Field Flow Testing Program

woodardcurran.com
COMMITMENT & INTEGRITY DRIVE RESULTS

223604.02

Woodridge Lake Sewer District

June 2011

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 AQUIFER TESTING OVERVIEW

Woodard & Curran (W&C) has designed this field flow testing program to help evaluate the performance of the existing Woodridge Lake Sewer District (WLSD) disposal facility. WLSD owns and operates a collection system and water pollution control facility (WPCF) in Goshen, Connecticut that serves approximately 650 existing users in an area surrounding Woodridge Lake.

The majority of facilities in the WLSD system were constructed in the early 1970's; although the system has been maintained over the years; aspects of the system require modification, upgrade, or replacement. The District has an outstanding Consent Order with the Connecticut Department of Environmental Protection (DEP) that was issued in 1989 that requires, as a minimum, upgrade of the WPCF effluent distribution and disposal system.

The existing disposal system consists of numerous ridge and furrow beds as shown on Figure 1. Four infiltration beds have been selected for field flow evaluation including A-8, F-5, D-1, and G-4. These beds have been selected based on their locations, ongoing performance of the system, historic hydrogeologic evaluations, and results of the short term tests previously conducted by W&C. W&C anticipates that the loading tests proposed herein will be completed June 2011. Weather and mobilization may require modifications to this schedule.

1.2 BACKGROUND

Nathan L. Jacobson & Associates, Inc. (NLJ) completed a hydrogeologic summary and investigation in the early to mid-1990's at the WLSD facility. As described in the Jacobsen report, the following subsurface investigations have been completed at this site:

- "Subsurface Investigation, Soil Disposal Site 2, Woodridge Lake Sewer District, Goshen, Connecticut", E. D'Appolonia Consulting Engineers, 1971;
- Letter to Hiram A. Tuttle & Associates from Soil Environmental Services, Inc of East Lyme, Connecticut dated June 19, 1990;
- Letter to Warren Hunt of Business Engineering Services from Geological Service, Inc. of East Hartland, Connecticut dated February 11, 1992; and
- "Woodridge Lake Sewer District, Ridge and Furrow Wastewater Disposal Facilities, Report on Hydraulic Capacity Analysis", NLJ, August 1995.

The NLJ report provides a brief summary of each of these investigations in its August 1995 report titled, *Woodridge Lake Sewer District, Ridge and Furrow Wastewater Disposal Facilities, Report on Hydraulic Capacity Analysis*. WLSD and W&C have been attempting to acquire the historic reports including the D'Appolonia, Tuttle, and Warren Hunt reports, but have not received them as of the date of this plan.

According the NLJ report, the D'Appolonia investigation in 1970 and 1971 included four percolation tests, test pits, and grain size evaluation of thirteen samples. D'Appolonia concluded that based on the data obtained from this information, the site had the capacity to accept and renovate wastewater flows of 200,000 gallons per day.

Subsurface investigations were completed by Hiram A. Tuttle & Associates in 1989 including installation of monitoring wells, test pitting, and collection of permeability core samples. The conclusions reached from this investigation are unknown at this time.

Investigations were completed by Warren Hunt of Business Engineering Services Inc. in 1990 and included installation of monitoring wells, and a bed infiltration capacity hydraulic load test of 150 linear feet of bed A-4. The infiltration test included application of 53,000 gallons of effluent over a 250 minute period. Water levels in the bed were measured during dosing and for almost 27 hours after dosing ceased. The load test indicated an initial bed infiltration rate of 94 gallons per minute during dosing and 7.7 gallons per minute after dosing. Mr. Hunt concluded that the facility provided the hydraulic capacity to accept and renovate a design wastewater discharge of 200,000 gallons per day.

