NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE SPECIFICATION
(FOR USE WITH NRCS 642—WATER WELL CONSERVATION PRACTICE STANDARD)

642 – WATER WELL

I. SCOPE

Work shall consist of furnishing all equipment, materials, tools, labor and transportation, and in performing all operations in connection with the satisfactory construction, development and disinfection of the well.

The extent of the work is described with the understanding that the exact conditions of the subsurface are not known prior to commencement of the work.

Refer to CT Department of Public Health Code Section 19-13-B51 and the CT Department of Consumer Protection Well Drilling Code Section 25-128-33 through 25-128-64 for all applicable regulatory requirements for new well construction in their entirety.

II. PERMITS & LICENSING

The final well completion shall be designed and installed by a water well drilling contractor, licensed by the Department of Consumer Protection. Work shall meet the requirements set forth by the local regulating agency.

The landowner is responsible for obtaining all permits and water rights. All wells shall comply with applicable federal, state, and local laws and regulations.

III. SITE PREPARATION

The area immediately surrounding the well site shall be cleared, smoothed, and graded to allow for a safe and dry working area.

IV. CASING MATERIALS

All casing materials shall meet or exceed requirements set forth by the local enforcing agency. Materials used for casing a well other than a dug well shall be made of steel or other material approved by the commissioner of health for the State of Connecticut.

If the water is to be used for human consumption, plastic pipe shall be approved by the National Sanitation Foundation.

All well casing pipe and couplings shall be homogeneous throughout and shall be free from visible cracks, holes, foreign materials, or other injurious defects and shall have watertight connections. The well casing pipe and couplings shall be as uniform in color, density, and other physical properties as is commercially possible.

The well casing pipe shall be marked according to the ASTM specification for the material used.

Steel

Steel pipe used for well casing shall meet or exceed requirements specified in ASTM A589.

The maximum differential head [1] and nominal size shall be used to determine the minimum thickness for the steel water well casing, as shown in **Table 1**. A thinner casing may be used if it is determined that it will not collapse, based on analysis using the Timoshenko Elastic Formula and guidelines set forth in NRCS National Engineering Handbook (NEH) Part 631, Chapter 32, (http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=26985.wba). Thicker casing shall be used where corrosive conditions are expected.

Only new steel pipe casings shall be used in driven wells.

[1] Maximum differential head equals the maximum difference in static head between the inside and outside of the casing. The static head may be determined by either (1) subtracting the elevation of the bottom of the casing from the elevation of the water table, or (2) subtracting the elevation of the depth of maximum allowable drawdown from the elevation of the water table.

Thermoplastic

Thermoplastic pipe used for well casing may be made of acrylonitrile-butadiene-styrene (ABS) or polyvinyl chloride (PVC), and shall meet or exceed requirements specified in ASTM F480.

Used casing and casing with obvious eccentricity or other defects shall not be used.

The material type and the SDR marked on the pipe shall be used to determine maximum allowable depth, as shown in **Table 2**. Higher SDR-rated pipe may be used if it is determined that it will not collapse, based on a site-specific determination of the maximum differential head using Clinedinst Equation as documented in NRCS National Engineering Handbook (NEH) Part 631, Chapter 32 and ASTM F480.

In known geothermal areas, the maximum allowable depth for thermoplastic pipe shall be reduced by a percentage determined using **Figure 1.**

Concrete

Concrete well casings shall be reinforced and shall meet or exceed the requirements of ASTM C76. The minimum 28-day compressive strength shall be 4,000 lbs/in^2.

V. SCREEN AND FILTER PACK MATERIALS

Screen Well screens may be constructed of commercially manufactured screen sections, well points, or field-perforated sections. Screens shall have a minimum length of two feet. The screen shall have openings free of rough edges, irregularities or other defects that may contribute to corrosion or clogging and shall be equipped with fitting necessary to seal the top of the screen to the casing and close to the bottom. Wells constructed in coarse gravel are not required to have a screen or if a screen is employed in this scenario, it may be open on the bottom. The length and open area of the screen shall be sized to limit entrance velocity of the water into the well to less than or equal to 0.7 feet per second.

All screen materials shall be homogeneous throughout and shall be free from visible cracks, holes, foreign materials, or other injurious defects.

Filter Pack

The filter pack shall be at least 2 inches thick and consist of sand to gravel size material having a D_{30} grain size 4 to 9 times the D_{30} grain size of the aquifer material.

