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GUIDELINES

FOR

WATER WELL CONSTRUCTION

As recommended by the
Saskatchewan Ground Water Association Inc.

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GUIDELINES FOR WATER WELL CONSTRUCTION
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SECTION 1.0: DEFINITIONS

For the purpose of these guidelines, the following definitions are established as uniform terminology within the industry.

1.1 ABANDONED WELL or BOREHOLE: (See definition for DECOMMISSIONED WELL.)

1.2 ADEQUATE WATER SUPPLY: The yield delivered by the well pump and distribution system shall be sufficient to meet the owner's stated requirements.

1.3 ALIGNMENT: The variation of the well centreline from true straightness.

1.4 ANNULAR SPACE: A ring-shaped space, such as the opening between a drill hole and a casing pipe or between a casing pipe and a liner pipe.

1.5 AQUACLUDE: A saturated formation through which virtually no water moves.

1.6 AQUIFER: A formation or stratum below the surface of the earth that both transmits and stores water in quantities that are economically feasible to extract.

1.7 AQUITARD: A formation or stratum that stores, but does not yield, water freely to a well or spring. An aquitard may transmit water to, or from, adjacent aquifers.

1.8 ARTESIAN WELL: A well deriving its water from a confined aquifer in which the water level stands above the upper surface of the aquifer without the aid of pumping equipment. A flowing artesian well is one where the water level is above the ground level.

1.9 BENTONITE: A mixture of swelling clay minerals, predominantly sodium montmorillonite.

1.10 CASING: A pipe, generally of metal, polyvinyl chloride, or fibreglass, which is installed in the borehole to maintain the opening.

1.11 CONSOLIDATED FORMATION: Any geological formation which has become firm and coherent through natural rock-forming processes. Examples of such rocks are granite, basalt, sandstone, shale, limestone, and conglomerate.

1.12 CONTAMINANT: Any deleterious solid, liquid, gas, micro-organism, odour, heat, sound, vibration, radiation, or combination thereof which is not normally present in the environment.

1.13 CONTAMINATION: The alteration of biological, chemical, or physical properties of water so as to render the water either actually or potentially detrimental, injurious, or harmful to health and safety.

1.14 DECOMMISSIONED WELL: A well or borehole that has been properly sealed so as not to produce water nor provide a conduit for movement of water.

1.15 DEVELOPMENT: The act of repairing damage to the formation caused by drilling procedures and increasing the porosity and permeability of the materials surrounding the intake or well screen.

1.16 DISINFECTION: The use of any chemical agent or process which adequately inactivates organisms (such as coliform).

1.17 DRAWDOWN: The extent of the lowered groundwater level resulting from water being pumped or flowing from a well. The difference between static and pumping water levels.

1.18 DRILLING FLUIDS: Includes air, clean water, or scientifically prepared mixtures of special purpose materials. The drilling fluid function is to lift the cuttings from the bottom of the borehole to the ground surface, to prevent caving, to seal the borehole wall to prevent fluid loss, and to cool and lubricate the drilling bit.

1.19 ESTABLISHED GRADE (OR SURFACE): The final position of contact of the ground or artificial surface with the casing pipe of the well.

1.20 FILTER PACK (SAND OR GRAVEL): Clean, well rounded, smooth, uniform sand or gravel which is placed in the annulus of the well between the borehole wall and the well screen to prevent formation material from entering the well.

1.21 GROUT: A fluid mixture (such as bentonite and/or cement), which is designed to seal all, or portions, of a borehole. For example, this may include sealing the annular space around or between well casings or filling and sealing abandoned wells.

1.22 HYDRO-FRACTURING: A method of well development whereby water (or air) is used to fracture the formation to increase the permeability.

1.23 LINER CASING: Any casing, screen, or other device inserted into a larger casing, screen, or open hole as a means of maintaining the structural integrity of the well or as a means of sealing off undesirable formation material.

1.24 PLUMBNESS: The drift, inclination, or horizontal deviation of the well centerline from vertical.

1.25 POTABLE WATER: Water that is safe for human consumption.

1.26 PUMPING WATER LEVEL: The sum of the depth to static water level plus the drawdown when a well is being pumped. This varies with both time and pumping rate.

1.27 RECOVERY LEVEL: The water level in the well at a specifIc time after the pump has been stopped.

1.28 SCREEN: Screens allow water to enter the well while screening out aquifer material. They are available in various slot sizes to match the characteristics of the aquifer. Materials used include plastic, fibreglass,and stainless steel. A properly screened and developed well will maximize the yield of sand-free water from an aquifer.

1.29 SPECIFIC CAPACITY: The yield per unit of drawdown in a water well. Usually expressed as litres/second/meter (gpm/foot) at a specific elapsed time.

1.30 STATIC WATER LEVEL (non-pumping level): The position of the water surface in a well when the well is not affected by pumping or free flow.

1.31 TREMIE PIPE: A small diameter pipe used to place materials, such as filter pack or grout, in a well.

1.32 UNCONSOLIDATED FORMATION: Any naturally occurring, loosely cemented, or poorly indurated earth material, including such formations as gravel, sand, silt, and clay.

1.33 WATER WELL: An artificial opening in the ground from which water is obtained or an opening made for the purpose of exploring for or obtaining water.

1.34 WATER WELL OWNER: Legal owner of a water well.

SECTION 2.0: SITE LOCATION

2.1 General Guidelines.

Although the water well driller is legally responsible for locating underground utilities prior to the commencement of any excavation, it is in the owner's own best interest to request or complete utility location prior to the arrival of the water well driller.

Every well shall be located:

2.1.1 So it is protected against surface wash or flooding and surrounded by an area which can be kept in a sanitary condition.

2.1.2 As far removed from any known or probable source of contamination as the general layout of the premises and surroundings permits and in accordance with all provincial health, sanitation, and sewage disposal regulations.

2.2 Relationship to Buildings.

The placement of a well in any building is not recommended. Should it be necessary, the following guidelines will be applicable.

2.2.1 No well shall be located so that the top of the well will be within any building used as a domestic dwelling. When a well is located adjacent to a building (other than a pump house), it shall be located so that the centre line of the well extended vertically will clear any projection from the building by no less than three (3) meters (ten (10) feet).

2.2.2. The pump house structure shall be such that it will permit access to the pumping equipment and the well for maintenance and repair. The pump house, in any event, shall be fitted with roof hatches; wall clearances shall be such to permit access to the well with rigs, if necessary.

2.3 Relationship to Property Lines, Highways, and Utilities.

2.3.1 Provincial regulations in respect to property lines, right-of-ways, boundaries, and road and highway setbacks shall be adhered to.

If development permits are required by provincial or municipal authorities, the well owner should be responsible for obtaining the applicable permit.

2.3.2 The minimum horizontal distance between an upright mast and an overhead uninsulated high tension power line shall be twelve (12) meters (forty (40) feet) or the height of the mast, whichever is greater.

If the power line is insulated and operates at less than 750 volts, a minimum horizontal distance of six (6) meters (twenty (20) feet) is permitted.

NOTE: Wind can cause the conductors of overhead power lines to swing out sideways. Where the distance between supporting structures of power lines exceeds thirty (30) meters (one hundred (100) feet), it may be necessary to increase the placement distances specified above.

2.3.3 The person responsible for an excavation shall ensure that no excavation work (drilling) is undertaken within one (1) meter (three (3) feet) of any underground power cable (or pipeline) unless:

2.3.3.1 the excavation work is done under the control of the operator of the underground power cable (or pipeline), and

2.3.3.2 the excavation work method is approved by the operator of the underground power cable (or pipeline), or

2.3.3.3 as the Provincial Regulatory Agency requires.

SECTION 3.0: WATER WELL CONSTRUCTION

3.1 Any completed drilled well shall have inserted in the drill hole a thoroughly tight continuous casing so as to effectively prevent the entrance of surface water or other deleterious matter into any aquifer and to prevent the intermixing of water between aquifers.

3.2 If in the drilling or construction of a well, non-potable water is found, the driller shall:

3.2.1 immediately notify the owner that non-potable water has been encountered, and

3.2.2 immediately seal off, or cause to be sealed off, the non-potable water in a manner so as to prevent the contamination of potable water in other water-bearing zones.