NLJ completed additional investigations including: soil borings, installation of monitoring wells, test pitting, grain size analysis of soil samples, and testing of saturated permeability. NLJ generated estimates of hydraulic capacity using information collected during the subsurface investigations and from unsaturated soil thicknesses (using water level) measurements collected between 1991 and 1993. Two estimates were evaluated including true site permeability using the geometric mean of the 33 permeability samples and a conservative estimate using Burgy and Luthin methodology to evaluate the permeability samples. The estimates were broken down into the eight hydraulic elements depicted on Plat 3 of the NLJ Report. Estimates from the 1995 NLJ Report indicated the following capacities of the various elements of the WLSD effluent disposal system:

Table 1: NLJ Hydraulic Capacity Estimates

Hydraulic Element	1	2	3	4	5	6	7	8	Total
Geometric Mean Capacity Estimate (gpd)	7,599	4,211	1,261	359	764	1,245	10,956	7,766	34,162
Conservative Capacity Estimate (gpd)	5,301	2,938	880	250	533	868	7,644	5,418	23,834

Based on this evaluation NLJ concluded that the onsite soils have wastewater disposal capacity far less than the original design and subsequent testing.

1.3 SHORT TERM LOADING TESTS

Short term loading tests were completed by W&C in May 2011 at infiltration beds A4, A5, A8, A21, B8, D1, F5, and G4. The short term tests were completed using the following methodology:

- Selected beds were scraped clean of accumulated vegetative mat and the surface was scarified if “smeared” during scraping.
- Each bed or bed portion tested was fitted with a staff gage and transducer for recording the depth of accumulated pool and the decay rate during the loading and drainage phase of the tests. The staff gage was constructed from a driven post.
- Each bed (or tested portion of a bed) was filled to a predetermined pool depth using the existing discharge infrastructure, and then loading ceased and draining of the pool was recorded.

The volume of water discharged per square foot was estimated at each short term test by multiplying the bed area constructed by the depth each bed was loaded to. In addition, the length of time required to drain each bed was recorded by evaluating the transducer data to determine when the water level had reached the bottom of the bed. The following table summarizes the results of these short term tests.

Table 2: Short Term Loading Test Summary

Infiltration Bed Number	Area of Bed (square feet)	Discharge Volume (gallons)	Volume Per Square Foot (Gallons/square foot)	Drainage Time (minutes)	Approx. Drainage Rate (gallons per square foot per day)
A-4	504	4,147	8.23	2,800	4.23
A-5	460	3,544	7.70	3,600	3.08
A-8	504	3,845	7.63	370	29.69
A-21	409	4,583	11.21	910	17.73
B-10	480	2,765	5.76	3,600	2.30
D-1	432	4,201	9.72	1,565	8.95
F-5	516	5,404	10.47	1,800	8.38
G-4	441	2,804	6.36	760	12.05

The infiltration evaluation of A-4 by Warren Hunt of Business Environmental Services completed in 1990 resulted in a 7.7 gallons per minute infiltration rate after dosing a 150 foot linear section of the bed. Assuming an average width of 25 feet in A-4, then this historic test reveals an approximate drainage rate of 3.0 gallons per square foot per day. This rate compares reasonably well with our short term test result of 4.23 gallons per square foot per day, especially given that based on the information provided the historic test was conducted with the vegetative base layer fully intact.

1.4 BED SELECTION

The Short Term testing completed in May, as described above, provides the opportunity for at least a qualitative ranking of beds for infiltrative capacity at various locations on the site. (See Table 2 above).

W&C is aware that the maximum treated wastewater loading to infiltration beds allowed by DEP is 1.2 gallons per day per square foot of bed area (gpd/ft^2). It is understood that the design load for discharge at the Brush Hill site will likely be approximately 100,000 gpd. Given that the typical existing width of the beds on the site is 25 feet, it will require about 3,300 linear feet of beds, as a minimum, to accept the design wastewater load at the maximum DEP loading rate of 1.2 gpd/ft^2. The need for 3,300 feet minimum of infiltration bed, suggests that beds of both higher and moderate infiltration capacity will have to be in service in the future.

