18.0 Well Rehabilitation

18.1 Introduction

Groundwater monitoring wells and groundwater recovery wells often degrade in quality with age. Such degradation can be caused by a number of factors, which include:
clogging of the filter pack with fine material from the adjacent formation;
silting in of the well due to infiltration of fine material from the adjacent formation;
chemical precipitation of deposits such as silica or calcium carbonate onto the well screen from the groundwater;
bio-fouling of the well screen from micro-organisms such as algae in the groundwater;
degradation of the well seal around the well head due to weather or impact; and
damage to the well head protector due to weather or impact.

Clogging of the filter pack or well screen from fine material, chemical deposits or bio-fouling can result in a distinct loss in efficiency of the well (i.e., the ability to pump groundwater from the surrounding formation through the well). Degradation of the well seal or well head protector may allow damage to the well head, unauthorized access to the well, and the ability of surface water and contaminants to enter the subsurface through the well or the well seal.

If the condition of a well degrades to a point where it is no longer practical to use the well for its intended function, or the integrity of the subsurface or of the well itself is threatened, the well must be rehabilitated or abandoned. It is the project manager’s responsibility to inform the customer of such a situation and to present options and related costs to the customer to remedy the situation.

18.2 Purpose

The purpose of this document is to present a standard protocol for the rehabilitation of a damaged or degraded well. Well rehabilitation will be divided into two main categories:

1. re-development of the well screen and filter pack to increase well efficiency, and
2. repair to damaged or degraded well heads.

Category 1 is usually performed on groundwater monitoring and recovery wells, while category 2 applies to all types of wells, including observation wells and vadose zone wells.

It is important to note that wells sometime degrade in such a way that they cannot be rehabilitated and their continued existence is a threat to subsurface integrity, for example the degradation of the well seal separating two aquifers in a deep well, or damage to a well head that is beyond repair. The project manager must recognize these situations and immediately communicate to the customer the need to abandon such wells.

18.3 References

The following ASTM Standard was consulted in the preparation of this SOP:

D 5521-94 Guide for the Development of Ground-Water Monitoring Wells in Granular Aquifers

18.4 Equipment

Field scientists who will supervise the rehabilitation of wells should select the appropriate equipment from the following list for the field, depending on the repair to be done:

- a 50-ft. measuring tape with a stainless steel weight (**do not** use a lead weight),
- a field instrument for measuring depth to water (and depth to product if applicable),
- a field meter capable of monitoring volatile organic compounds (VOCs);
- an LEL meter,
- a bailer for extracting groundwater from the borehole or well,
- bailer string,
- clean rags or paper towels,
- non-phosphate detergent,
- a 10% nitric or hydrochloric acid wash, if appropriate,
- methanol, if appropriate,
- deionized water,
- 3 to 4 wash buckets,
- cement, if needed,
- bentonite, if needed,
- a wheelbarrow, if needed
- clean water, if none available at the site,
- appropriate hand and power tools,
- appropriate rental tools and power source,
- well repair items (new well head protector, riser section and collar, etc.) as needed,
- protective gloves,
- appropriate safety gear for personal protection and traffic safety.
- the project field log,
- a site plan showing well location(s),
- a clipboard, and
- waterproof ink pens.

18.5 Re-Development of the Well Screen

18.5.1 General Considerations

It is important to keep a check on the efficiency of the wells at a site over time. As indicators of well efficiency such as maximum discharge rate and recharge rate begin to decline it is important to identify the point at which rehabilitation should be performed. The more degraded a well becomes due to clogging with fines or the build-up of foreign material on the well screen, the more difficult it will be to rehabilitate it. Past a certain point of degradation, the well will not respond to re-development. Well re-development should be considered if the well efficiency declines by about 30 to 50% depending on its use. The cost to re-develop a well should be evaluated against the additional cost incurred by the loss of efficiency (i.e., slower groundwater pump-and-treat rate, additional time to sample wells, etc.)