3.3 The minimum final casing diameter for a drilled well should be large enough to accommodate the pumping equipment, with adequate clearance to the casing.

3.4 Driven casing may be fitted at its lower end with a threaded or welded drive shoe.

3.5 The casing shall be new water well casing with the minimum specifications as shown in Table 1.0 / 1.1.

3.5.1 If API or ASTM casing is required by engineering specifications, refer to Table 2.0 / 2.1 or commercially available charts.

3.5.2 PVC casings are also acceptable provided they meet the standards of Table 3.0 / 3.1.

3.6 When corrosive water or soil is likely to be encountered, thicker wall pipe or casing than those listed in Tables 1.0 / 1.1 should be used. Steel/metal casing should also be surrounded with at least a fifty (50) mm (two (2) inch) neat cement grout in the annular space. It is recommended that sulphate-resistant cement be used. As an alternative, PVC casing could be used.

MINIMUM STANDARDS FOR PVC CASING
PVC casing (pipe) used for well casing should be at least Schedule 40.

3.6.1 PVC casing used in a water well shall meet or exceed the standards set by the Canadian Society of Testing Materials (CSTM) and/or the American Society of Testing Materials (ASTM).

3.6.2 Where PVC casing is used, it must be designated for potable water and carry the designations ASTM F-480 PVC 12454.

3.6.3 Where PVC casing is used, it shall be protected by a metal surface casing firmly anchored into the ground in such a way as to prevent damage to the PVC casing. The metal protector casing should extend from the top of the PVC casing to a depth of at least one and one-half (1.5) meters (five (5) feet) below ground surface.

3.7 The casing of any drilled well shall project not less than four hundred and sixty (460) mm (eighteen (18) inches) above the established ground surface, and at least six hundred (600) mm (twenty-four (24) inches) above the highest flood level of record. No casing shall be cut off below ground surface, except to install a pitless unit.

3.8 There shall be no opening in a casing wall below its top, except:

3.8.1 by the use of a properly installed pitless adapter designed and fabricated of such materials that will keep soil and water from entering the well during the life of the casing,

or

3.8.2 for the opening drilled into the casing to install the bonding, grounding, and electrical wires, as specified in the Canadian Electrical Code. Such minimal opening is generally located fifty (50) mm (two (2) inches) below the top of the casing.

3.9 The fluids or water used in the drilling and construction of a water well shall be free from harmful contamination. All water used in the drilling fluid should be obtained from a potable water source or be thoroughly disinfected to assure non-contamination of the water-bearing zones.

3.10 Lubricants used on drill pipe, bits, casing, or other downhole applications should be free from harmful contaminants.

3.11 Pitless adapters and pitless units shall be installed for underground water line hook-up. Pit-enclosed wells are prohibited as they impede cleaning, inspection, repair, acid treatment, and chlorine treatment. If pits must be used, they must be a minimum of six (6) meters (twenty (20) feet) away from the well.

TABLE 1.0
MINIMUM WALL THICKNESS FOR METAL WATER WELL CASING
(Metric Measurements)

Nominal Size in Inches	External Diameter (Millimeters) (mm)	Internal Diameter (Millimeters) (mm)	Wall Thickness (Millimeters) (mm)	Weight in Kilograms per Meter (kg/m) (Plain Ends)
5 1/2	140.0	130.48	4.76	16.09
5 9/16	141.3	131.78	4.76	16.09
6 5/8	168.3	158.78	4.76	19.27
7	177.8	166.0	5.90	24.90
8 5/8	219.1	206.4	6.35	33.31
10 3/4	273.1	260.4	6.35	41.77
12 3/4	323:9	311.2	6.35	49.73

TABLE 1.1
MINIMUM WALL THICKNESS FOR METAL WATER WELL CASING
(Imperial Measurements)

Nominal Size in Inches	External Diameter (Inches)	Internal Diameter (Inches)	Wall Thickness (Inches)	Weight in Pounds (lbs./ft.) (Plain Ends)
5 1/2	5.500	5.124	.188	10.70
5 9/16	5.563	5.187	.188	10.79
6 5/8	6.625	6.249	.188	12.93
7	7.000	6.538	.231	16.70
8 5/8	8.625	8.125	.250	22.36
10 3/4	10.75	10.250	.250	28.04
12 3/4	12.75	12.250	.250	33.38

NOTE: Only commonly used sizes are specified.
Metal Liner Casing: Thinner wall casing may be used for liner purposes.

TABLE 2.0
MINIMUM WALL THICKNESS DIMENSIONS AND WEIGHTS
STANDARD API CASING

(Metric Measurements - For Rotary Drilling)

Nominal Pipe Size (millimeters)	Outside Diameter (millimeters)		Thickness Inches (millimeters)	Weight Per Foot (kilograms)	Working Pressure (KPA)
101.60	114.30	SCH 40	6.02	0.92	1517
		SDR 21	5.44	0.84	1379
		SCH 80	8.56	1.28	2206
114.30	125.48	SDR 21	6.55	1.11	1379
127.00	141.29	SCH 40	6.30	1.25	1310
		SDR 21	6.73	1.28	1379
		SCH 80	9.53	1.78	2000
152.40	168.28	SCH 40	7.11	1.62	1241
		SDR 21	8.03	1.82	1379
		SCH 80	10.97	2.44	1931
203.20	219.08	SCH 40	8.18	2.45	1103
		SDR 21	10.41	3.08	1379
		SCH 80	12.70	3.71	1724
254.00	273.05	SCH 40	9.27	3.47	965
		SDR 21	12.98	4.79	1379
		SCH 80	15.09	5.53	1586
304.80	323.85	SCH 40	10.31	4.59	896
		SDR 21	15.39	6.74	1379
		SCH 80	17.48	7.60	1586

TABLE 2.1

MINIMUM WALL THICKNESS DIMENSIONS AND WEIGHTS
STANDARD API CASING

(Imperial Measurements - For Rotary Drilling)

Nominal Pipe Size (inches)	Outside Diameter (inches)		Thickness Inches (inches)	Weight Per Foot (pounds)	Working Pressure (PSI)
4	4.50	SCH 40	0.237	2.03	220
		SDR 21	0.214	1.85	200
		SCH 80	0.337	2.82	320
4 1/2	4.94	SDR 21	0.258	2.44	200
5	5.5625	SCH 40	0.248	2.76	190
		SDR 21	0.265	2.83	200
		SCH 80	0.375	3.82	290
6	6.625	SCH 40	0.280	3.58	180
		SDR 21	0.316	4.01	200
		SCH 80	0.432	5.38	280
8	8.625	SCH 40	0.322	5.40	160
		SDR 21	0.410	6.79	200
		SCH 80	0.500	8.17	150
10	10.75	SCH 40	0.365	7.66	140
		SDR 21	0.511	10.57	200
		SCH80	0.594	12.19	130
12	12.75	SCH40	0.406	10.12	130
		SDR 21	0.606	14.87	200
		SCH 80	0.688	16.76	230

TABLE 3.0

MINIMUM THICKNESS FOR PVC WELL CASING
ASTM F-480 PVC 12454
(Metric Measurements)

Outside Diameter (inches) Actual	External Diameter (Millimeters) (mm)	SDR/SCH	Wall Thickness Kilograms/Meter (mm)	Weight in Air (Kg/m)	Hydraulic Collapse Pressure (KPa)
4.950	125.73	SDR 21	6.54	4.392	7922.93
5.563	141.30	SCH 80	9.52	5.982	2413.25
		SDR 21	6.72	4.286	792.93
		SCH 40	6.54	4.182	723.98
6.000	152.40	SDR 21	9.52	6.087	2206.4
6.625	168.30	SCH 80	10.96	8.155	2165.03
		SDR 21	8.02	6.087	634.34
		SCH 40	7.10	5.432	537.81
6.90	175.00	SDR 18	10.00	7.98	1034.00
8.625	219.05	SCH 80	12.70	12.382	1489.32
		SDR 21	10.40	10.283	792.93
		SCH 40	8.18	8.185	372.33
9.05	230.00	SDR 18	13.0	13.75	1034.00
10.750	273.05	SCH 80	15.06	18.379	1268.68
		SDR 21	12.98	15.968	792.93
		SCH 40	9.26	11.578	275.80