In addition to infiltration capacity requirements, the disposal facility is supposed to meet a 21 day travel time from point of release of the wastewater into the groundwater to the point where the wastewater/groundwater reaches the natural surface environment. At the Brush Hill site, the points of release to the natural surface environment are the Bantam River wetlands on the west and the unnamed beaver pond east of the site. The 21 day travel time consideration suggests that beds as far as possible from the surface release points will be the most favorable for use if the District is to continue using the Brush Hill facility.

Based on the three considerations mentioned above (qualitative ranking of beds, need for 3,300 feet of infiltration capacity minimum, and the 21 day travel time), W&C has selected four beds for the detailed testing under this work plan. We have selected following beds: A-8, F-5, A-5, and G-4. These beds are located at close to the maximum available distance from surface water features adjacent to the site, represent a mix of relative infiltration capacity, and collectively, within the entire beds selected for testing provide 1,900 linear feet, (over ½ the total minimum area necessary to accommodate the design flow).

2. FLOW TEST PREPARATION

Prior to or concurrent with the flow tests the following activities will be completed:

- Groundwater elevation survey of existing monitoring wells concurrent with or after testing,
- Installation of monitoring wells/piezometers to supplement the existing network prior to the initiation of the flow tests,
- Completion of test pitting in locations near to the selected beds before the flow testing begins,
- Preparation of the beds for loading prior to test initiation, and
- Antecedent Monitoring.

Further description of each of these activities is described below.

2.1 GROUNDWATER ELEVATION SURVEY

WLSD are in the process of testing existing monitoring wells and collecting groundwater elevation from operable locations. This information will be compiled to generate a draft groundwater contour map of the site.

2.2 INSTALLATION OF WELLS/PIEZOMETERS

In order to supplement the existing groundwater monitoring well network additional groundwater elevation monitoring wells/piezometers will be installed surrounding the beds selected for the full flow tests. One test will include a comprehensive array of monitoring points in order to evaluate the groundwater mound more completely. This monitoring network will include piezometers adjacent to each corner of the infiltration bed, at least two monitoring points upgradient and two downgradient from the bed, and piezometers every fifty feet within the beds. The center piezometer within the bed will be a nested pair of wells screened at different elevations. Monitoring points will be constructed in conformance with Connecticut regulations.

The remaining three beds that will be tested will utilize existing monitoring wells in the vicinity of the beds and a piezometer every fifty feet within the beds.

The layout of the beds is depicted in Figure 1. Well/Piezometer construction detail is provided in the schematic included as Figure 3.

2.3 TEST PITTING

Approximately two to four test pits will be completed surrounding each bed to be tested. The purpose of the test pitting will be to determine depth to bedrock, view subsurface materials, and collect soil samples for sieve analysis.

2.4 PREPARATION OF BEDS FOR LOADING

Beds will be constructed by building berms around 200 foot linear sections of the beds. In preparation for testing the 200 foot test sections of each infiltration bed, the bed will be stripped of the existing vegetative cover.

The bed stripping is planned for two reasons:

1. Any likely use of the Brush Hill for continued disposal will involve installation of a pressurized dosing system. Rebuild of the beds for this system will require removal of the vegetative cover;

2. During the proposed testing, the existing vegetative mat will inhibit dosing the underlying soil at the prescribed (and intended) dosing rate of 1.2 gpd/ft^2. The vegetative mat will delay the arrival of the test water to the "working soil column". This delay will distort the actual period of loading of the groundwater. Thus despite that rate at which water is applied to the bed, the groundwater system will only be stressed at the rate of infiltration through the vegetative mat. Any excess water applied to the beds will merely "stack up" as stored water ponded in the test section of the bed.

The net result will be that the mat will be a limiting layer in the whole system. Some water will arrive at the natural groundwater, but there will be no way to know during the application period what the functional dosing rate actually is. That defacto dosing rate, through the vegetation, could only be known once the pool has finally drained. The groundwater mound will reflect that dosing rate, but we will be prevented from knowing if the bed could accept a significantly greater dosing rate (up to the limit of 1.2 gpd/ft^2).