Material used in gravel-packed wells shall come from clean sources and thoroughly washed before being placed in the well. Gravel purchased from a supplier should be washed at the pit or plant prior to delivery at the well site.

VI. INSTALLATION

A well under construction shall be protected so that there can be no drainage or surface wash into the well. Workers employed in such construction shall exercise sanitary precautions in disposal of wastes and handling of construction materials so as to avoid contamination of the well and aquifer. All water used in constructing a well shall be disinfected with 100 milligrams per liter (parts per million) of chlorine in order to protect the well from contamination. No polluted water shall be used in connection with the construction of a well.

Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within legal limits. All work and operations shall be conducted in accordance with proper safety codes for the type of construction being performed, and with due regards to the safety of all persons and property. The completed job shall present a professional and aesthetic appearance.

Table 1. Minimum thickness for steel water well casings

		Nominal Casing Size (inches)							
O.D. (inches) ->		**4** 4.500	**5** 5.563	**6** 6.625	**8** 8.625	**10** 10.75	**12** 12.75	**14** 14.00	**16** 16.00
Max differential head (feet)	≤ 50	18	16	14	14	12	12	12	10
	51-100	16	14	14	12	12	10	10	8
	101-150	16	14	12	12	10	8	8	3/16
	151-200	16	14	12	10	10	8	3/16	7/32
	201-300	14	12	12	10	8	3/16	7/32	1/4
	301-500	12	12	10	8	3/16	7/32	1/4	9/32
	501-800	12	10	8	3/16	1/4	9/32	5/16	3/8

Thickness in U.S. Standard Gauge*

Thickness in inches

* **18** Ga = 0.048 in.; **16** Ga = 0.060 in.; **14** Ga = 0.075 in.;
12 Ga = 0.105 in.; **10** Ga = 0.135 in.; **8** Ga = 0.164 in.

Table 1 values are based on information from two sources: 1) Suggested minimum thickness for steel water well casing in Roscoe Moss Company's "A Guide to Water Well Casing and Screen Selection" (http://roscoemoss.com/wp-content/uploads/publications/ggwc.pdf); and 2) Differential head limitations for selected sizes of ASTM A-139 Grade B carbon steel casings listed in Table 32-5 of NRCS NEH Part 631, Chapter 32, Well Design and Spring Development (http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=26985.wba) .

Table 2. Maximum differential head of casing for thermoplastic pipe.

					Nominal Casing Size (in) -> O.D. (inches) ->	**4** 4.500	**5** 5.563	**6** 6.625	**8** 8.625	**10** 10.75	**12** 12.75	**14** 14.00	**16** 16.00
SDR = Standard Dimension Ratio = outside diameter casing (in) / wall thickness casing (in)					Sched 40 PVC-12454 SDR ->	19.0	21.6	23.7	26.8	29.5	31.4	32.0	32.0
					Sched 80 PVC-12454 SDR ->	13.4	14.8	15.3	17.3	18.1	18.6	18.7	19.0
Maximum differential head (ft)	***Maximum* allowable SDR for common thermoplastic casing materials** (assumes μ=0.38; bold numbers identify standard sizes)					Shaded boxes below indicate where both Schedule 40 and Schedule 80 PVC-12454 meet criteria					Light shaded boxes below indicate where Schedule 80 PVC-12454 meets criteria		
	PVC-12454 (E=400,000 psi)	**ABS-434** (E=360,000 psi)	**PVC-14333** (E=320,000 psi)	**ABS-533** (E=250,000 psi)									
≤ 50	35.5	34.5	33	30.5									
51-100	28.5	27.5	26.5	24.5									
101-150	25	24	23	21.5									
151-200	22.5	22	**21**	19.5									
201-300	20	19	18.5	**17**									
301-500	**17**	16	15.5	14.5									
501-800	14.5	14	**13.5**	12.5									

Reference: National Engineering Handbook (NEH) Part 631, Chapter 32, Well Design and Spring Development (http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=26985.wba). Maximum SDR values are calculated using the Clinedinst equation, assuming Poisson's ratio = 0.38, and using the highest value listed for the range of maximum differential head.