TABLE 3.1

MINIMUM THICKNESS FOR PVC WELL CASING
ASTM F-480 PVC 12454
(Imperial Measurements)

Outside Diameter (inches) Nom.	Actual	SDR/SCH	Wall Thickness Min. (in.)	Weight in Air lbs/100ft.	Hydraulic Collapse Pressure (PSI)
4.5	4.950	SDR 21	.258	230	115
5	5.563	SCH 80	.375	391	350
		SDR 21	.265	283	115
		SCH 40	.258	276	105
6	6.000	SDR 21	.375	428	320
6	6.625	SCH 80	.432	538	314
		SDR 21	.316	387	92
		SCH 40	.280	358	78
6.9	6.13		.383	536	150
8	8.625	SCH 80	.500	818	216
		SDR 21	.410	678	115
		SCH 40	.322	539	54
9.05	8.05		.502	924	150
10	10.750	SCH 80	.593	1210	184
		SDR 21	.511	1050	115
		SCH 40	.365	764	40

TABLE 4.0

MINIMUM WALL THICKNESS DIMENSIONS AND WEIGHTS
STANDARD API CASING
(Metric Measurements - For Percussion and Rotary Drilling)

Nominal Size in Inches	External Diameter (Millimeters) (mm)	Internal Diameter (Millimeters) (mm)	Wall Thickness (Millimeters) (mm)	Weight in Kilograms per Meter (kg/m) (Plain Ends)
5 1/2	140	128.4	5.79	19.14
6	152.4	140.3	6.04	21.84
6 5/8	168.3	155.8	6.22	24.88
7	178.8	166.2	5.90	24.89
7 5/8	193.7	180.9	6.40	29.35
8 5/8	219.1	205.7	6.70	35.14
9 5/8	244.5	231.2	7.10	41.80
10 3/4	273.0	258.9	7.09	46.51
11 3/4	298.4	283.3	7.62	54.70
13 3/8	339.7	322.9	8.38	68.55
16	406.4	390.56	7.92	77.83
18 5/8	473.1	450.98	11.05	126.00
20	508.0	485.74	11.13	136.37

TABLE 4.1

MINIMUM WALL THICKNESS DIMENSIONS AND WEIGHTS STANDARD API CASING

(Imperial Measurements - For Percussion and Rotary Drilling)

Nominal Size in Inches	External Diameter (Inches)	Internal Diameter (Inches)	Wall Thickness (Inches)	Weight in Pounds (lbs/ft.) (Plain Ends)
5 1/2	5.500	5.044	.228	12.84
6	6.000	5.524	.238	14.65
6 5/8	6.625	6.135	.245	16.69
7	7.000	6.538	.231	16.70
7 5/8	7.625	7.125	.250	19.69
8 5/8	8.625	8.097	.264	23.57
9 5/8	9.625	9.063	.281	28.04
10 3/4	10.750	10.192	.279	31.20
11 3/4	11.750	11.150	.300	36.69
13 3/8	13.375	12.715	.330	45.98
16	16.000	15.375	.312	52.36
18 5/8	18.625	17.755	.435	84.51
20	20.000	19.124	.438	91.41

SECTION 4.0: USE OF GROUTING MATERIALS

4.1 A water well shall be constructed so as to effectively prevent the entrance of surface water or other deleterious matter into an aquifer and to prevent the intermixing of formation water.

4.2 The casing may be set to the top of the aquifer or into an aquaclude or aquitard, and the casing shall be surrounded by a bentonite or bentonite-cement grout of at least fifty (50) mm (two (2) inches) in thickness. Such grout seal shall extend the entire length of the casing that is in the borehole to prevent the intermingling of waters from different aquifers on the outside of the casing.

4.3 In unconsolidated formations of a caving nature, the placement of a grout seal the entire length of the casing may be impractical and/or impossible to attain. In these situations the SGWA recommends that the top five (5) meters (sixteen (16) feet) of the borehole be drilled one hundred (100) mm (four (4) inches) larger than the finished well casing to permit the placement of the grout seal in order to prevent the intermingling of waters from different aquifers on the outside of the casing. It may be necessary in these situations to use a temporary larger casing to hold back the caving formation. This casing could then be removed as the grout is placed.

4.4 The SGWA recommends that if the casing is being driven in an unconsolidated, caving formation, the annulus should be kept full of a bentonite slurry so that it will follow the casing down the hole. This does not supersede the requirement of Section 4.3, but is in fact an added recommendation in an attempt to enhance the grouting process.

SECTION 5.0: FLOWING WELLS

5.1 The water well contractor shall, before commencing the drilling of any well, determine whether the area in which he proposes to drill has a history of flowing wells.

5.2 If the well is drilled in an area that has a history of flowing wells, it shall be assumed that the well being drilled has the potential of being a flowing well, and the well shall be drilled in such manner so as to enable the contractor to stop any flow of water that might occur from a flowing well. Notwithstanding #5.1 above, the contractor shall take all reasonable precautions to prevent any well from flowing out of control.

5.3 All completed flowing wells should be equipped with a device to completely control the flow of water from the well.

After the installation of the control device, the driller should be able to stop the flow of water by adjusting the control valve and should ensure that no water escapes up the annulus between the casing and borehole. If water does escape, the annulus should be effectively sealed by grouting.

5.4 The owner of a flowing well shall ensure that the well is at all times fitted with a flow control device, and the well should not be allowed to flow in excess of the requirements of the well owner.

5.5 The SGWA strongly endorses the concept that the onus of responsibility for control of flowing wells, and the problems associated with flowing wells, should not lie solely with the water well contractor, but also with the owner and the respective provincial agency responsible for the administration of the groundwater resource. All legislation enacted should recognize that the occurrence and subsequent development and control of flowing water wells can be unpredictable and costly.

5.6 The SGWA recommends use of mud-weight material in anticipation of flow problems.

5.7 The SGWA recommends prior installation of adequate surface casing and that the casing be cemented with calcium chloride concentration.

5.8 Water wells constructed in flow areas should be constructed on as high of ground as practicable.

SECTION 6.0: BORED AND DUG WELLS

6.1 General.

The following applies to bored wells (dug or augered wells):

6.1.1 Every well shall be provided with a cover that is securely fastened, has not more than a six (6) mm (one-quarter (1/4) inch) clearance between the overlap and the casing, and does not allow water to enter through the top.

The cover of a bored or dug well shall be made of substantial reinforced water-tight concrete at least fifty (50) mm (two (2) inches) thick, or steel of at least three (3) mm (one-eighth (1/8) inch) thick, or fibreglass of sufficient strength to support a minimum weight of one hundred and thirty (130) kilograms (three hundred (300) pounds) and of sufficient diameter to overlap the well cribbing by at least fifty (50) mm (two (2) inches). The cover shall be free from joints. A tight joint shall be provided between the top of the well and the cover. The top of the slab shall be sloped to drain away from the well.

6.1.2 A pipe or other similar type connection made to the casing shall be effectively sealed.

6.1.3 The well shall in no case be constructed of wood.

6.1.4 An impervious seal shall be placed below the frost line to prevent contamination. The top portion of backfill material shall be clay or material natural to the environment and sloped to drain away from the well.

6.1.5 Fibreglass, plastic, or corrugated steel cribbing are acceptable well construction materials.

6.1.6 All steel water well cribbing shall meet the corrugated steel pipe institute spec. C.S.A. CAN3-G401-M81, deleting reference to products not applicable to well cribbing size.

6.1.7 Any bored well shall be constructed so that sand can not enter the well from the bottom. This can be accomplished by setting the cribbing into clay (impermeable formation) or by adding a bottom cap during installation.

6.1.8 If water is used in boring, it shall be chlorinated with a solution containing two hundred and fifty (250) mg/l (ppm) chlorine to insure sanitation of the well.

6.1.9 Before proceeding with a bored well, it is strongly recommended that a small diameter test hole be drilled to locate an aquifer. A chemical analysis of the water may be done at the time the test hole is drilled.