In addition to stripping the beds, discharge pipes will be installed and outfitted with valves, flow meters, and spreader pipe to disperse the wastewater throughout the test area. The bed construction is depicted in Figure 2.

Beds will be loaded using existing wastewater generated at the facility. An existing holding tank onsite may be utilized in order to generate excess discharge capacity to ensure ample flows for the tests. The maximum discharge rate during the test will not exceed the CT DEP regulatory limit of 1.2 gpd/ft^2.

2.5 ANTECEDENT MONITORING

Ambient groundwater conditions will be monitoring using automated pressure transducers at least one week prior to testing. The purpose of the monitoring is to define any background trend in water levels that may occur during the pumping period of the aquifer test. An onsite rain gauge and offsite USGS gauge information will be utilized to evaluate impacts from precipitation occurring during the tests, if any.

The USGS maintains a network of groundwater monitoring wells in Connecticut. These include wells installed in till in various counties in the state. The two USGS till wells nearest to the WLSD site are located in Granby and northwest of Sharon. These wells are currently still showing water levels above normal at the end of May, indicating that water levels in till remain high. This further indicates that the proposed testing will likely be reflective of operation under high water table conditions. Figure 4 depicts the plot of water levels relative to normal for the two till wells discussed above.

3. FLOW TEST STUDY

The goals of the full flow tests are to determine the infiltration rates that can be discharged while maintaining separation from discharge elevation to the top of the groundwater mound. DEP has a requirement of 3 ft unsaturated thickness of soils between the top of a groundwater mound under a loaded bed and the bottom of the loading facility. It is expected that this requirement can be facilitated in part by engineering design using fill if the groundwater mound too closely approaches a bed surface. Engineering and fill design could be used to compensate for a groundwater mound that may rise too closely to the original bed surface.

It is the intent to test each bed at the max allowed application rate of 1.2 gpd/ft^2 and to monitor the response of the groundwater mounding to this stress. If the groundwater mound rises higher than the allowed 3 feet of separation, then the loading will be modified to find an equilibrium between dosing rate and groundwater mound as high as 1.5 feet below current the current bed surface.

Once equilibrium between discharge and separation is attained then the characteristics of the resulting groundwater mound can be measured to help evaluate aquifer characteristics including hydraulic conductivity. It is anticipated that each flow bed will be loaded for approximately 48 hours.

3.1 STARTUP DAY

Water level measurements will be collected manually and also via automated pressure transducers during the startup day. Frequent monitoring of the separation between the bottom of bed and groundwater level within the basins will be required initially to help stabilize the discharge rate. A summary of the start-up day activities, including manual water level measurements events is summarized in Table 3.

Table 3: Start Up Day

Time Interval	Activity
Before 10 am	Full manual water level round download and reset transducers
Around 10 am	Valve on, rapid manual monitoring of separation, discharge rate
Between 10 am and 3 pm	Frequent manual water level measurements, monitoring of separation, and adjust discharge rates to maintain separation
Between 2 - 5 pm	Download and reset transducers
Between 3 - 7 pm	Two full water level rounds
After 7 pm	Transducer measurements, staff to monitor separation and discharge rate as necessary

3.2 DAY ONE

- Full manual water level monitoring at approximately 7 am and 7 pm, hourly monitoring of separation and discharge rate.

3.3 DAY TWO (SHUTDOWN DAY)

Water levels measurements will be collected on the shutdown day, generally using the same intervals after shutdown as completed after startup on the start-up day. A summary of Shutdown day activities is described in Table 4.

Table 4: Shut Down Day

7 - 8:00 am	Full manual water level round.
9 - 10:00 am	Full manual water level round
10:00 am - 3:30 pm	Shutdown infiltration, rapid manual water level measurements
4 pm - 5 pm	Download and reset transducers

3.4 DAY THREE

- Full manual water levels at approximately 12 pm.

3.5 RECOVERY MONITORING

Approximately two days after shutdown, W&C will return to the site, download and remove transducers from site monitoring locations.

