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(54) **METHOD AND APPARATUS FOR SAMPLING LOW-YIELD WELLS**

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(58) **Field of Search** 166/53, 66, 68.5, 166/250.03, 250.15, 264, 373

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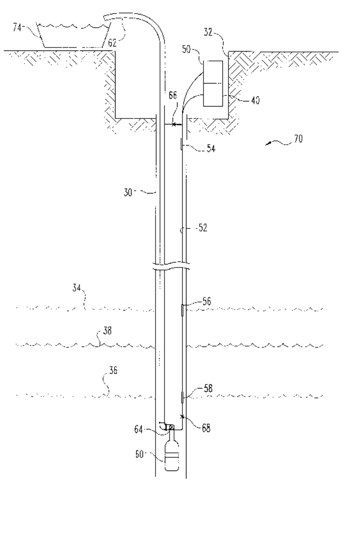
(57) **ABSTRACT**

An apparatus and method for collecting a sample from a low-yield well or perched aquifer includes a pump and a controller responsive to water level sensors for filling a sample reservoir. The controller activates the pump to fill the reservoir when the water level in the well reaches a high level as indicated by the sensor. The controller deactivates the pump when the water level reaches a lower level as indicated by the sensors. The pump continuously activates and deactivates the pump until the sample reservoir is filled with a desired volume, as indicated by a reservoir sensor. At the beginning of each activation cycle, the controller optionally can select to purge an initial quantity of water prior to filling the sample reservoir. The reservoir can be substantially devoid of air and the pump is a low volumetric flow rate pump. Both the pump and the reservoir can be located either inside or outside the well.

37 Claims, 5 Drawing Sheets



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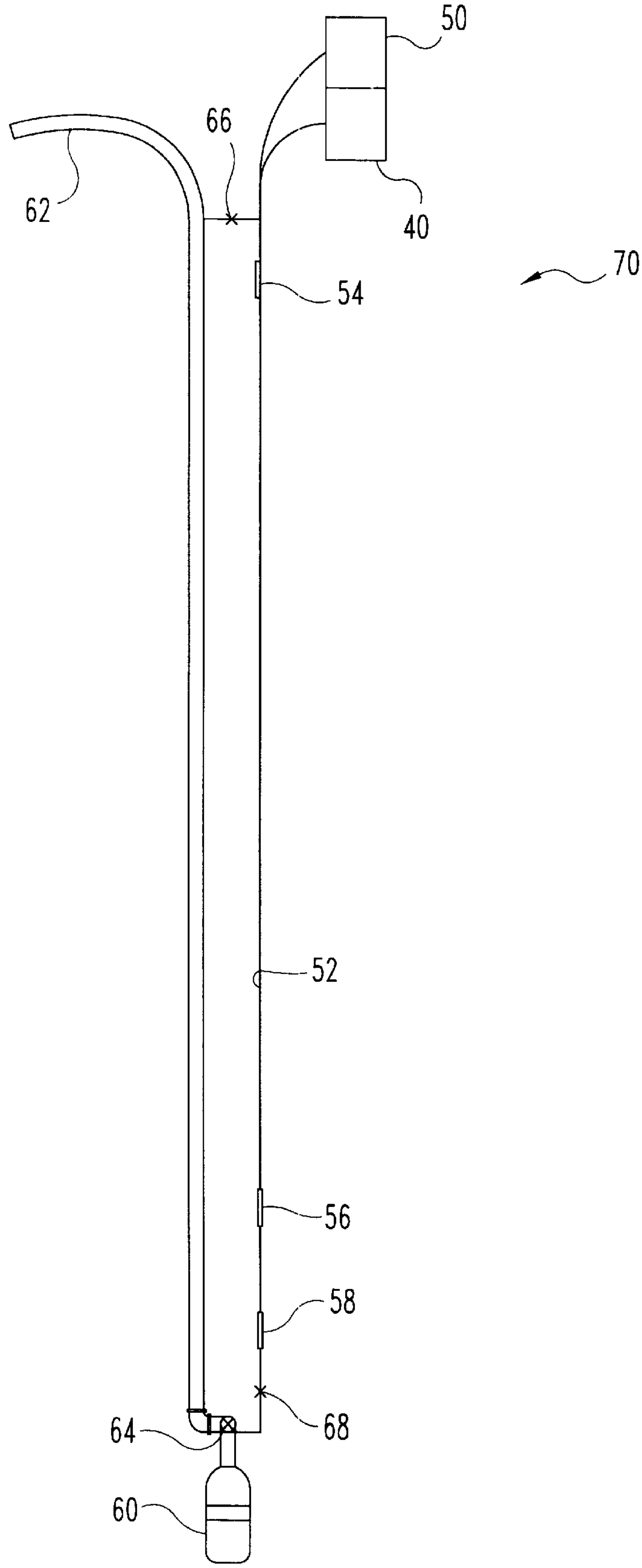