6.2 Equipment Location.

6.2.1 No installation of pumping equipment or appurtenances requiring access to the interior of the well for maintenance or repair operations which requires personnel to enter into the well is permitted.

SECTION 7.0: DEVELOPMENT

7.1 The drilling contractor shall develop the well so that upon final completion no damage to the water system shall result due to excessive sediment content in the water or continuous pumping of any sand.

7.2 Developing can be accomplished by bailing, air-lift pumping, jetting with water, or with a surge block to remove fine sediment from the well.

SECTION 8.0: PUMP TESTING

8.1 No water well contractor shall complete the construction of a well without performing an adequate yield test to determine the rate of yield of the well.

8.2 The test shall be carried out in accordance with the regulations of water well construction and testing procedures as determined by the provincial regulatory agency. However, SGWA recommends that for domestic wells the following should be considered:

8.2.1 The rate of the flow during the testing of a well must be at least equal to the expected pumping rate of the well.

8.2.2 The test shall be conducted:

8.2.2.1 for at least two (2) hours, or

8.2.2.2 until twelve thousand (12,000) litres (two thousand six hundred and forty (2,640) gallons) have been removed with the pumping rate held constant.

8.2.3 A static water level shall be measured prior to the commencement of each yield test. Drawdown shall be measured and recorded on the Water Well Driller's Report.

8.3 A schedule of measurements shall be taken for drawdown and recovery. A sample schedule is displayed below:

1 minute	20 minutes
2 minutes	25 minutes
3 minutes	30 minutes
4 minutes	40 minutes
6 minutes	60 minutes
8 minutes	80 minutes
10 minutes	100 minutes
13 minutes	120 minutes
16 minutes	

When pumping is completed, use the same schedule of readings for an equal period of recovery.

8.4 In domestic water well applications, yield testing should be done using a pump; however, air lift pumping or bailing would be considered as an acceptable alternative provided a static water level is recorded, the discharge flow is maintained at a constant measured rate, and recovery measurements of an equal time to the air lift pumping or bailing time are taken and recorded.

8.5 In municipal, industrial, and commercial water well applications, a minimum of twenty-four (24) hours of pump testing and recovery time is required, unless otherwise instructed by Sask Water.

SECTION 9.0: PLUMBNESS AND ALIGNMENT

9.1 The well shall be sufficiently plumb and straight to ensure that no interference occurs during installation, operation, or removal of the pump.

9.2 For larger diameter drilled wells, where lineshaft turbine pumps may be used, it is recommended that the American Water Works Association Al00 standards (1990) be used. The maximum horizontal deviation of the well from vertical shall not exceed two-thirds of the inside diameter of the smallest portion of that part of the well being tested per thirty point five (30.5) meters (one hundred (100) feet). If submersible pump equipment is to be used, a larger tolerance, as advised by the supplier, may be acceptable.

9.3 Alignment is tested by lowering a twelve (12) meter (forty (40) foot) pipe into the well. The outside diameter of pipe shall not be less than twelve point seven (12.7) mm (point five (0.5) inches) than the casing or hole being tested. This pipe, often referred to as a dummy, shall move freely throughout the length being tested.

SECTION 10.0: WELL COMPLETION

10.1 Screens.

10.1.1 Well screens can be manufactured of polyvinyl chloride (PVC), 304 or 316 stainless steel, or fibreglass. Use of well screen is highly recommended in all well construction. SGWA can not overemphasize the listed criteria below when considering efficiency and long-term life of a well. Screens may be screwed or welded or telescoped.

10.1.1.1 Large percentage of open area.
10.1.1.2 Non~clogging slots.
10.1.1.3 Corrosion resistant / acid resistant.
10.1.1.4 Sufficient column and collapse strength.
10.1.1.5 Control sand pumping in all aquifers.

10.1.2 Screens shall have openings properly sized to exclude the granular material from the developed aquifer.

10.1.3 Telescoping screens shall be sealed to the inside of the casing using a neoprene packer or similar seal. Screens shall be set through the casing in a manner that will permit removal and replacement without adverse effect on the water-tight construction of the well.

10.1.4 Screens shall have a corrosion-resistant bottom – a bail plug, self-closing type or washdown type.

10.2 Open Hole.

In areas where geological conditions permit, open hole construction is acceptable provided that the casing used is sealed according to Section 4.0 of these Guidelines.

10.3 Perforated or Slotted Liner Completion.

Perforated or slotted liner completion is an approved method where geological conditions require the borehole to be supported and where protection of the pumping equipment is necessary. Liners shall extend into the surface casing and be of material acceptable to local geological and water quality factors.

The use of perforated casing as a working casing as the hole is being drilled is not recommended.

SECTION 11.0: WELL SERVICING SAFETY

11.1 Comply with existing regulations. Refer to Occupational Health & Safety Act, Workers' Compensation, TDG (Transport of Dangerous Goods) Act, WHMIS (Workplace Hazardous Materials Information Systems).

SECTION 12.0: EXPLORATION HOLES

12.1 Drilled exploration holes.

12.1.1 A good quality E-Log should be obtained for each exploration hole, and the test hole driller's log and the original E-log shall be submitted to the well owner and Sask Water.

12.1.2 Logs are headed with company name, well owner's name, date, accreditation number, legal land description, log scales, mud conductivity, drill water conductivity, operator, address and phone number, bit number, and depth.

12.1.3 Water for E-logging purposes should not exceed one thousand five hundred (1,500) umhos/cm for logging purposes.

12.1.4 Each electric logger is to be accredited and renewed regularly and is to be in good working order.

12.1.5 For an open hole, when an aquifer is encountered, the hole should be continuously plugged with bentonite, cement slurry, or grout from below the lowest aquifer to above the highest aquifer.

12.1.6 If no water-bearing aquifer is encountered, then the test hole should be filled with the material removed. A bentonite plug shall be placed at the top one (1) metre (three point two eight one (3.281) feet) to prevent any surface contamination from entering the hole.

12.2 Augered exploration holes.

12.2.1 If a sand or gravel layer is encountered, and no well is to be completed at this site, then the hole shall be filled with cuttings, compressed with the auger, and a mixture of bentonite and cuttings should extend from three (3) metres (ten (10) feet) below ground to the surface.

12.2.2 Test hole logs for all of the augered holes shall be submitted to Sask Water.

SECTION 13.0: DECOMMISSIONING (ABANDONMENT) OF WELLS

13.1 When a completed well or water well is to be decommissioned (abandoned), it shall be effectively sealed with suitable uncontaminated material to prevent the entry of both surface water and the intermixing of groundwater from different aquifers.

13.2 If non-potable water enters a well after the date of completion of a well, the owner shall immediately seal off, or cause to be sealed off, the non-potable water in a manner as prescribed by the Provincial Regulatory Agency, so as to prevent impairment of the quality of other water.

13.3 If a water well is abandoned as stated, suitable uncontaminated material (e.g. sand, drill cuttings, etc.) should be placed opposite the aquifers with the bentonite or cement-bentonite grout between the aquifers. If the distance between aquifers is such that it is impractical to fill the borehole with grout for the entire length, suitable uncontaminated material may be used provided the grout plug is placed to prevent the vertical movement of the water.

13.4 Decommissioning (abandonment) of wells with casings or screens in the borehole. The hole must be filled with suitable uncontaminated material opposite the screen, perforation, or open hole areas where aquifers exist. Grout plugs must be placed so as to prevent intermixing of waters from different aquifers or the vertical movement of water.

13.5 In all decommissioning (abandonment) situations, the top three (3) meters (ten (10) feet) shall be a cement-bentonite grout.

13. 6 Abandoned wells shall have the casing or curbing removed one (1) meter (three point three nine (3.39) feet) below ground and be backfilled with compacted excavation material to the original ground level.

13. 7 Report abandonment to Sask Water.

SECTION 14.0: WATER ANALYSIS

14.1 Since the water well contractor has no control over the quality of water present in any specific aquifer, the onus for obtaining a water analysis and the cost thereof must be the responsibility of the well owner. Provincial health and/or environmental regulations generally state parameters of drinking water standards.