If all the wells are installed to a specific standard into much the same subsurface formation material, and each is typically purged of similar volumes of water over a given time frame, then the rate of degradation (e.g., clogging or fouling) should be expected to proceed at about the same rate for all of the wells. The rate of degradation of a continuously pumped well will likely be different than that of a monitoring well.

Wells that become clogged with fine formation materials can be developed in the same ways that new wells are developed, as such methods are generally used to flush fines from around the well screen and the filter pack. These methods may also be effective for loosening and removing chemical and biological deposits unless they are particularly hard or thick.

Alternative methods such as acid washing can be used to remove stubborn deposits, but caution must be used in evaluating the use of any method that introduces a chemical to the subsurface. Considerations concerning the use of chemicals to re-develop a well include:
it is usually illegal to introduce a chemical to the subsurface without the review and approval of the controlling agency;
harsh or corrosive chemicals such as acids can damage certain well screen materials such as PVC;
harsh or corrosive chemicals such as acids can degrade the integrity of the adjacent formation material and actually cause a clogging problem such as silting to become worse; and
Foreign chemicals introduced into formation materials can significantly alter groundwater chemistry in the vicinity of a well for prolonged periods.

Therefore, the use of chemicals to rehabilitate wells must be considered a last resort, and must not be employed until all of the above considerations are thoroughly researched and evaluated.

18.5.2 Well Development Process

The well development process consists of two phases: preliminary development and final development.

Preliminary Development:

Methods used to accomplish this task include surging, bailing, hydraulic jetting, and air lifting. The primary purpose of this operation is to apply sufficient energy in the well to facilitate removal of accumulated fine-grained materials from the screen, filter pack, and formation; break-up and removal of deposits that are fouling the screen, and re-establishment of an effective hydraulic interface between the filter pack and the formation.

During preliminary development, the preferred technique is to gradually apply the selected method, increasing intensity as long as the well responds to treatment (i.e., increased yields and sediment). Do not attempt to develop a well that appears to be plugged because the well could be damaged or destroyed as a result.

Final Development:

Final development refers to procedures performed with a pump, such as pumping and surging, and backwashing. If preliminary development has been effective, the time required for final development should be relatively short.

18.5.3 Selection of a Well-Development Method

Factors that must be considered in selecting the method(s) used for developing a well include:
the construction of the well (i.e., material used for well casing and screen, type and open area of well screen, type and joint between casing sections, screen length and slot size, casing and screen diameter. And filter pack thickness);
characteristics and hydraulic conductivity of the formation materials adjacent to the well screen;
water quality in the aquifer in which the well is installed (to determine health and safety and water handling and disposal measures);
consequences of introducing foreign fluids (i.e., air, water, or chemical solutions);
depth to static water level and height of the water column in the well;
type and portability of available equipment;
time available for development; and
cost effectiveness of the method.

18.5.4 Duration of Well Development

The duration of well development is based on the primary purpose(s) of the development process. For example, if the primary purpose of development is to rectify bio-fouling of the screen, the time for development may be based on the response of the well to pumping. If the primary purpose is to remove accumulated fine-grained materials, development may continue until visibly clear water is discharged from the well or until the turbidity of water removed from the well is at some specified level.

Note: Removal of fine-grained materials to an acceptable level may be difficult or impossible to achieve in formations with a significant fraction of fine-grained material.

Another criterion used for determining when well development is complete is the stabilization of certain indicator parameters (i.e., temperature, specific conductance, pH, redox potential, dissolved oxygen) that can be measured in the field. While this criterion may indicate when native formation water is being produced, it does not necessarily indicate that well development is complete.

18.5.5 Equipment Decontamination

Any equipment or materials used to develop a monitoring well should be thoroughly cleaned following decontamination procedures presented in Section 2.11 of SOP No. 12. Cleaning should take place prior to the use of any equipment in any well, and between uses in the same well or in other wells.