Percent reduction in maximum allowable differential head for PVC casing in geothermal areas

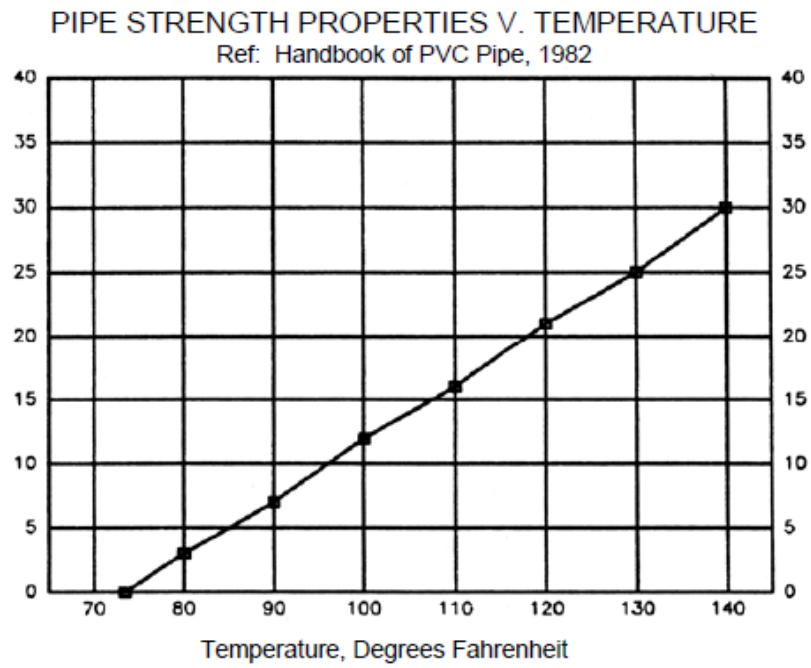

Figure 1. PVC Temperature Service Factor for PVC Casing
Source: NRCS-MT Construction Specification MT-642

Table 3. Minimum wall thickness (inches) for reinforced plastic mortar (RPMP) water well casings

		Casing Diameter (inches)				
		8	**10**	**12**	**14**	**16**
Max. Differential Head (ft)	**10-60**	0.17	0.17	0.19	0.22	0.25
	61-200	0.23	0.28	0.34	0.34	0.36
	201-300	0.23	0.28	0.34	0.40	0.46
	301-500	0.29	0.36	0.43	0.46	0.46
	501-750	0.33	0.41	0.46	0.46	0.46

Table 3 values are taken from Table 32-8 of NRCS NEH Part 631, Chapter 32, Well Design and Spring Development (http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=26985.wba).

Drilling

Drilling fluids used in the construction of water wells may either be water or air based. Only clean, potable water shall be used in drilling fluid, whether employed alone or in combination with drilling additives. For unconsolidated alluvium and outwash deposits, water based drilling fluids with clay or polymeric additives are typically used. Drilling fluids containing bentonite should be avoided to minimize the potential for "caking" the sides of the borehole which would result in decreased permeability and well development ability. All drilling fluids must be nontoxic and of food grade quality and drilling fluid additives should be biodegradable, NSF or UL approved. Drilling fluid additives should be stored in clean containers and should be free of material that may adversely affect the well, the aquifer, or the quality of the water to be pumped from the well.

Lead- and mercury-bearing materials shall be strictly prohibited from the wellhead area during construction.

Whenever there is an interruption of work on the well (e.g. overnight shutdown, inclement weather), the well opening shall be closed and secured with a cover designed to ensure public safety, prevent damage to the well, and prevent introduction of unwanted materials into the well. The contractor shall be responsible for any objectionable material that may fall into the well and the effect it may have on water quality, until completion and acceptance of the work by the land operator and NRCS.

Alignment. Drilled wells shall be round, plumb, and aligned so as to permit satisfactory installation and operation of a pump of the proposed size and type to the greatest anticipated depth of setting.

Special Considerations for Wells Drilled into Bedrock

Bedrock (artesian) wells can be developed by either drilling or pounding. Bedrock wells are constructed in two stages; stage 1 requires the well driller to drill a hole into firm bedrock, install protective casing and add grout to secure the casing in place. Stage 2 consists of drilling the well to the desired depth once the grout has cured and the casing is secure. In some cases, grouting may be effectively performed after completing all the drilling. Care should be taken to ensure that grout is not placed into the open-rock portion of the well. Casing should be a minimum of 20 feet in length and extend at least five feet into solid bedrock. The bottom end of the primary casing shall be equipped with a hardened drive shoe of the appropriate size. A driller may opt for plastic PVC casing because of the presence of corrosive groundwater.