During the test drilling, the water well contractor may provide some preliminary guidance as to water quality by testing the conductivity, hardness, and iron content of the water.

14.2 The SGWA recommends that well owners be made aware that it is to their benefit to have an analysis done periodically on their well water.

SECTION 15.0: DISINFECTION

15.1 General.

15.1.1 Disinfection of any well will kill only the bacteria present in the well or on the pumping equipment. However, if there is some external source of contamination, the problem will be solved only temporarily by a single application of chlorine solution.

15.1.2 In order to protect water wells from contamination by iron bacteria, or the contamination of an aquifer by iron bacteria from a contaminated aquifer in the same well, a minimum chlorine residual of 250 mg/l (ppm) should be maintained continuously in the drilling fluid.

15.1.3 All drilling tools shall be thoroughly cleaned and disinfected with a chlorine compound prior to each new well construction.

15.1.4 Every well, after construction or repair, shall be disinfected.

15.2 Time of Disinfection.

15.2.1 Normally, the time that a well should be disinfected is when construction is considered complete and the well has been tested for yield.

15.2.2 If a well is intended for the production of water for human consumption, the driller shall:

15.2.2.1 when the drilling contractor installs the pump fittings, disinfect the well after the installation of the pump and fittings, and

15.2.2.2 when the drilling contractor does not install the pump, disinfect the well when the drilling contractor completes work on the well.

15.2.3 The quantity of chlorine compounds used for disinfecting a well shall be sufficient to produce two hundred and fifty (250) mg/l (ppm) of chlorine solution when mixed with the total volume of water retained within the well. Refer to Tables 5.0 and 6.0.

15.2.3.1 Well without pump - liquid chlorine: Measure the diameter of the well and calculate the volume of chlorine bleach (5.25% active chlorine) required, using Table 5.0. Take the volume of chlorine bleach determined from the Table and mix this in at least forty-five (45) litres (ten (10) gallons) of water. Pour this solution into the well and let it stay in the well for at least twelve (12) hours. Pump the well for at least one (1) hour to remove the chlorine solution.

15.2.3.2 Well with pump - liquid chlorine: Measure the diameter of the well and calculate the volume of chlorine bleach (5.25% active chlorine) required, using Table 5.0. Take the volume of chlorine bleach determined from the Table and mix this in at least forty-five (45) litres (ten (10) gallons) of water. Pour the solution into the well between the drop pipe and the outer casing. This may be done by pouring or siphoning through the air vent or by removing the well seal. Where the casing has a well cap, remove the well cap and pour the solution directly into the well. Open all faucets in the system and let the water run until the chlorine odor or taste is detected. Turn the water off and add a second volume of chlorine bleach (the same amount as initially added). Seal the top of the well. Let the system sit idle for twelve (12) hours. Discharge the water from all outlets until chlorine odor and taste have disappeared. Faucets on fixtures discharging to septic tank systems should be temporarily diverted to an outside discharge point, to avoid overloading the disposal system.

15.2.3.3 Disinfection with chlorine tablets or powder: Chlorine tablets normally contain about 65 to 70% available chlorine present in calcium hypochlorite. Users should be aware that these tablets may cause chemical burns, fire, or explosion if adequate safety precautions are not taken. Always follow the directions on the label prior to usage. Measure the diameter of the well and calculate the weight of the tablets required per thirty (30) meters (one hundred (100) feet) of water using Table 6.0 (250 mg/l (ppm) solution). Place the required weight of tablets into the well by removing the well cap or seal. When the plumbing system is also being disinfected, pump the chlorine solution until a chlorine odor is detected at each faucet or tap. Leave the solution in the well and plumbing system for at least twelve (1 2) hours. Discharge water from all outlets until the chlorine odor and taste have disappeared.

15.2.3.4 The time of contact with the chlorine solution referred to in this subsection shall be at least twelve (12) hours.

METHODS FOR DISINFECTING WATER WELLS

TABLE 5.0
WELL WITHOUT PUMP — LIQUID CHLORINE

Well Diameter mm	Well Diameter inches	Litres of 5% Bleach per 30 Meters (100 Feet) of Water in Well (for 250 mg/l (ppm) solution)
100	4	1.5
130	5	2.25
150	6	3.0
200	8	5.0
250	10	8.5
300	12	12.0
610	24	43.5

TABLE 6.0
DISINFECTION WITH CHLORINE TABLETS OR POWDER

Well Diameter mm	Well Diameter inches	Grams of 65-70% Chlorine Tablets 30 meters (100 feet) of Water in Well (for 250 mg/l (ppm) solution) Dry Weight g	oz
100	4	100	3.5
150	6	282.5	10.0
200	8	425	15.0
250	10	565	20.0
300	12	850	30.0
610	24	3400	120.0

SECTION 16.0: PUMP INSTALLATION

16.1 Use of pitless adapters or pitless units are strongly recommended by the SGWA.

16.2 The placement of a well inside of a building is not recommended. Should it be necessary to locate a well in a pump house, the Guidelines as set out in Section 2.2.1 & 2.2.2 of these Guidelines shall be followed.

16.3 All pitless adapters shall be welded, threaded to, or otherwise secured to the casing in a water-tight manner so as to prevent the entrance of surface water or contaminated matter of any kind into the well. There shall be no opening below ground through the wall of the well or the adapter casing for vents, wire, air lines, etc., and the casing shall extend not less than five hundred (500) mm (eighteen (18) inches) above level of established grade.

16.4 Pitless Adapter (See Figure IA / Figure IB)

A pitless adapter is designed with a quick-disconnect mechanism that allows easy access for well servicing. It also provides a quick and easy method for removing the submersible pump from the well.

16.5 All small diameter well caps or covers should be waterproof, insect proot and vented.

16.6 When polyethylene pipe is used, a minimum 160 psi submersible drop pipe shall be used. When using polyethylene pipe, all fittings in the well shall be brass or stainless steel, with all clamps stainless steel. When the limitations of the polypropylene rope are exceeded due to depth or weight, a stainless steel safety cable shall be installed. Polypropylene rope may only be used in bored wells.

16.7 Wire size for submersible electrical cable is approved as per manufacturer specifications, or any local code that may supersede, and such cable shall be grounded in an approved manner as per motor manufacturer specifications.

16.8 The submersible electrical cable shall be fastened to a drop pipe at a minimum of three (3) meter (ten (10) foot) intervals. Examples of common fasteners are electrical tape, clamps, or straps.