18.5.6 Cautions and Limitations of Well Development

Well development should be applied with great care to wells installed in predominantly fine-grained formation materials, as vigorous development of such wells can actually cause turbidity in the water removed from the wells to increase many times over. In some fine-grained formations, no amount of development will improve formation hydraulic conductivity or the hydraulic efficiency of the well.

Any water added to a well should be of a known and acceptable chemistry. The impact of added water on in situ water should be evaluated and, to the extent possible, this water should be removed by pumping when development is complete.

Development methods using compressed air (i.e., air-lift pumping) should be attempted only after great care has been taken to remove any compressor oil or any other foreign substances from the air stream prior to introduction into the well. Air should not be forced into the formation or allowed to be released directly into the well without the use of a containment device (i.e., an eductor pipe). Injection of air into the formation may result in a dramatic reduction in formation hydraulic conductivity. An uncontrolled release of air into the well may cause significant chemical changes to the well water and the adjacent formation.

> **Note**: Even when filtered, compressed air is likely to introduce minute quantities of oil into the well during development. This fact should be weighed against the intended use of the well (e.g., monitoring for petroleum hydrocarbons).

Development methods that rely only on pumping ("passive" development), especially at low flow rates, do not effectively remove fine-grained material or screen deposits. Effective development action requires movement of water in both directions through the well screen openings.

Development should be applied very cautiously to wells that are known or suspected to be contaminated with hazardous substances. Appropriate safety precautions must be taken to protect field personnel from inhalation or dermal contact with contaminant vapors or contaminated water. Also, contaminated water and sediment removed during well development may have to be stored in appropriate containers until they have been chemically tested and evaluated to determine an appropriate treatment or disposal method.

Wells installed in high-permeability zones of karst and fractured-rock aquifers frequently exhibit high turbidity if finer particles from the fractures, conduits and other dissolution zones are drawn into the well. These wells will require more extensive development than most monitoring wells. Turbidity in these wells may be a persistent problem, particularly during and after storm events. If siltation is a persistent problem, routine maintenance to remove the accumulated sediment may be necessary.

18.5.7 Methods and Processes Available for Well Development

General:

The development method(s) most appropriate for use in a given situation depends on a variety of factors discussed in Section 18.5.3, above. The user should evaluate the methods described below and select the method that is most appropriate for the situation at hand.

Mechanical Surging:

Mechanical surging is accomplished by using a close-fitting surge block affixed to the end of a length of drill pipe, a solid rod, or a cable, operating like a piston in the well casing or screen. The up-and-down plunging action alternately forces water to flow into (on the upstroke) and out of (on the downstroke) the well. Figure 18-1, attached, shows a typical mechanical surging application. Several designs for surge blocks are shown in Figure 18-2, attached. A heavy bailer or pump fitted with flexible disks similar to those on a surge block can be used, but these are not as effective as a close-fitting surge block.

The proper procedure for mechanical surging is as follows:

- Bail or pump the well first to make sure the well will yield water. If the screen is completely plugged and water does not enter the

well upon purging, do n

ot attempt surging as it may damage the well.

- When it is determined that the well will yield water, lower the surge block into the well until it is below the static water level and (if possible, depending on the design of the well) above the screen.

- Start a relatively slow, gentle surging action. This will allow any material blocking the screen to break up, go into suspension and move into the well.

- The surge block should be operated with particular care if the formation above the screen consists mainly of fine-grained materials which may slump into the screened interval.

- As water begins to move easily in and out of the well, lower the surge block (in steps) farther into the well and increase the speed of the surging movement.

  Note: if initial development is too vigorous, surging can harm a well rather than improve it.

- Begin surging above the screen (if possible) or as close to the top of the screen as possible and move progressively downward to prevent the surge block from becoming sand locked (i.e., stuck in the well due to the accumulation of sand around the surge block) and to prevent damage to the screen.

- Lower the surge block in intervals equal to the length of the stroke until the entire screen has been surged. Generally, a 2 to 3 ft. (0.61 to 0.91 m) stroke is sufficient to achieve proper well development with mechanical surging.