4. DATA ANALYSIS AND REPORTING

The field testing results and evaluation of hydrogeologic data will be incorporated into a report that will become a component of the Facilities Plan currently being prepared for WLSD. This evaluation will be presented in general accordance with the concepts outlined in the DEP's Guidance for Design of Large-Scale On-Site Wastewater Renovation Systems. The report will provide details of data collection and analysis including the following components:

- Narrative of proposed project and description of previous investigations.
- Characterization of site soils in conformance with U.S. Department of Agriculture
- Natural Resource Conservation Service (NRCS) descriptions, as completed during previous investigations.
- USGS groundwater levels during time of testing compared to seasonal highs
- Ground water characterization, including depth from existing ground to seasonal high
- Water table, hydraulic gradient and local direction of ground water flow.
- Maps - Area Map, Site Plan, Surficial Geology Map and Bedrock Geology Map based on previous mapping by others, Soils Map based on NRCS soil mapping, and Groundwater Contour Map.
- Description and quantification of proposed discharges to the ground water.
- Supporting calculations, tables and figures.
- Conclusions as to project requirements for meeting the Department's criteria for a discharge to the ground waters of the State.

The final report will include sections addressing the following topics:

1. Introduction
2. Summary of Previous Investigations
3. Flow Load Testing Methodology and Results
4. Hydraulic Capacity Assessment
5. Time of Travel Assessment
6. Proposed Engineering Enhancements to Address Groundwater Separation and Breakout

FIGURES

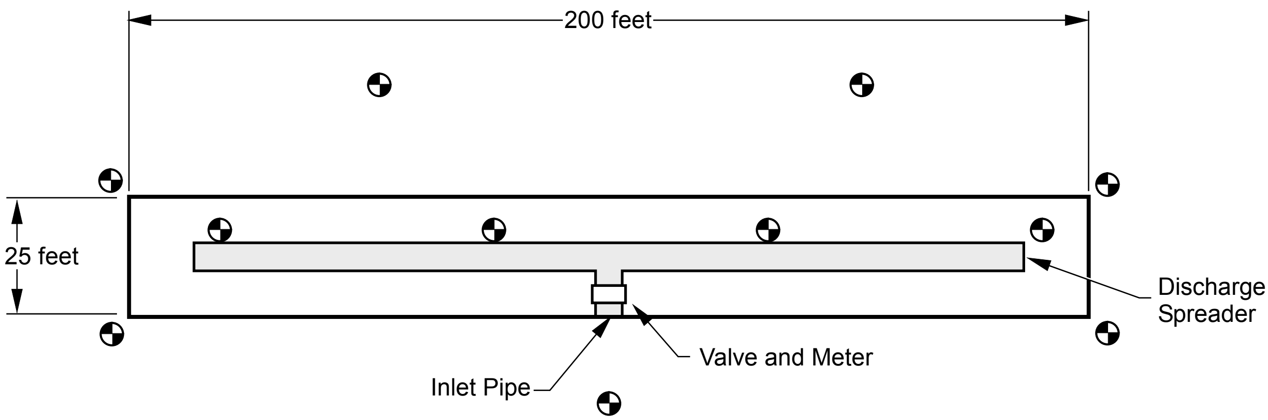
Figure 1
Hydraulic Elements
WLSD

Source: Nathan L. Jacobson and Associates, 1995.