PITLESS ADAPTER FOR SUBMERSIBLE PUMPS

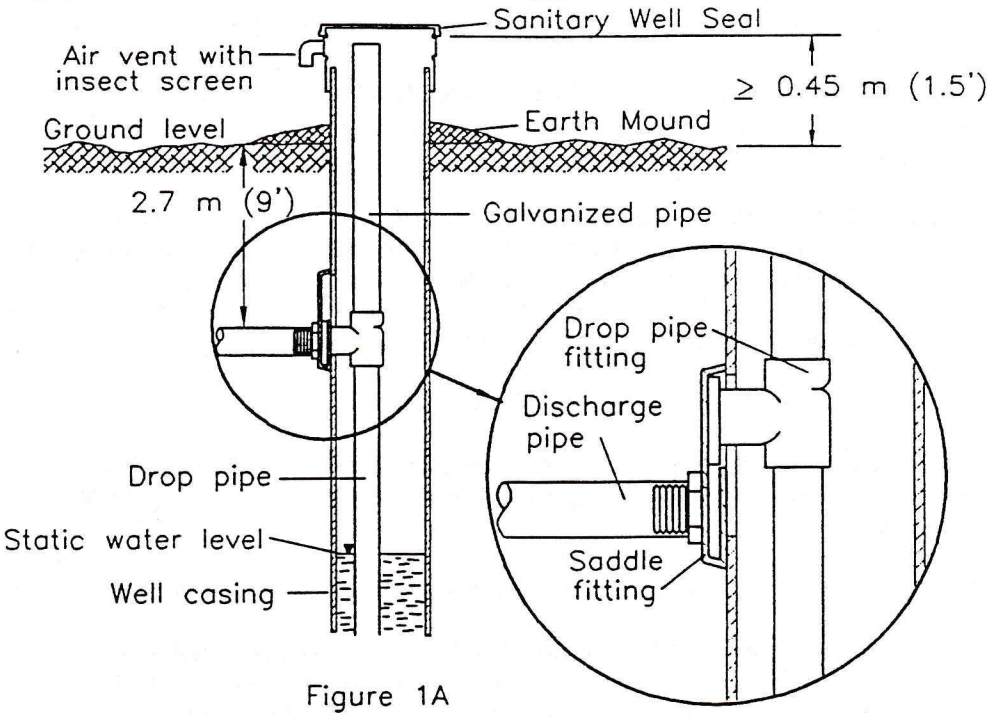

Figure 1A

POLYMER COMPOSITE PITLESS ADAPTER FOR SUBMERSIBLE PUMPS

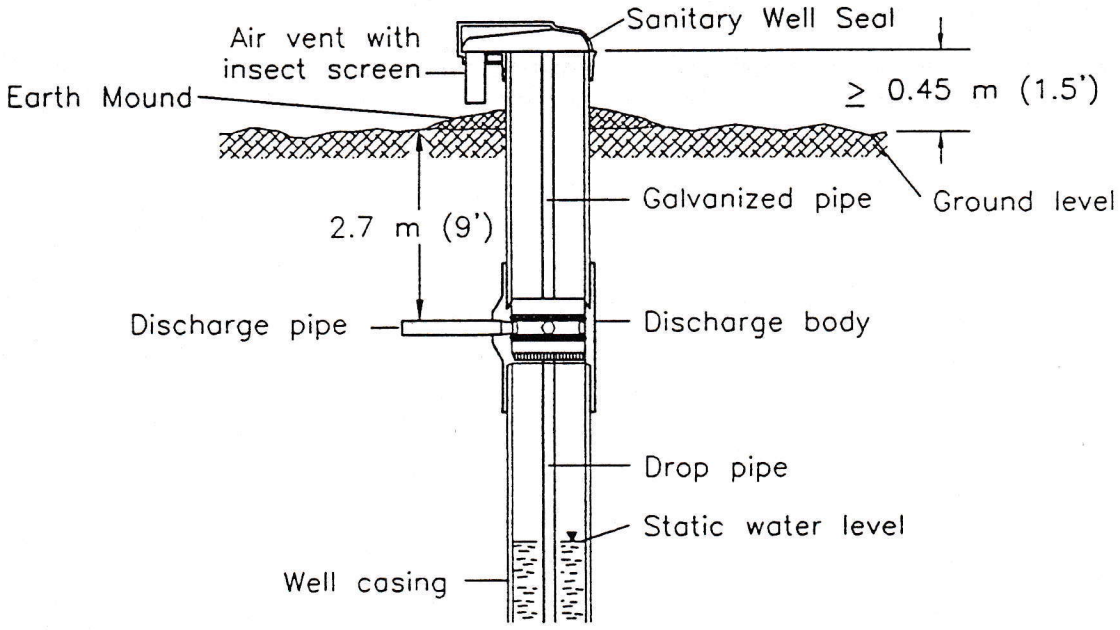

Figure 1B

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SECTION 17.0: REPORTS, PERMITS, AND LICENSES

17.1 Provincial regulatory agencies requires that a Water Well Driller's Report be completed within sixty (60) days of the date of completion of any test hole or well.

17.2 The Water Well Report shall be completed in triplicate:

17.2.1 The white copy forwarded to the Provincial Regulatory Agency;

17.2.2 The yellow copy to the owner of the well;

17.2.3 The pink copy to be retained by the drilling contractor.

After the well installation has been completed, the well log, well construction details, pump test results, and E-log shall be given to the well owner. The originals of this information shall be submitted to the Provincial Regulatory Agency (Sask Water).

17.3 The SGWA recommends that all provinces should give trade designation to the profession of water well drilling and establish training programs so that reciprocal agreements regarding qualification of drillers would be recognized across Canada.

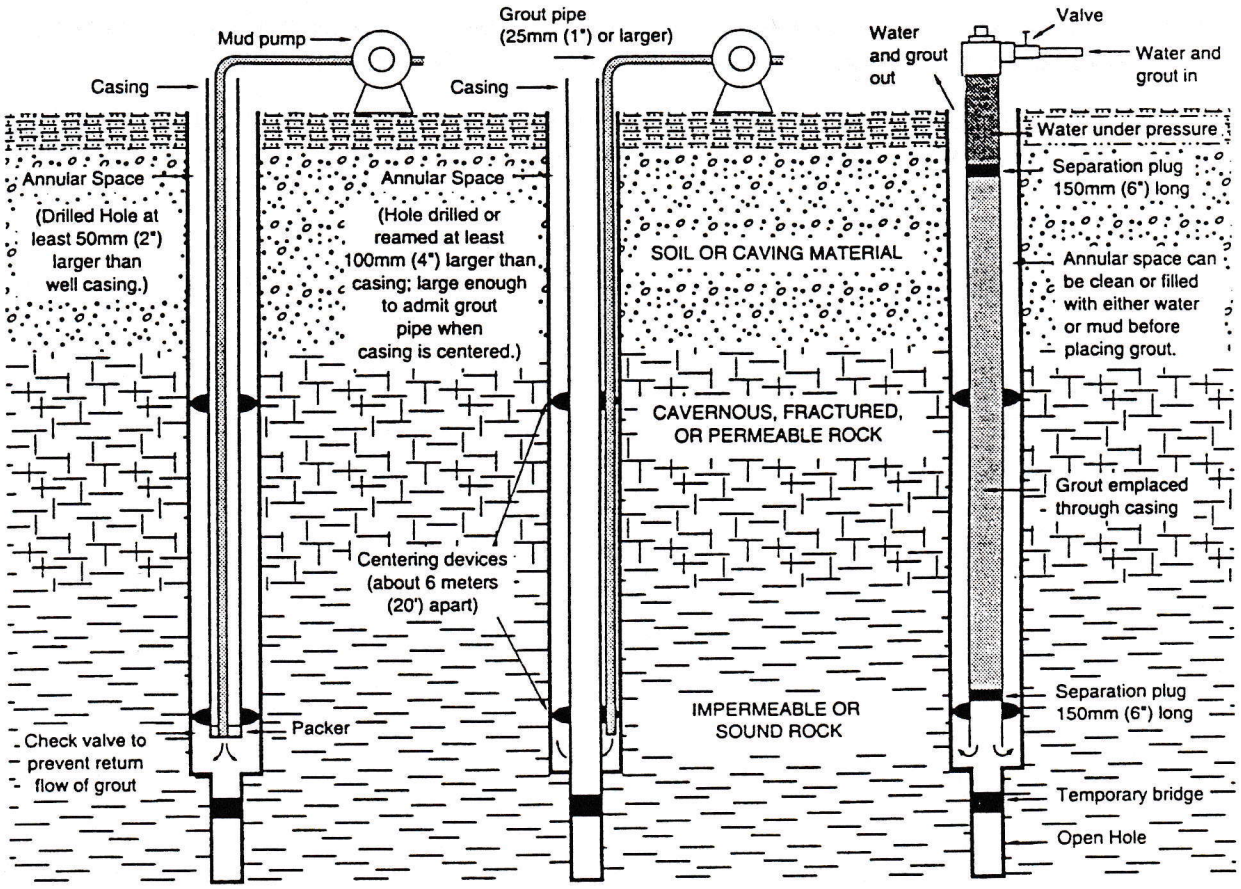
17.4 The SGWA recommends that all water well drilling contractors be licensed and that the training and certification of drillers be a prerequisite to obtaining the license.

17.5 The SGWA recommends that all provinces establish standards of well construction, licensing, and permitting. These standards and regulations should be prepared in consultation with the industry association of each province.

17.6 The SGWA recommends that any regulations put into effect be enforced by the Provincial Regulatory Agency. The SGWA recognizes the need to protect ground water from pollution and contamination. As a result, a strict adherence to a practical and workable regulation through enforcement is the key to success.