In some cases, poor water quality from certain fractures, or a poor seal of the casing to the bedrock, can be eliminated by sealing off particular fracture zone(s). This can be achieved by the use of a special mechanical seal (Jaswell Seal) or concrete grouting. For PVC casings, Bentonite or a Jaswell-type seal shall be employed to effectively seal the annular space around the PVC casing. Cement grout is not permitted for use with PVC casings.

Casing

All wells shall be cased to a sufficient height above the ground surface to prevent the entry of surface and near surface water. The height of the casing above the ground surface shall not be less than one foot. The top of the casing shall be cut off reasonably smooth and level. Where a pump is not installed immediately following the construction of the well, the well shall be tightly sealed and suitably vented.

In unconsolidated formations, the casing shall extend to the screen.

For artesian aquifers, the casing shall be sealed into the overlying impermeable formations so as to retain the artesian pressure.

Sand Point Wells: The depth of a sandpoint well should be sufficient to prevent breaking suction when pumping the well at a rate 50% greater than the capacity of the permanent pump. When possible, the casing should extend to a minimum depth of 20-feet or 10-feet below the pumping level, whichever is greater. It is recommended that the individual sandpoint wells installed are 2-inches in diameter and have a minimum installation depth of 50-feet.

Bedrock Wells (drilled wells): A 20-foot minimum length shall be required with the following exceptions for specific geological and hydrological conditions: all unconsolidated overburden and other loose, caving zones shall be cased with the casing pipe or other adequate protective seal extending as great a distance below the caving zone as the driller deems necessary to ensure well stability; in consolidated formations, the casing shall extend through the overburden material to an elevation at least 10 feet into consolidated materials unless the upper ten feet of bedrock constitute the primary potable water producing zone(s), in which case, the casing length may be reduced. Annular space shall be grout filled from the frost level to the bottom of the casing except where special or unusual conditions exist, the annular space shall be grout filled from the frost level to a distance of at least ten feet below the ground surface.

Dug Wells: Dug well casings shall be made watertight to a depth of at least 8 feet below the ground surface. There should be watertight joints between the dug well's cement tiles or other approved material used to construct the side walls. The casing or side walls should extend to a depth of at least 10-feet below grade. Casing or side walls should be constructed of watertight concrete that is at least 4-inches thick or other CT Dept. of Public Health approved material.

Joining

Joints for well casing shall have adequate strength to carry the load due to the casing length and still be watertight, or shall be mechanically supported during the installation process to maintain joint integrity. Such mechanically supported casings shall terminate on firm material that can adequately support the casing weight.

Couplings used with plastic well casing may be solvent–welded or threaded, and shall have a strength equal to or greater than the pipe to which they are attached. Couplings shall be made of a material compatible with the casing and recommended for use by the casing manufacturer. If they are made of material susceptible to corrosion, provisions must be made to protect them. Threaded couplings for SDR pipe shall conform to requirements set forth in ASTM F480.

Solvent cement must meet the requirements of the ASTM specification appropriate for the material used:

ABS	D2235
PVC	D2564

To prevent galvanic corrosion, dissimilar metals shall not be joined. No solder containing more than 0.2% lead shall be used in making joints and fittings in any public or private potable water supply. In the event casing pipes are assembled together, they shall be joined by means of watertight welded joints, screw coupling joints, or slip joints. In the use of welded joints, the weld shall be at least as thick as the wall thickness of the well casing.

Screen and Filter Pack

Filter pack materials shall be approved by well driller. Materials shall be protected from the weather and contamination until installed. Materials that come in contact with the ground shall not be used.

Centralizers. Centralizers shall be installed if casing and/or screen assemblies over 40 feet long are installed in drill holes having nominal diameters 2 inches or larger than the outside diameter of the casing.

To prevent galvanic corrosion, metallic guides shall be of the same alloy as the casing or screen assembly to which they are attached. Metallic guides shall not be directly welded to the screen, but rather on short sections of blank casing that can be inserted into the well at the desired interval.

Filter Pack. Where an artificial filter pack is to be installed, the diameter of the drilled hole shall provide for adequate annular space to permit the passage of the tremie pipe(s), including couplings.

