	NA
Sep 12	51°	72°	39° (1985)	91° (1983)	0.11"	NA
Sep 13	51°	72°	38° (1985)	81° (1997)	0.11"	NA
Sep 14	50°	72°	39° (1985)	82° (1990)	0.11"	NA
Sep 15	50°	71°	39° (1986)	85° (1993)	0.11"	NA
Sep 16	50°	71°	38° (1984)	87° (1993)	0.11"	NA
Sep 17	49°	71°	37° (2007)	85° (1991)	0.11"	NA
Sep 18	49°	70°	40° (1984)	85° (1991)	0.11"	NA
Sep 19	49°	70°	38° (1990)	85° (1992)	0.11"	NA
Sep 20	48°	70°	34° (1979)	86° (1983)	0.11"	NA
Sep 21	48°	69°	35° (1979)	89° (1983)	0.11"	NA
Sep 22	47°	69°	36° (1991)	85° (1983)	0.11"	NA
Sep 23	47°	68°	38° (1997)	83° (1989)	0.11"	NA
Sep 24	47°	68°	34° (1992)	79° (1984)	0.11"	NA
Sep 25	46°	68°	34° (1992)	79° (1984)	0.11"	NA
Sep 26	46°	67°	36° (1987)	84° (2007)	0.11"	NA
Sep 27	45°	67°	36° (1987)	87° (2007)	0.11"	NA
Sep 28	45°	67°	34° (1989)	81° (1998)	0.11"	NA
Sep 29	45°	66°	30° (2000)	76° (1990)	0.11"	NA
Sep 30	44°	66°	31° (2000)	81° (1987)	0.12"	NA

New Rule for New Hampshire Drivers

(Oct 2012) Rye - If you drive in New Hampshire you better read this... Learn More »

Insurance.Comparisons.org

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Seacoastonline.com Food

Jump N Gym gets active in new Portsmouth location
Breaking News From Seacoastonline.com

Budget Discipline
New Hampshire Watchdog

Shutting things out
Poetry Where You Live

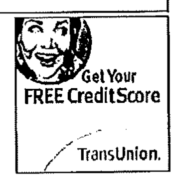
Someone to trust
Poetry Where You Live

Local news powered by Patch

1 Weird Photography Trick

Check out this one amazing trick for taking breathtaking pictures.

UglyHedgehog.com



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The Ski & Snow Section is

Current Results
research news & science facts

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Average Weather
USA > New Hampshire >

Monthly Humidity Averages for New Hampshire

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Weather Extremes
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- Coldest
- Hottest
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- Snowiest
- Cloudiest
- Sunniest

Indoor Humidity Control able911.com/humidity-control/
Moisture Causes Serious Damage! Get a Humidity Control Estimate Now

Tall Timber Lodge www.talltimber.com
Landmark Lodging & Dining. NH's CT Lakes Region Information.

Get $39 Lift Ticket Rates www.raggedmountainresort.c
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Temperature And Humidity www.grainger.com/Humi
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AdChoices

The humidity averages for each month are listed below for Concord, New Hampshire. The tables give the daily averages along with highest and lowest relative humidity levels.

Relative humidity measures the actual amount of moisture in the air as a percentage of the maximum amount of moisture the air can hold.

All the numbers here are averages for the years 1961 to 1990.

Average Humidity

In this table, the **Daily** number for the month or year is the average of humidity readings taken every three hours throughout the day. **Morning** percentages are for 7 am and **Afternoon** measures are for 4 pm local standard time.

Average relative humidity (%) for Concord, New Hampshire

Daily		Morning	Afternoon
68	January	75	57
66	February	75	53
65	March	76	51
62	April	75	45
65	May	76	46
71	June	82	52
72	July	84 AVE=	51 AVE= 52%
75	August	88 85%	53
76	September	90	55
73	October	87	53
73	November	83	60
72	December	79	63
70	Annual	81	53

Highest and Lowest Humidity

Below are the monthly and yearly averages for maximum and minimum humidity levels in New Hampshire. The hours when a month's highest and lowest humidity readings usually occur are given in local standard time.