- The first surging run should be very short (several minutes). After this run, estimate the amount of sediment entering the screen by removing the surge block and measuring the amount of sediment that has accumulated in the bottom of the well. Lengthen the time of each subsequent run, keeping records of hoe quickly sediment enters the screen.

- When sediment accumulates to a point where it begins to block off the bottom of the screen, remove it by bailing or pumping.

- Record the rate and volume of sediment accumulation (and removal) during surging.

- Continue surging and cleaning until little or no sediment is measured after surging.

On the downward stroke, the surge block assembly must be of sufficient weight to free-fall through the water colu mn in the well and create a vigorous outward surge. The surge block should not be allowed to fall out of plumb as it may damage the well.

Manual surging is very tiring and could lead to back and shoulder injuries. Manual surging is not generally recommended except in very shallow, small-diameter wells (i.e., wells less than 4 in. in diameter and less than 50 ft. deep) The use of two or more persons who can alternate should be considered for manual surging of wells.

The outside diameter of the surge block should ideally be within to ¼ in. (0.32 to 0.64 mm) of the inside diameter of the casing. Care should be taken during well assembly to assure a smooth inner surface, especially at joints. Avoid sandlocking the surge block. If sandlocking is a concern, use a slightly smaller diameter surge block or a valved or vented surge block (see Figure 18-2). Prior to surging, lower the surge block carefully into the well to be certain it will fit without becoming lodged.

Accumulated sediment should be removed as often as possible during development. It may be possible to surge and pump simultaneously, using a specially designed surging tool . Surging should not be attempted when the screen is full of sediment as the screen could become damaged.

The time required to properly surge a well depends on the character of the aquifer material and its apparent response to development, and may vary widely from well to well.

Overpumping and Backwashing:

Overpumping, i.e., pumping at a higher rate than the well will be pumped when it is purged or sampled, is the simplest method for removing formation fines. Important limitations to overpumping include:

a) overpumping by itself will not adequately develop a well because water flow is only in one direction;
b) it may cause bridges to form in the formation or filter pack, or both;
c) it often requires the use of larger pumping equipment than will fit onto small-diameter casings that are used in many monitoring wells;
d) it subjects the pump used in the operation to abrasion, excessive wear, and loss of efficiency, as well as the possibility of sandlocking;
e) it results in the production of potentially large volumes of water that may need containment or treatment;
f) because the pump is normally set above the bottom of the well screen, most of the development takes place in the higher conductivity zones at the top of the

well screen, and water

subsequently entering the well may flow preferentially through these zones, leaving the rest of the well poorly developed.

Overpumping is best used in conjunction with backwashing, which is the method of well development where water is added to the well to cause flow reversal.

A common backwashing procedure is to pump water into the well in a sufficient volume to maintain a head greater than that in the formation. This requires a high-capacity water source. Water can be obtained by diverting part of the water pumped from the well into a large tank. After the well is pumped, the stored water is pumped back down the well. **Do not** use this method if the groundwater is known or suspected of being contaminated.

“Rawhiding” consists of starting and stopping a pump intermittently to produce rapid changes in the pressure head within the well. The alternate lifting and dropping of a column of water in the pump discharge pipe creates a surging action in the well. Supplemental water is generally added when water in the discharge pipe combined with natural well recharge do not allow the water level in the well to reach static discharge level between pumping events. The success of this method depends on the frequency of flow reversals. The pump used must not be equipped with a check valve or other backflow prevention device.

Use the following procedure to develop a well by rawhiding:

- Before beginning the rawhiding procedure, start the pump at a reduced capacity and gradually increase to full capacity to minimize the danger of sandlocking the pump.

- When the pump discharge is clear of sediment, shut off the pump and allow the water in the pump discharge pipe to fall back into the well.

- Repeatedly start and stop the pump as rapidly as the power unit and starting equipment will permit. The pump control unit should be equipped with a starter lockout so the pump cannot be started when it is back spinning.

- During the rawhiding procedure, pump the well occasionally to remove the sediment that has been brought into the well by the surging action.