Fig. 1

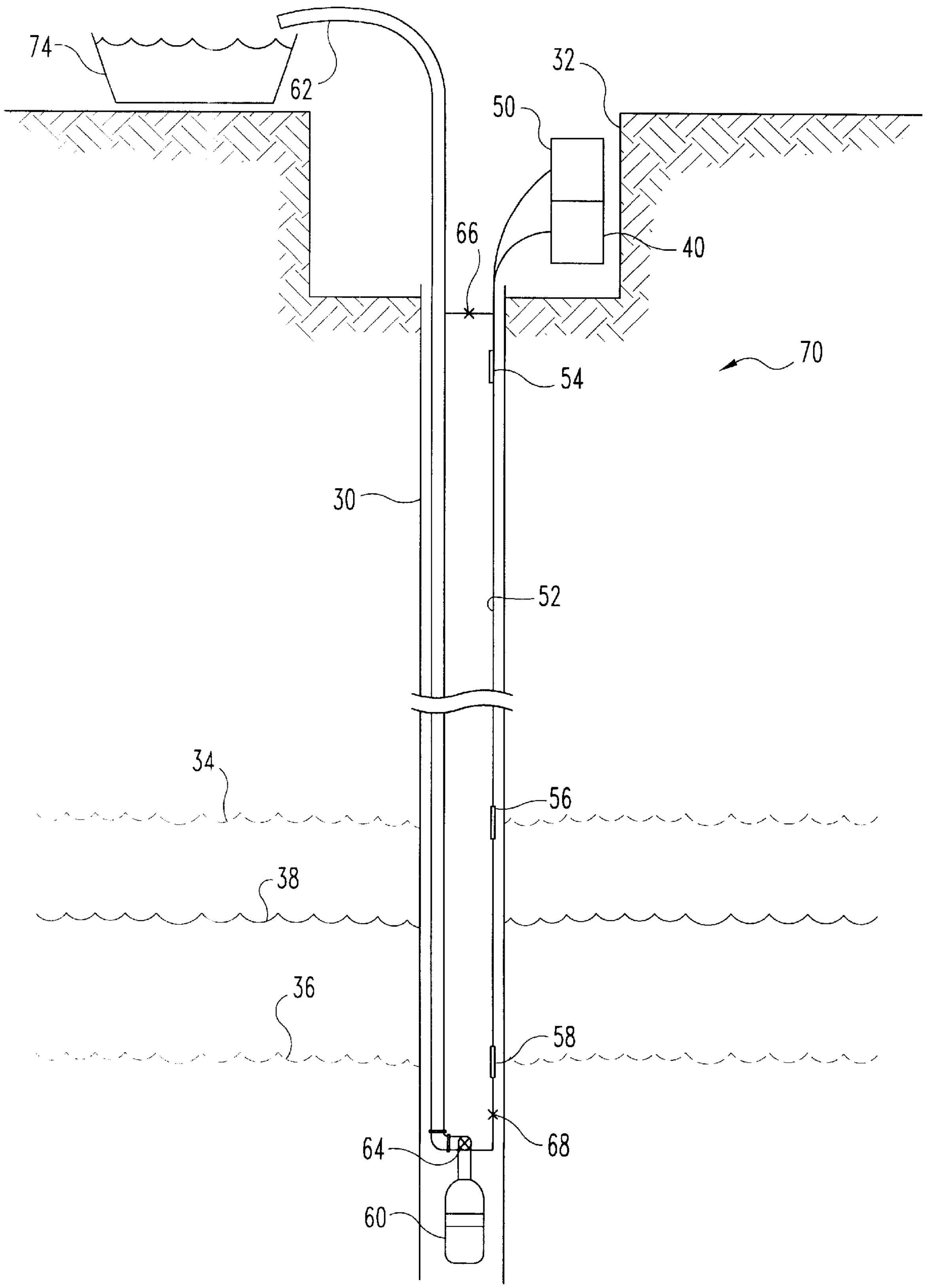