Daily high and low relative humidity (%) averages in Concord, New Hampshire

High	Time	Low	Time

climate
ZONE.com

United States
Alaska
Great Plains
Hawaii
Mid-Atlantic
Midwest
Northeast
Rocky Mountains
South
Southwest
West

World Map

Continents
Africa
Asia
Australia
Europe
Middle East
North America
Oceania
South America

Countries A-Z
A B C D E F G
H I J K L M N
P R S T U V W
Y Z

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Hurricane Books
Meteorology Books
Tornado Books
Weather Books

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Hygrometers
Outdoor Thermometers
Rain Gauges
Weather Stations

→ World / North America / United States / Northeast / New Hampshire / Concord

Concord

The tables below display average monthly climate and weather indicators in Concord New Hampshire.

Temperature by: Fahrenheit / Centigrade

Concord Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Temperature	18.6	21.8	32.4	43.9	55.2	64.2	69.5	67.3	58.8	47.8	37.1	24.3	45.1
Avg. Max Temperature	29.8	33.0	42.8	56.3	68.9	77.3	82.4	79.8	71.6	60.7	47.1	34.2	57.0
Avg. Min Temperature	7.4	10.4	22.1	31.5	41.4	51.2	56.5	54.7	46.0	34.9	27.0	14.4	33.1
Days with Max Temp of 90 F or Higher	0.0	0.0	0.0	< 0.5	1.0	2.0	5.0	3.0	< 0.5	0.0	0.0	0.0	11.0
Days with Min Temp Below Freezing	30.0	27.0	26.0	17.0	5.0	< 0.5	0.0	< 0.5	2.0	14.0	21.0	29.0	172

Concord Heating and Cooling	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Healing Degree Days	1438	1210	1011	633	312	70.0	13.0	39.0	196	533	837	1262	7554
Cooling Degree Days	0.0	0.0	0.0	0.0	8.0	46.0	153	111	10.0	0.0	0.0	0.0	328

Concord Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation (inches)	2.5	2.5	2.7	2.9	3.1	3.1	3.2	3.3	2.8	3.2	3.7	3.2	36.4
Days with Precipitation 0.01 inch or More	11.0	10.0	11.0	12.0	12.0	11.0	10.0	10.0	9.0	9.0	11.0	11.0	126
Monthly Snowfall (inches)	18.0	14.4	11.2	2.5	0.1	< 0.05	0.0	0.0	< 0.05	0.1	4.0	13.7	64.0

Other Concord Weather Indicators	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Wind Speed	7.3	7.9	8.1	7.8	7.0	6.5	5.7	5.4	5.6	6.0	6.6	7.0	6.7
Clear Days	9.0	8.0	8.0	7.0	6.0	6.0	7.0	8.0	9.0	9.0	6.0	8.0	90.0
Partly Cloudy Days	7.0	8.0	8.0	8.0	10.0	12.0	12.0	11.0	9.0	9.0	8.0	8.0	109
Cloudy Days	15.0	13.0	15.0	15.0	15.0	12.0	12.0	12.0	12.0	13.0	16.0	15.0	166
Percent of Possible Sunshine	52.0	55.0	53.0	53.0	55.0	58.0	62.0	60.0	56.0	53.0	42.0	47.0	54.0
Avg. Relative Humidity	54.5	67.5	66.0	64.0	61.5	64.0	68.0	69.5	71.5	71.0	67.5	69.5	71.0

Avg = 6.0

Weather information for other cities in New Hampshire

- Mt. Washington Weather

UNDERWOOD ENGINEERS, INC.

25 Vaughan Mall, Unit 1
Portsmouth, NH 03801-4012
Tel: (603) 436-6192
Fax: (603) 431-4733

99 North State Street
Concord, NH 03301-4334
Tel: (603) 230-9898
Fax: (603) 230-9899

JOB 1789 - WOLFEBORO EFFLUENT
SHEET NO. ______ OF ______
CALCULATED BY CSM DATE 12/3/12
CHECKED BY ______ DATE ______
SCALE ______

POWER REQUIREMENTS FOR FOG NOZZLES

$P_h = \frac{h_A Q}{3956}$

$h_A = 55'$ (ELEVATION) + 40 psi (2.31 ft/psi)