- Record the estimated volume of sediment removal during development.

Some wells respond well to rawhiding while in others the surging effect is not vigorous enough to obtain optimum results. Also, rawhiding is very hard on pumping equipment.

To be effective for development by rawhiding, a pump must be capable of pumping at a rate of at least 5 to 10 gal/min (18.93 to 37.85 L/mm). Surface centrifugal or diaphragm pumps can only be used if the well is less than about 20 ft. (6.1 m) deep. Submersible centrifugal pumps are effective at greater depths, but such pumps can be damaged when pumping sediment. Air-lift pumps can be used effectively in deep, small-diameter wells, but air-lift pumping and backwashing results in aeration of well and adjacent formation water which can temporarily alter groundwater quality.

High-Velocity Hydraulic Jetting:

This method is more easily applied to wells of four in. diameter or greater. Development by high-velocity hydraulic jetting employs several horizontal jets of water operated from inside the well screen so that high-velocity streams of water loosen deposits on the screen and fine-grained material from the filter pack and formation. The loosened material moves inside the well screen and can be removed from the well by concurrent pumping or by bailing. Figure 18-3, attached, shows a typical jetting application.

Equipment required for jetting includes a jetting tool with two or more equally-spaced nozzles; a high-pressure pump, hose and connectors; a string of pipe; and a water tank or high-volume water supply. Figure 18-

4, attached, shows a typical jetting tool. A jetting tool should be used that is as close to the inside diameter of the well screen as practical (generally within ½ in. (1.27 cm)). If the jetting tool diameter is too small, much of the energy of the jet will be dissipated by turbulence in the well.

Water used for jetting should be essentially free of sediment, as sediment-laden water can damage the nozzles and can damage the well screen if the jets are directed at one area for a prolonged period of time.

Optimum nozzle velocities range from 150 to 300 ft/sec (45.7 to 91.4 m/s). In general, 200 psi at the nozzle is the preferred operating pressure for jetting metallic screens. However, PVC screens should be jetted with pressures not exceeding 100 psi (note that pressures greater than 100 psi are generally needed in predominantly fine-grained formations and filter-packed wells).

Jetting is generally accomplished using a drilling rig with a fluid pump that can provide the required down-hole pressure. The jetting tool is attached to the bottom of the drill string and tool rotation is controlled by the rig. The following procedure is used to develop a well by jetting:

- Lower the jetting tool to the bottom f the screened interval.

- Begin jetting while rotating it slowly and pulling it upward at a rate of 5 to 10 min/ft (1.57 to 4.57 min/m) of screen.

- Remove accumulated material that is loosened from the screen filter pack and formation and brought into the well either concurrently (by simultaneous pumping (see below) or by periodically removing the jetting tool from the well and bailing or pumping out the accumulated sediment.

- Make several passes up and down the screen until the amount of additional material removed from the formation becomes negligible.

  Note: never operate the jetting tool in a stationary position, as it could damage the well screen.
- Record the estimated rate and volume of sediment accumulation (and removal) during jetting.

Optimal removal of sediment by jetting will depend on the time allotted to the process. Because the jetting energy can focus on only a small part of the formation at a given moment, more time may be necessary for jetting than for other methods that affect a larger portion of the formation.

High-Velocity Hydraulic Jetting Combined with Simultaneous Pumping:
Maximum development efficiency is achieved when jetting is combined with simultaneous pumping.

The volume of water simultaneously pumped from the well should always exceed the volume pumped in during jetting, by as much as 1.5 to 2 times, so that a gradient is created toward the well. The movement of water into the well helps remove formation material loosened by the jetting. The pump then removes the sediment from the well before it can settle in the screen. Pumping while jetting permits an appraisal of the effectiveness of jetting based on the size and volume of the sediment removed by the pump.

An air-lift pump is the most common type of pump employed in this operation because of its small diameter and efficiency in removing sediment without damage to the pump mechanism. The air-lift system operates best when the air line is at least 40% submerged. Figure 18-5, attached, shows a typical jetting and air-lift pumping application.