PERSONAL NOTATIONS

METHODS OF GROUTING



TYPES OF WELLS

It is impossible to describe all types of wells. However, the following diagrams provide some idea of the most common types of well completion. In constructing any well, the following principles should be kept in mind:

1. The well should be designed so that water-bearing formations that are contaminated or have an undesirable quality of water are sealed off.

2. The well should be so designed that no openings will be formed between the ground surface and the water-bearing formation, other than that through which the water is produced.

3. The materials that are to be part of the permanent well should be of the highest quality available for use in normal well construction in the specific area.

TYPE 1: UNCONSOLIDATED FORMATION. CAVING MATERIAL ONLY.

If the formations are of a caving nature for the full depth of a well, finished with a screen at the bottom, a single casing may be sufficient. It is recommended, however, that the opening made during construction outside the upper part of the casing be filled with bentonite grout to minimize the likelihood of surface pollution working down around the casing. In order to place the grout, it may be necessary to install a larger temporary casing which is withdrawn as the grout is placed. In this type of construction, the screen is sealed to the well casing by means of a packer and it may be replaced if necessary.

TYPE 2: UNCONSOLIDATED FORMATION UNDERLYING CLAY OR MATERIAL THAT IS NON-CAVING. SCREENED COMPLETION.

When the aquifer lies beneath non-caving material, the grout should extend the entire length of the casing to ensure sealing of the annular space. This method should be used whenever possible. It does require drilling a hole one hundred (100) mm (four (4) inches) larger than the diameter of the casing to allow for placement of the grout.

Type 3, 4, and 5 open hole well completions are generally not suitable for conditions encountered in the Saskatchewan prairie setting. Therefore, unless exceptional conditions present themselves, open hole well completion is not recommended.

TYPE 3: CONSOLIDATED FORMATION UNDERLYING CAVING FORMATION. OPEN HOLE COMPLETION.

When the aquifer lies beneath caving formations, it may be necessary to place a larger temporary casing in the top five (5) meters (fifteen (15) feet) of the hole to allow for the placement of grout. The grout seal should be placed as the temporary casing is withdrawn.

TYPE 4: CONSOLIDATED FORMATION UNDERLYING NON-CAVING FORMATION. OPEN HOLE COMPLETION.

TYPE 5: CONSOLIDATED FORMATION UNDERLYING NON-CAVING FORMATION. SLOTTED LINER COMPLETION.

BASIC WELL DESIGN FOR GRANULAR AQUIFERS

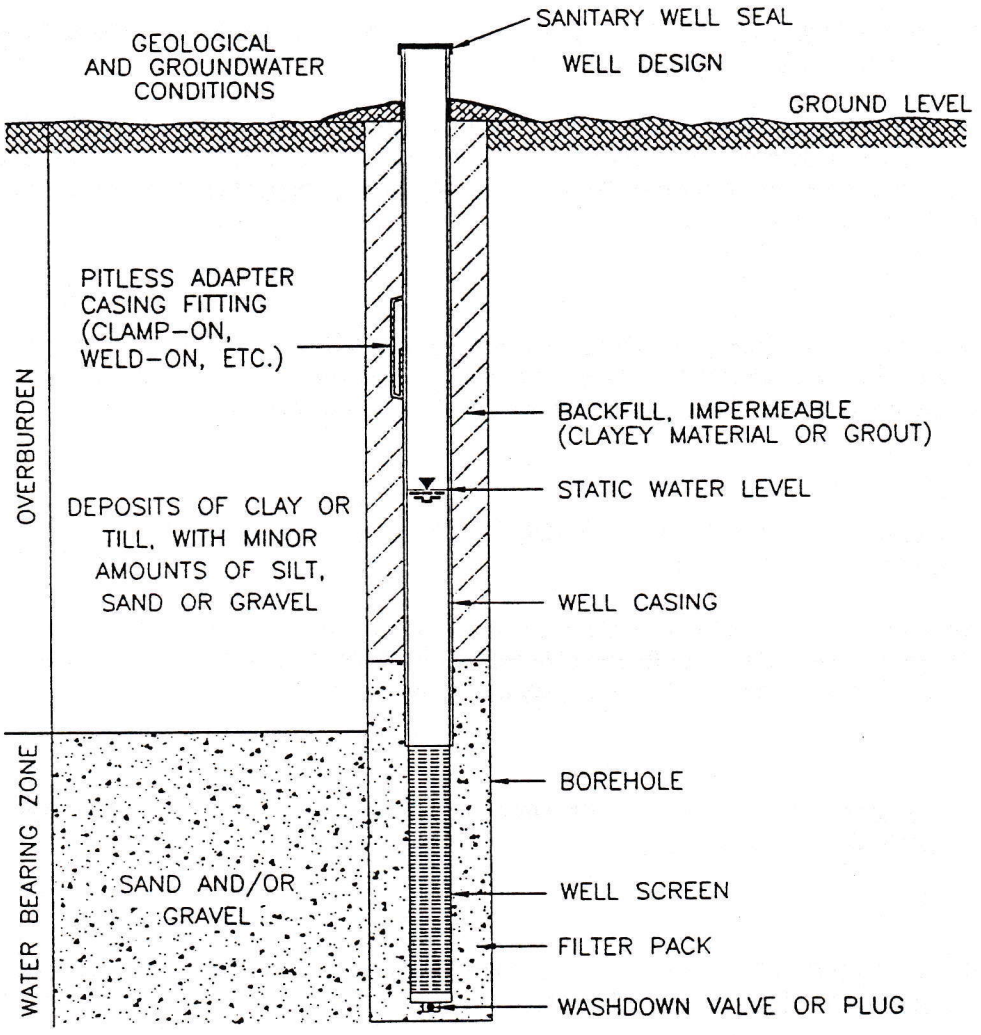


Figure 2

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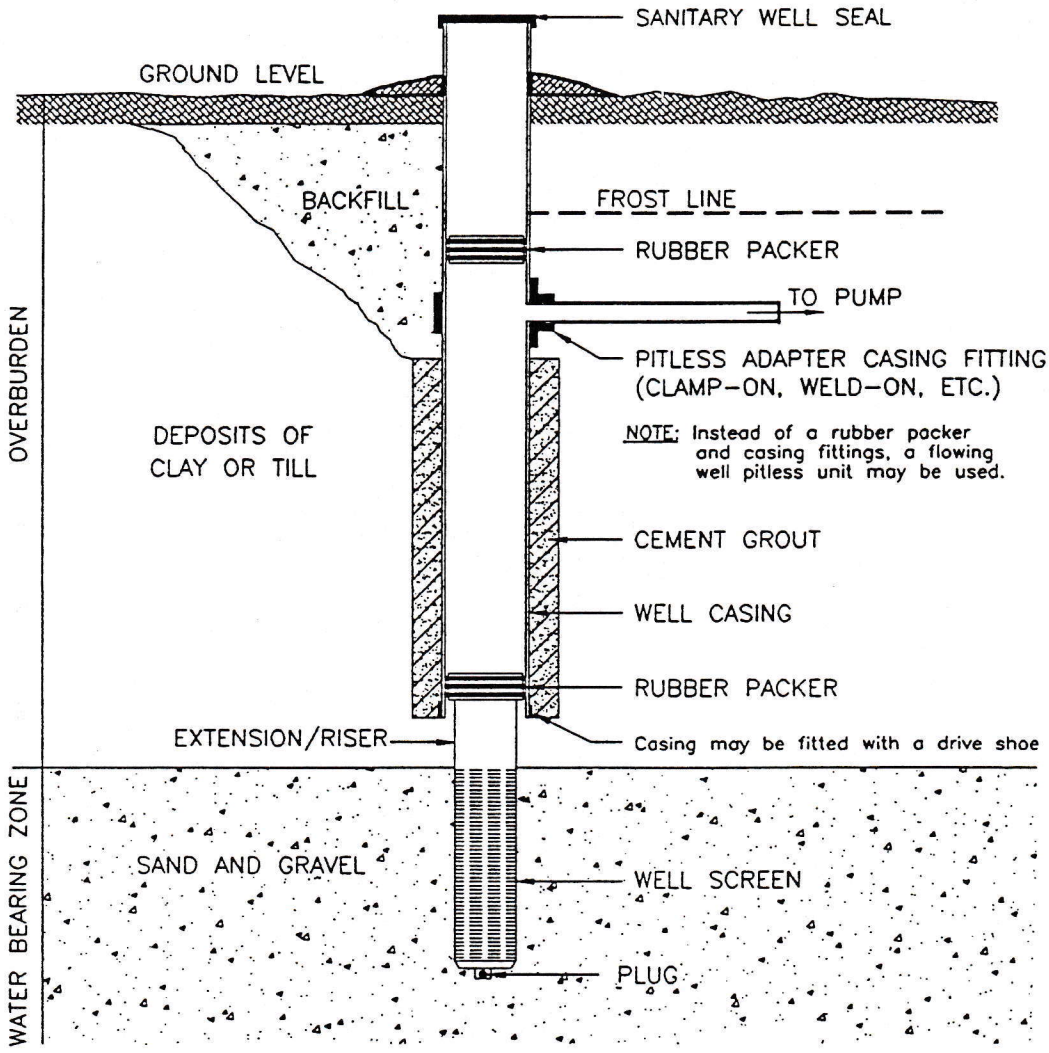
BASIC WELL DESIGN FOR CONTROLLED FLOWING WELLS