$h_A = 147'$

$Q = 500$ gpm

$P_h = \frac{(147')(500\text{ gpm})}{3956} = 18.6$ HP

18.6 HP (0.7457) = 13.9 KW

60% EFFICIENCY = 23 KW

COST

(23 KW)(12 Hours)($0.14 / KW-HR) = $40 / Day +/-

$40/DAY FOR 11,000 - 18,000 gpd disposal under good conditions

ASSUME 2MG TO 3MG ANNUAL DISPOSAL VOLUME
ELECTRICAL COST → $7,200 / year +/-

$2,400 TO $3,600 PER MG
(ASSUME ABOUT $3,000)

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Tel: (603) 230-9898
Fax: (603) 230-9899

JOB ______
SHEET NO. ______ OF ______
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

SPRAY SYSTEM

SPRAY AREA #2

$h = (35\ psi)(2.31) = 81'$
$t = (9{,}523{,}600\ gal / 496.5\ gpm)/60 = 320$ Hours
$q = 496.5$ gpm
$P_h = \frac{(81')(496.5\ gpm)}{3956} = 10.2$ Hp → $10.2(0.7457) = 7.6$ KW
$(7.6\ kw)(320\ hr) = 2425.8$ KW·hr → 4,043 KW·hr @ 60% efficiency
$570 to dispose of 9,523,600 gal @ $0.14/kw·hr

SPRAY AREA #4

$h = (100') + (35\ psi)(2.31) = 181'$
$t = (10{,}121{,}700 / 467.6\ gpm)/60 = 470$ hours
$q = 467.6$ gpm
$P_h = \frac{(181)(467.6)}{3956} = 21.4$ Hp → 16.0 KW
$(16\ kw)(470\ hrs)/0.6$ → 12,497 kw·hr @ 60% efficiency
$1,750 to dispose of 10,121,700 gal @ $0.14/kw·hr

SPRAY AREA #5

$h = (165') + (35\ psi)(2.31) = 246'$
$t = (7{,}740{,}100\ gal / 340.8\ gpm)/60 = 380$ hours
$q = 340.8$ gpm
$P_h = \frac{(246)(340.8)}{3956} = 21.2$ Hp → 15.8 KW
$(15.8)(380\ hrs)(0.6) = 10{,}009$ kw·hr @ 60% efficiency
$1,400 to dispose of 7,740,100 gal @ $0.14 kw·hr

TOTAL ELECTRICAL COST = $3,720 to DISPOSE OF 27,580,300 gal in 2012

$135 /MG DISPOSAL

$\Delta = \frac{\$5{,}000\ (MG)}{\$135} = 37$ TIMES MORE EXPENSIVE FROM ELECTRICAL CONSUMPTION

Table 18.5 Hydraulic Horsepower Equations[a]

	Q (gal/min)	$\dot{m}$ (lbm/sec)	$\dot{V}$ (ft^3/sec)
h_A in feet	$\frac{h_A Q(\text{SG})}{3956}$	$\left(\frac{h_A \dot{m}}{550}\right)\times\left(\frac{g}{g_c}\right)$	$\frac{h_A \dot{V}(\text{SG})}{8.814}$
Δp in psi[b]	$\frac{\Delta p Q}{1714}$	$\left(\frac{\Delta p \dot{m}}{(238.3)(\text{SG})}\right)\times\left(\frac{g}{g_c}\right)$	$\frac{\Delta p \dot{V}}{3.819}$
Δp in psf[b]	$\frac{\Delta p Q}{2.468\times 10^5}$	$\left(\frac{\Delta p \dot{m}}{(34{,}320)(\text{SG})}\right)\times\left(\frac{g}{g_c}\right)$	$\frac{\Delta p \dot{V}}{550}$
W in $\frac{\text{ft-lbf}}{\text{lbm}}$	$\frac{WQ(\text{SG})}{3956}$	$\frac{W\dot{m}}{550}$	$\frac{W\dot{V}(\text{SG})}{8.814}$

(Multiply horsepower by 0.7457 to obtain kilowatts.)
[a]Table 18.5 is based on $\rho_{\text{water}} = 62.4\ \text{lbm/ft}^3$ and $g = 32.2\ \text{ft/sec}^2$.
[b]Velocity head changes must be included in Δp.