Filter pack material shall be placed with a tremie pipe from the bottom up in such a manner as to prevent segregation, bridging, or inclusion of excess material from the borehole sidewalls. The inside diameter of the tremie pipe shall be at

least 12 times the diameter of the coarsest pack material if placed by gravity, and at least 10 times if pumped. The top of the tremie pipe shall be fitted with funnel fittings so the filter pack can be shoveled or dumped into the tremie.

Clean water may be mixed with the filter pack to facilitate placement.

Artificial filter pack material shall extend a minimum of 20 feet above the top of the highest screened or perforated section, and shall extend through the entire length of the water-bearing formation penetrated by the well.

During placement of the artificial filter pack in the annular space, disinfectants (usually calcium hypochlorite in tablet or granular form) shall be added to the gravel at a uniform rate (two tablets per cubic foot or one pound of the granular form per cubic yard).

Sealing and Grouting

Any annular space between the outside of the casing and the natural materials penetrated by the well shall be filled with suitable material to make this space as impervious to the movement of fluids and competent to support the casing as are the natural materials surrounding the well.

Acceptable sealants include mortar containing expansive hydraulic cement, bentonite-based grout, bentonite chips and pellets, sand-cement grout, neat cement, or concrete.

A transition seal consisting of a 2-foot length of fine-grained sand shall be placed between the filter pack and the neat cement.

A packer or similar retaining device, or a small quantity of sealant that is allowed to set, shall be placed at the bottom of the interval to be sealed before final sealing operations begin.

Cuttings from drilling or drilling mud shall not be used for any part of the sealing material.

Dry additives should be mixed with dry cement before adding water to the mixture to ensure proper mixing, uniformity of hydration, and an effective and homogeneous seal. The water demand of additives shall be taken into account when water is added to the mix.

Venting

The well shall be properly vented at the well head to allow for pressure changes within the well. Air vents may be placed on top of the well cap or may be located on the underside of the well cap for newer style air vents. All air vents shall be screened and shielded to prevent unwanted pests from entering through the air vent.

Considerations for Installation of Pitless Adapters and Pitless Units

Installation and testing of Pitless Adapters and Pitless Units shall follow the Water Systems Council's "Pitless Adapter Standard" PAS 97(2012).

In general, Pitless Adapters shall be constructed and installed so as to prevent the entrance of contaminants into the well or water supply through opening in the well casings to which the adapters are attached. Pitless Adapters and Pitless Units shall be constructed of materials suitable to withstand normal handling, shipment, and installation practices. Below-ground lateral connections to the well casing may be made through bolt-through and compression gasket connections, by clamp and compression gasket, or by welding and shall be watertight. It shall provide adequate clearance within the internal diameter of the well to permit withdrawal or insertion of water system components from within the well through the upper terminal of the well casing. To test water tightness of the sanitary seal or its tamper, vermin and contaminant resistance, follow the Water Systems Council's "Pitless Adapter Standard" PAS 97(2012).

Wellhead Protection and Safety Considerations

Divert all surface runoff, precipitation, and drainage away from the wellhead. At the wellhead, compact, mound, and slope earth material away from the wellhead.

For some well sites, it may be necessary to install a 4-inch thick concrete slab apron extending at least 2 feet in all directions from the edge of the wellhead. The upper surface of the

base shall slope away from the well casing. Contacts between the base and the annular seal, and the base and the casing, shall be water tight and shall not cause the failure of the annular seal or the well casing.

Drilled wells often act as electrical grounds. Lightning protection of the motor and electrical controls is recommended. The National Electric Code requires a well pump to be grounded to the home's electric service and the grounding conductor to be bonded to the well casing if steel well casing is used.

VII. APPURTENANCES

Sanitary well seal. On completion, the well shall be provided with a suitable threaded, flanged, or welded cap or compression seal to prevent entry of contaminants into the well. All sanitary well caps shall be constructed of durable and weather resistant materials. Attach the cap using the manufacturer's assembly instructions to a length of well casing, meeting applicable standards, (ASTM #A53 Grade A Specification for steel, ASTM F-480 & ASTM 2241 for plastic).

For drilled wells, the well cap shall be watertight and equipped with a gasket. All bolts shall be properly secured to ensure compression of the gasket.

For a dug well, there should be a watertight joint between the well casing and the well cover. The well cover should be at least 4-inches thick and constructed of reinforced concrete. The well cover should overlap the well casing by at least 2-inches.