WOODARD&CURRAN

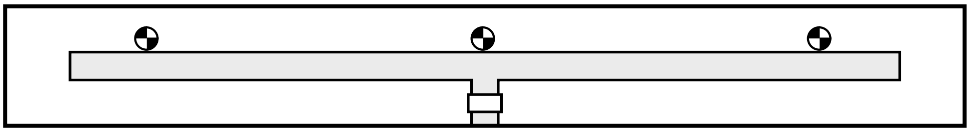
223604\gcs\hydraulic elements.cvx

Flow Test with Comprehensive Network



Standard Tests

2 Downgradient Existing Wells, as available



LEGEND

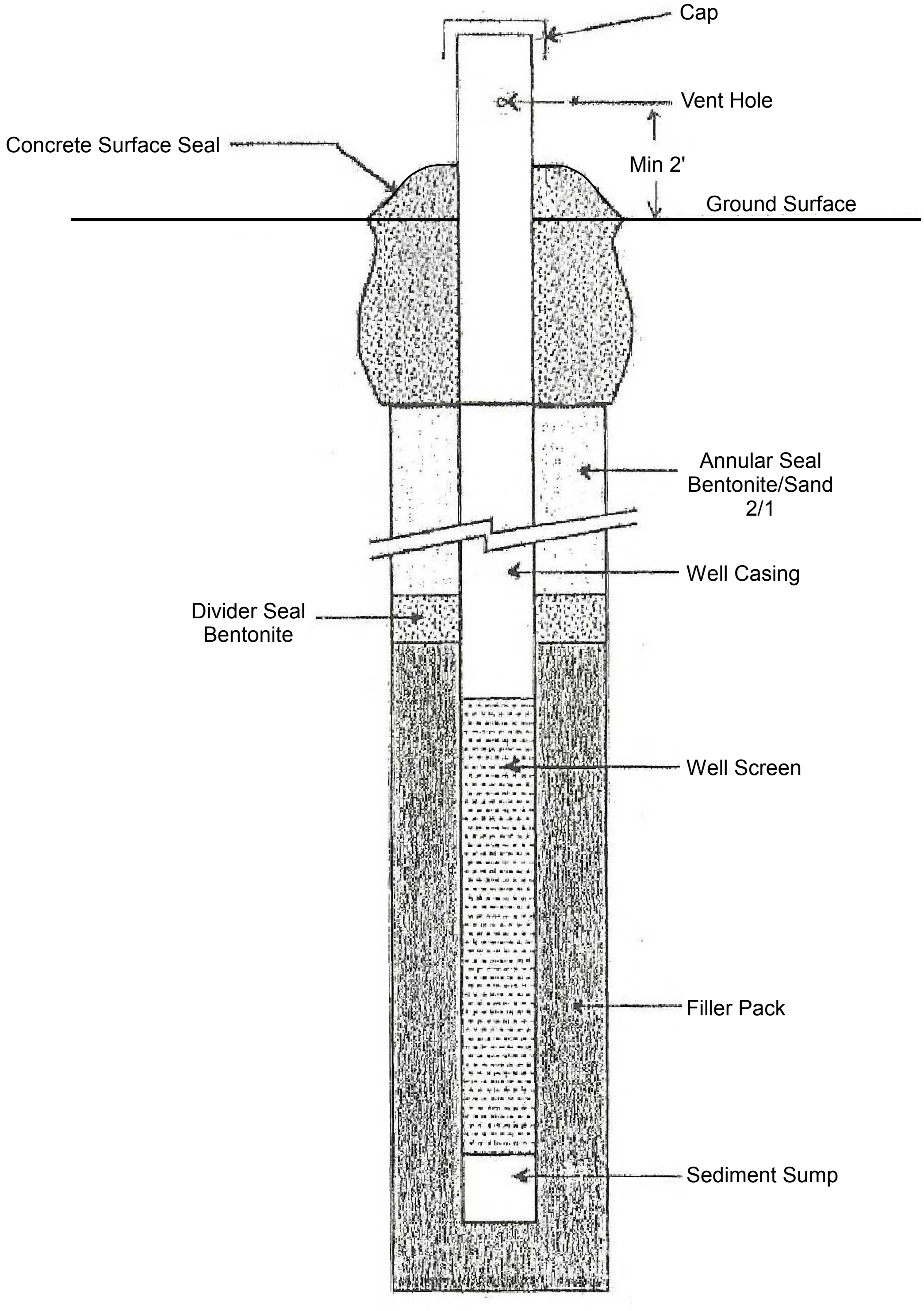
Piezometer/Well Location

Not to Scale

Figure 2
Flow Test Bed Layout
WLSD

WOODARD&CURRAN

223604\gcs\flow test bed layout.cvx

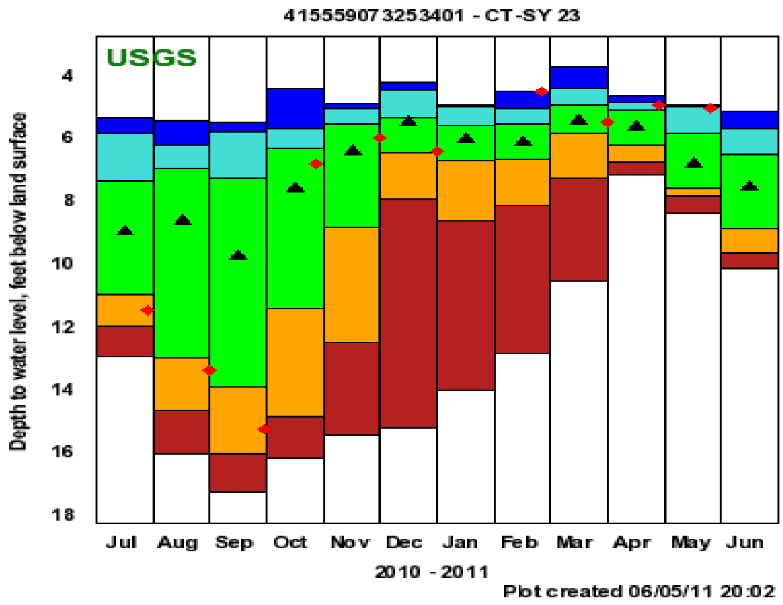


Not to Scale