Compressed air used for development should be filtered to remove any compressor oil or any other foreign substances from the air stream prior to introduction into the well. Even when filtered, however, compressed air is likely to introduce minute quantities of oil into the well during development.

A submersible pump can be used in place of an air-lift pump, but since the pump must usually be placed above the jetting tool, much of the sediment will fall to the bottom of the well. Therefore the jetting tool must be withdrawn periodically to remove sediment from the well.

Developing with Air:

Developing with air is not recommended for development of groundwater wells for the following reasons:

air development may force air into contact with the formation, which may alter the oxidation-reduction potential of the formation water and change the chemistry of the water in the vicinity of the well, the effects of which may last several weeks or more;

air can become entrapped in the narrow slots of some well screens and in the pores of the filter pack and adjacent formation material. Entrapped air is difficult to remove and it may significantly reduce hydraulic conductivity and well efficiency; and

where groundwater is contaminated, development with air may potentially result in the exposure of field personnel to hazardous materials.

18.5.8 Well Recovery Test

A well recovery test should be performed immediately after and in conjunction with re-development of a well. This test provides an indication of well performance, which can be compared against both the documented performance of the well when it was initially installed and the well performance just prior to re-development. Readings should be taken at intervals suggested in Table 1, below, until the well has recovered to 90% of its static water level.

Table 1 Suggested Recording Intervals for Well Recovery Tests

Time Since Starting Test	Time Interval
0 to 15 min.	1 min.
15 to 50 min.	5 min.
50 to 100 min.	10 min.
100 to 300 min. (5 hr.)	30 min.
300 to 1,440 min. (24 hr.)	60 min.

If a re-developed monitoring well does not recover sufficiently for sampling within a 24-hr. period, the well should no longer be used as a monitoring well for detecting or assessing low-level organic constituents. The well may, however, be used for long-term water level monitoring if measurements of shorter frequency water level changes are not required.

18.6 Well Head Repair

There are generally three types of well head repair:

1. repair of a damaged riser;
2. repair or replacement of a damaged or loose well head protector; and
3. repair of the grout seal around the well head.

18.6.1 Damaged Riser

A well riser can be damaged by cracking or breaking off (PVC) or by bending or crimping (metal), often due to a vehicle hitting an exposed riser or falling through a damaged traffic box. A damaged riser may inhibit insertion of down-hole monitoring devices, may prevent the placement of a sealable well cap onto the well, and may negate the surveyed elevation of the well, thereby rendering it unusable for determining groundwater gradient.

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iser can be repaired if the break or bend isn't too deep in the ground. If the damage is close to the ground surface or the grout seal, the seal may need to be broken up and removed to a depth that facili tates riser repair. The seal must then be reinst ated when riser repair is completed. Specific equip ment and materials needed to repair a damaged riser

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- a saw capable of cutting the riser material;
- a section of blank casing identical to the existing well riser;
- a collar made of the same (or compatible) material as the riser that will slip snugly over the riser pipe;
- an electric drill and power source;
- self-tapping screws about 1½ times the thickness of the riser pipe;
- a field meter capable of monitoring volatile organic compounds (VOCs) and/or an LEL meter;
- a jack hammer or other tool for breaking up concrete, if necessary;
- concrete, bentonite and a wheelbarrow,
- clean water,
- a shovel; and
- appropriate safety gear for personal protection and traffic safety.

Use the following procedure to repair a damaged riser:

- Take a field reading of VOCs around the well head with the well cap removed. If the vapor readings exceed acceptable action levels, then power tools or other sources of ignition cannot be used near the well.

- During repair be careful not to let loose material fall into the well. Leave the well cap on, if possible, until the damaged riser section is cut off, or use a rag or a piece of plastic sheeting and duct tape to temporarily seal the well opening.

- Remove all loose material from around the well head, including the well head protector if it is not affixed, loose soil and broken up pieces of the grout seal.