NOTE: 1. This design is also advisable in places where the water level is below ground level but above or near basement floor level.

2. A larger primary casing may be required to be cemented into clay or till before actual production hole is drilled and well casing is installed.

Figure 3

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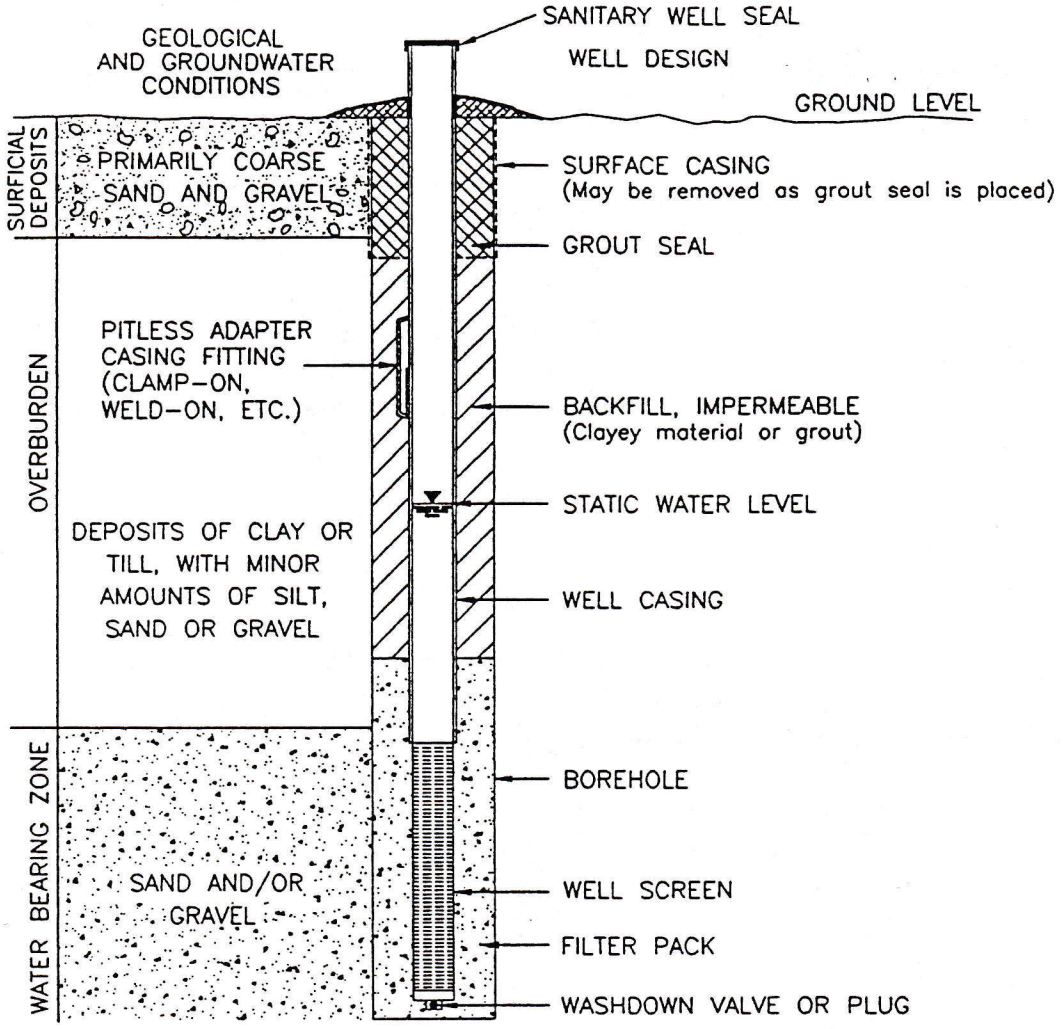
BASIC WELL DESIGN FOR GRANULAR AQUIFERS WITH SURFICIAL DEPOSITS PRONE TO CAVING



NOTE: Similar design could also be used where the entire overburden interval is subject to caving. In this case, another design option would be to place an impermeable seal along the entire length of the casing and telescope the well screen into place.

Figure 4

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LARGE DIAMETER WELL CONSTRUCTION IN SURFICIAL AQUIFER

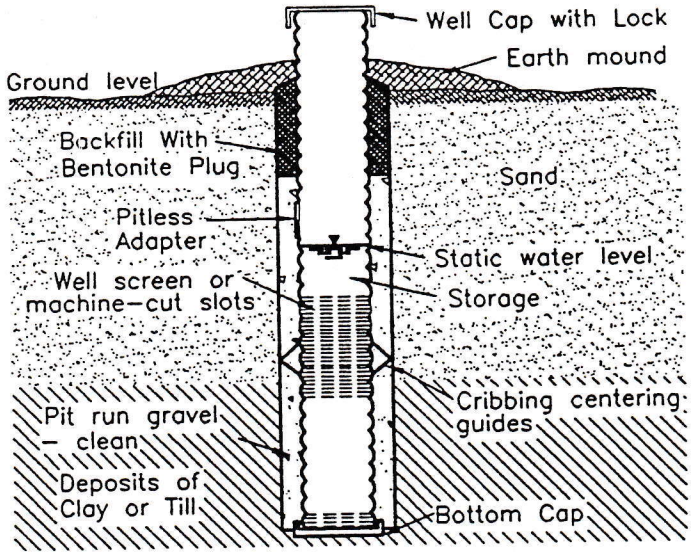

Figure 5A.

LARGE DIAMETER WELL CONSTRUCTION IN CONFINED AQUIFER

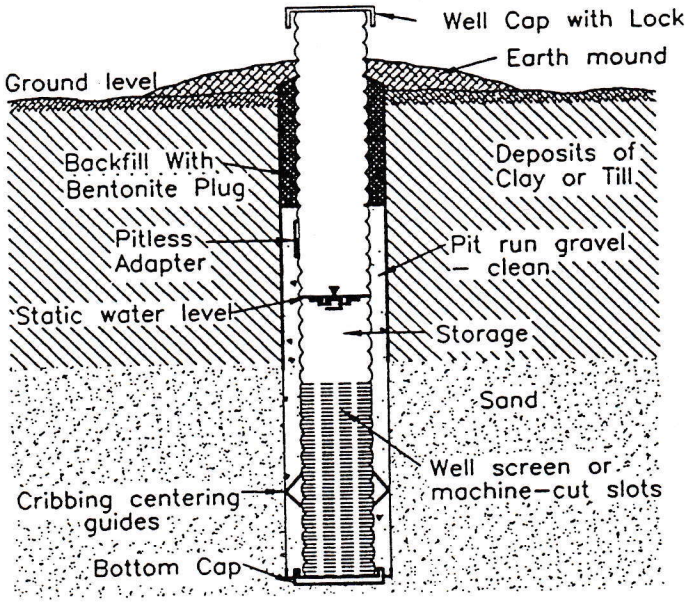

Figure 5B.

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