Table 18.6 Hydraulic Kilowatt Equations[a]

	Q (L/s)	$\dot{m}$ (kg/s)	$\dot{V}$ (m^3/s)
h_A in meters	$\frac{(9.81)h_A Q(\text{SG})}{1000}$	$\frac{(9.81)h_A \dot{m}}{1000}$	$(9.81)h_A \dot{V}(\text{SG})$
Δp in kPa[b]	$\frac{\Delta p Q}{1000}$	$\frac{\Delta p \dot{m}}{1000(\text{SG})}$	$\Delta p \dot{V}$
W in $\frac{\text{J}}{\text{kg}}$[b]	$\frac{WQ(\text{SG})}{1000}$	$\frac{W\dot{m}}{1000}$	$W\dot{V}(\text{SG})$

(Multiply kilowatts by 1.341 to obtain horsepower.)
[a]Table 18.6 is based on $\rho_{\text{water}} = 1000\ \text{kg/m}^3$ and $g = 9.81\ \text{m/s}^2$.
[b]Velocity head changes must be included in Δp.

Example 18.2

A pump adds 550 ft of pressure head to 100 lbm/sec of water. (a) Complete the following table of performance data. (b) What is the hydraulic power in horsepower and kilowatts? (Assume $\rho = 62.4\ \text{lbm/ft}^3$ or 1000 kg/m^3, and $g = 9.81\ \text{m/s}^2$.)

item	customary U.S.	SI
$\dot{m}$	100 lbm/sec	__ kg/s
h	550 ft	__ m
Δp	__ lbf/ft^2	__ kPa
$\dot{V}$	__ ft^3/sec	__ m^3/s
W	__ ft-lbf/lbm	__ J/kg
P	__ hp	__ kW

Solution

(a) Work initially with the customary U.S. data.

$$\Delta p = \rho h \times \left(\frac{g}{g_c}\right) = \left(62.4\ \frac{\text{lbm}}{\text{ft}^3}\right)(550\ \text{ft}) \times \left(\frac{g}{g_c}\right)$$
$$= 34{,}320\ \text{lbf/ft}^2$$

$$\dot{V} = \frac{\dot{m}}{\rho} = \frac{100\ \frac{\text{lbm}}{\text{sec}}}{62.4\ \frac{\text{lbm}}{\text{ft}^3}} = 1.603\ \text{ft}^3/\text{sec}$$

$$W = h \times \left(\frac{g}{g_c}\right) = 550\ \text{ft-lbf/lbm}$$

Now, convert to SI units.

$$\dot{m} = \frac{100\ \frac{\text{lbm}}{\text{sec}}}{2.201\ \frac{\text{lbm}}{\text{kg}}} = 45.43\ \text{kg/s}$$

$$h = \frac{550\ \text{ft}}{3.281\ \frac{\text{ft}}{\text{m}}} = 167.6\ \text{m}$$

$$\Delta p = \left(34{,}320\ \frac{\text{lbf}}{\text{ft}^2}\right)\left(\frac{1}{144\ \frac{\text{in}^2}{\text{ft}^2}}\right)\left(6.895\ \frac{\text{kPa}}{\frac{\text{lbf}}{\text{in}^2}}\right)$$
$$= 1643\ \text{kPa}$$

$$\dot{V} = \left(1.603\ \frac{\text{ft}^3}{\text{sec}}\right)\left(0.0283\ \frac{\text{m}^3}{\text{ft}^3}\right) = 0.0454\ \text{m}^3/\text{s}$$

$$W = \left(550\ \frac{\text{ft-lbf}}{\text{lbm}}\right)\left(1.356\ \frac{\text{J}}{\text{ft-lbf}}\right)\left(2.201\ \frac{\text{lbm}}{\text{kg}}\right)$$
$$= 1642\ \text{J/kg}$$

(b) From Table 18.5, the hydraulic horsepower is

$$\text{WHP} = \frac{h_A \dot{m}}{550} \times \left(\frac{g}{g_c}\right)$$
$$= \left(\frac{(550\ \text{ft})\left(100\ \frac{\text{lbm}}{\text{sec}}\right)}{550\ \frac{\text{ft-lbf}}{\text{hp-sec}}}\right) \times \left(\frac{g}{g_c}\right)$$
$$= 100\ \text{hp}$$

From Table 18.6, the power is

$$\text{WkW} = \frac{\Delta p \dot{m}}{(1000)(\text{SG})} = \frac{(1643\ \text{kPa})\left(45.43\ \frac{\text{kg}}{\text{s}}\right)}{\left(1000\ \frac{\text{W}}{\text{kW}}\right)(1.0)}$$
$$= 74.6\ \text{kW}$$