- expose the entire length of damaged riser and a sufficient undamaged portion below it so that it can be cut with the saw, leaving a sufficient length intact for affixing the collar. If necessary, break loose and remove the protective cover and break up and remove the top portion of the grout seal with the appropriate tool.

  Note: wet down the grout seal to suppress sparks while breaking it up.

- Carefully cut off the damaged section of riser with the saw. Take care to cut it as flat and smooth as possible.

- Cut a section of blank casing that is of sufficient length to replace the damaged riser section.

- Pre-drill about 3 to 4 evenly spaced holes through the collar where it will slip over the exposed riser on the well, and another 3 to 4 holes where it will slip over the blank casing. The holes should be of a diameter that causes the screws to tap snugly into the collar material when screwed in.

- Slip the collar over the exposed well riser and using the pre-drilled holes as guides, drill one hole at a time half-way through the riser then tap a screw through the collar and into the riser until it is snug. Repeat this step for all of the holes.

- Slip the section of replacement casing into the collar so that it rests snugly against the top of the riser and drill and screw the casing in place using the above procedure.

  Note: if vapors at the well head are a concern, the collar can be affixed to the casing section at a distance from the well, then affixed to the well riser using a hand-operated drill.

  For stainless steel well material in which holes are difficult to drill with portable equipment, pre-drill the holes a stainless steel collar and tap threads into them using shop equipment. Use hex-head bolts that can be threaded into the holes and tightened against the riser, thus securing the collar.

- Place the well cap onto the new riser section.

- If necessary, repair the well head protector and/or the grout seal following the procedures in Sections 18.6.2 and 18.6.3. If the repair collar is close to the ground surface, the grout seal should be built up around it for stability. Replace soil or gravel around the well head as necessary.

- Arrange to re-survey the well head elevation (See SOP No. 14).

18.6.2 Damaged or Loose Well Head Protector

Well head protectors (standpipes, traffic boxes, etc.) often become loose or damaged. In some cases they can be re-set using fresh grout, and damaged parts can be repaired. In other instances, the entire protective device will need to be replace.

Proceed with repairs as follows:

- Assess the level of damage to the protector and determine if a repair or replacement is necessary. If a repair is to be made using a welding torch or some other potential source of ignition, it is best to remove the protector and perform the repair a safe distance from the well.

  Note: do not proceed with well repairs involving hot work without first monitoring the well head for VOCs; if VOCs are present, conform to all health and safety protocol regarding work in the presence of volatile vapors.

- When replacing the new or repaired well protector, first remove any degraded portion of the existing grout seal and any other loose material from around the well. Wet down the remaining grout seal.

- Position the well head protector to allow room beneath it for the well cap and to allow the grout seal to be mounded around it to deflect rain water away from it.

- Seal the protector in place using a fresh grout mix that is compatible with weather conditions and with the existing grout seal (see SOP No. 13 for a more detailed discussion and references regarding installation of well protectors and grout seals).

18.6.3 Grout Seal

If a grout seal becomes degraded or damaged, the integrity of the well is in jeopardy. At worst, it may allow surface contaminants to enter the well annulus; at best the well head protector will loosen and become ineffective.

To repair a grout seal:

- Remove all loose or damaged material from around the well head. A jack hammer or other tool may be needed to fully remove the material. Fresh, undamaged seal material must be exposed before re-sealing the well head with new grout. If the damage extends to a depth that is impossible to repair, the well may have to be abandoned.

  Note: do not proceed with well repairs involving hot work without first monitoring the well head for VOCs; if VOCs are present, conform to all health and safety protocol regarding work in the presence of volatile vapors.

- Wet down the exposed fresh grout seal and add a fresh grout mix that is compatible with weather conditions and with the existing grout seal to replace what was removed.

- Position the well head protector to allow room beneath it for the well cap and complete the new grout seal by forming a mound around the protector to deflect rain water away from it (see SOP No. 13 for a more detailed discussion and references regarding grout seals).