Air release valves shall be placed in the well system to provide a positive means for air escape or air entrance as specified by the Engineer

Access Port. An access port with a minimum inside diameter of inch shall be installed to allow for unobstructed measurement of depth of the water surface, or shut-in pressure of a flowing well. Consult with your local well driller to determine the type of access port that will best suit your well head and enable water depth readings. Access ports and pressure gages or other openings in the cover shall be sealed or capped to prevent entry from vermin. Removable caps are acceptable as access ports.

VIII. DEVELOPMENT

Wells to be completed without a filter pack in unconsolidated granular aquifers shall be developed following guidelines set forth in ASTM D5521. The method shall be selected based on the geologic character of the aquifer, type of drilling rig, and type of screen.

The well shall be developed at a continuous discharge rate of up to 120 percent of the anticipated normal production rate, until it has stopped producing detrimental quantities of solid particles and when the predetermined fraction of the filter pack has been removed.

The discharge at particular rates may be held constant for as long as 2 hours. The test pump shall have neither a check nor foot valve, so that backwashing occurs when the power is shut off. Any sand damage to the pump is the responsibility of the contractor.

After aquifer development is complete, the accumulated sediment shall be removed from the bottom of the well bore by pumping or bailing.

IX. DISINFECTION

The pump installer shall disinfect each new well system before use. Disinfection shall be accomplished by treating the water in the well, storage tank and connected piping with a chlorine solution of 100 milligrams per liter (parts per million) strength so as to obtain a residual of ten milligrams per liter (parts per million) of chlorine after three hours detention. The side walls and piping shall be rinsed with the chlorine solution. The chlorinated water shall not be removed from the water system until after a detention period of at least three hours.

X. TESTING

Pumping tests shall be performed to determine aquifer characteristics, and to determine capacity and placement of the permanent pumping equipment. All wells shall be tested for yield

and capacity in accordance with Section 19-13-B51 K(b) of the Connecticut Public Health Code. The rate of test pumping shall equal or exceed the rate of withdrawal required for the particular installation. In the case of nonpublic water supply wells with a required withdrawal rate less than ten gallons per minute, the pumping period during the drilling and clearing may be included in the time of the yield test. The minimum length of such yield test shall be four hours for a well with a required withdrawal rate of less than ten gallons per minute;* thirty-six hours for a well with the required withdrawl rate of from ten to fifty gallons per minute; and seventy-two hours for a well with a required withdrawal rate of more than fifty gallons per minute. Test pumping shall be continuous at a constant rate for the period required. The well contractor or tester shall record the date of the yield test; the water level in the well shortly before the yield test begins; the length of the pumping period; the constant pumping rate; the water level in the well at reasonable intervals after pumping begins and within five minutes before the pumping ends; and the water level in the well at reasonable intervals thereafter for a sufficient time to allow recovery to the water level prior to the yield test.

Water pumped from the well may be discharged onto the surface of the ground adjacent to the well unless:

(1) The aquifer is shallow and unconfined and the test water may recirculate into the aquifer;

(2) Released water can cause flooding or erosional damage to property or structures at the site; or

(3) The practice is not allowed by the local regulatory agency.

XI. REPORTING

A record of the installation of this practice shall be made and submitted to the local health district and NRCS. The report shall be signed by the Local Health District Director and submitted within 60 days of completion to the Examining Board for Plumbing and Piping Work and to the CT Department of Energy and Environmental Protection (CT DEEP). The Well Completion report shall include (at a minimum):

a. Landowner's Name and Address. Name, title and address of person responsible for the well.
b. Date of completion of the well
c. Location of the well (by GPS, Lat/Long or other georeferencing convention to ensure the well can be readily re-located)
d. Total well depth
e. Geologic materials and thickness of materials penetrated (well logs recorded during construction)
f. Type of material/schedule and length of the casing and screening
g. Inside diameter of the well bore or casing
h. Static water levels and any other information which may be required by the regulations adopted under the CT Well Drilling Code.
i. Water chemistry after disinfection

XII. CONTRACTOR PERIOD OF RESPONSIBILITY

The well drilling contractor shall be responsible for a period of one year from the date of completion of work performed on the well to insure that the physical construction of the well meets the requirements of the Connecticut Department of Consumer Protection Code (Sec. 25-128-55a). The contractor shall *not* be responsible if work has been performed on the well by others, or if activities by others in the vicinity of the well have adversely affected the well.