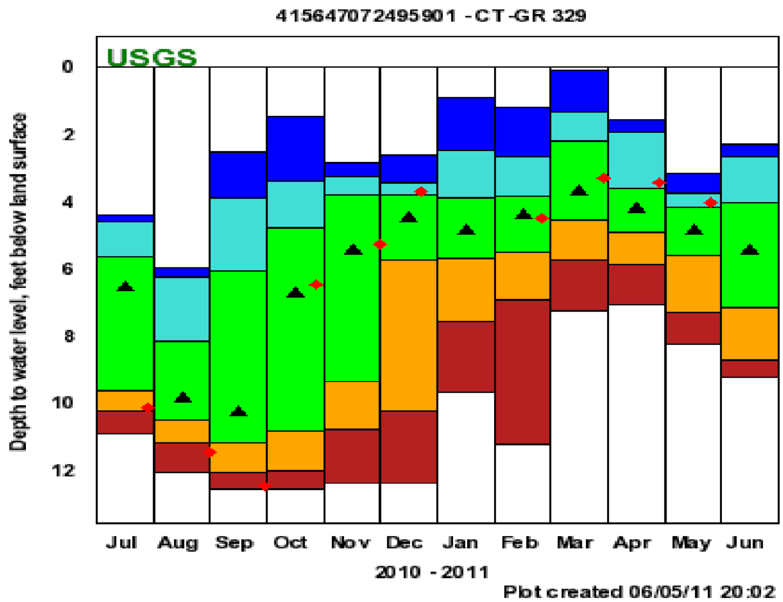
Figure 3
Well Component Diagram
WLSD

WOODARD&CURRAN

223604\gcs\flow test bed layout.cvx



A. Graphically depicts summary statistics for the Sharon Till Well



B. Graphically depicts summary statistics for the Granby Till Well

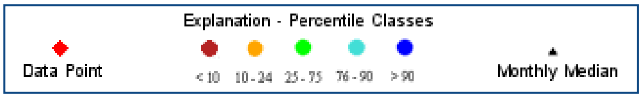


Figure 4
USGS Water Level Statistics for Two Till Wells
WLSD

WOODARD&CURRAN

223604\gcs\usgs water level stats for till wells.cvx