Fig. 2

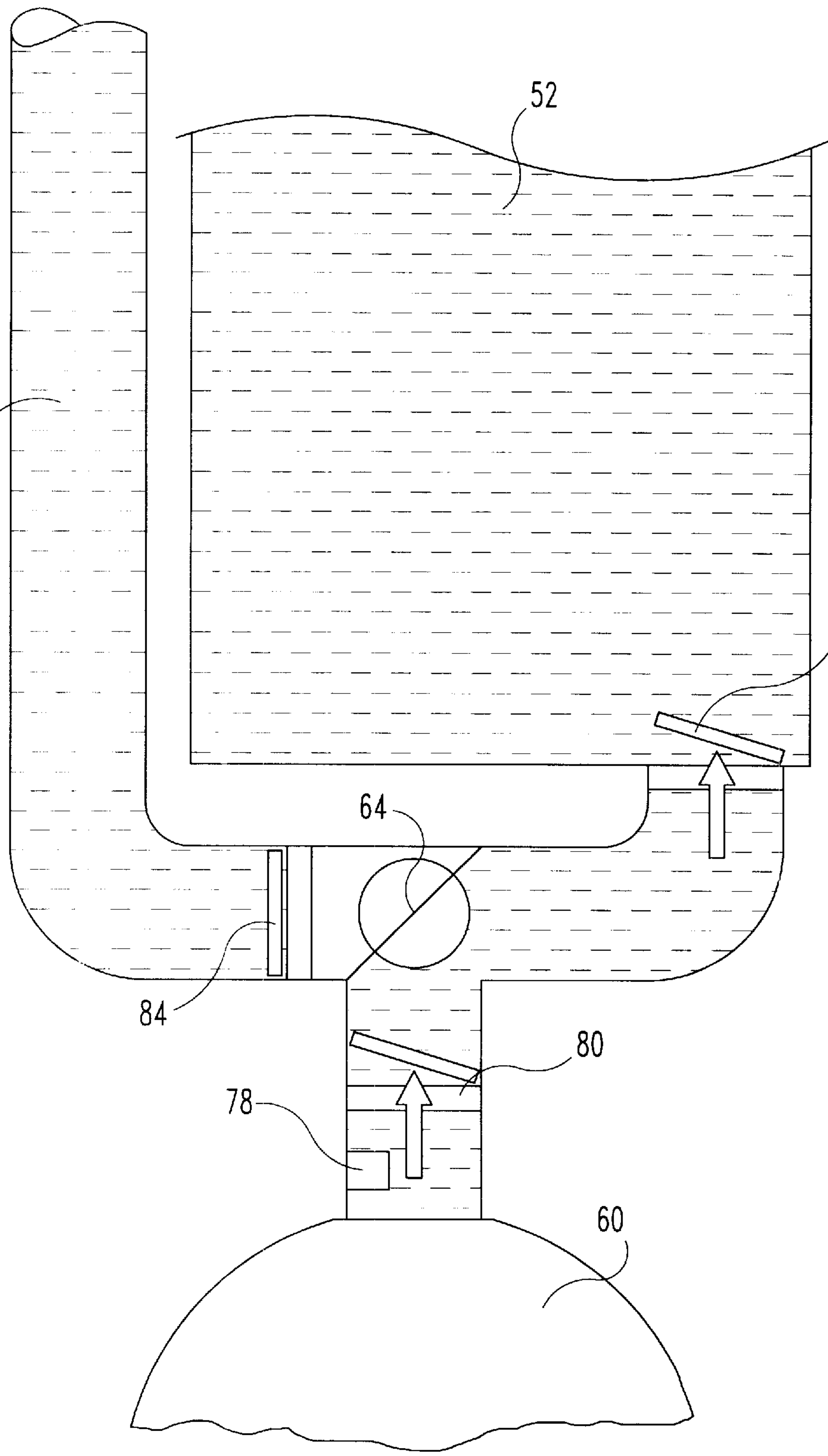

Fig. 3

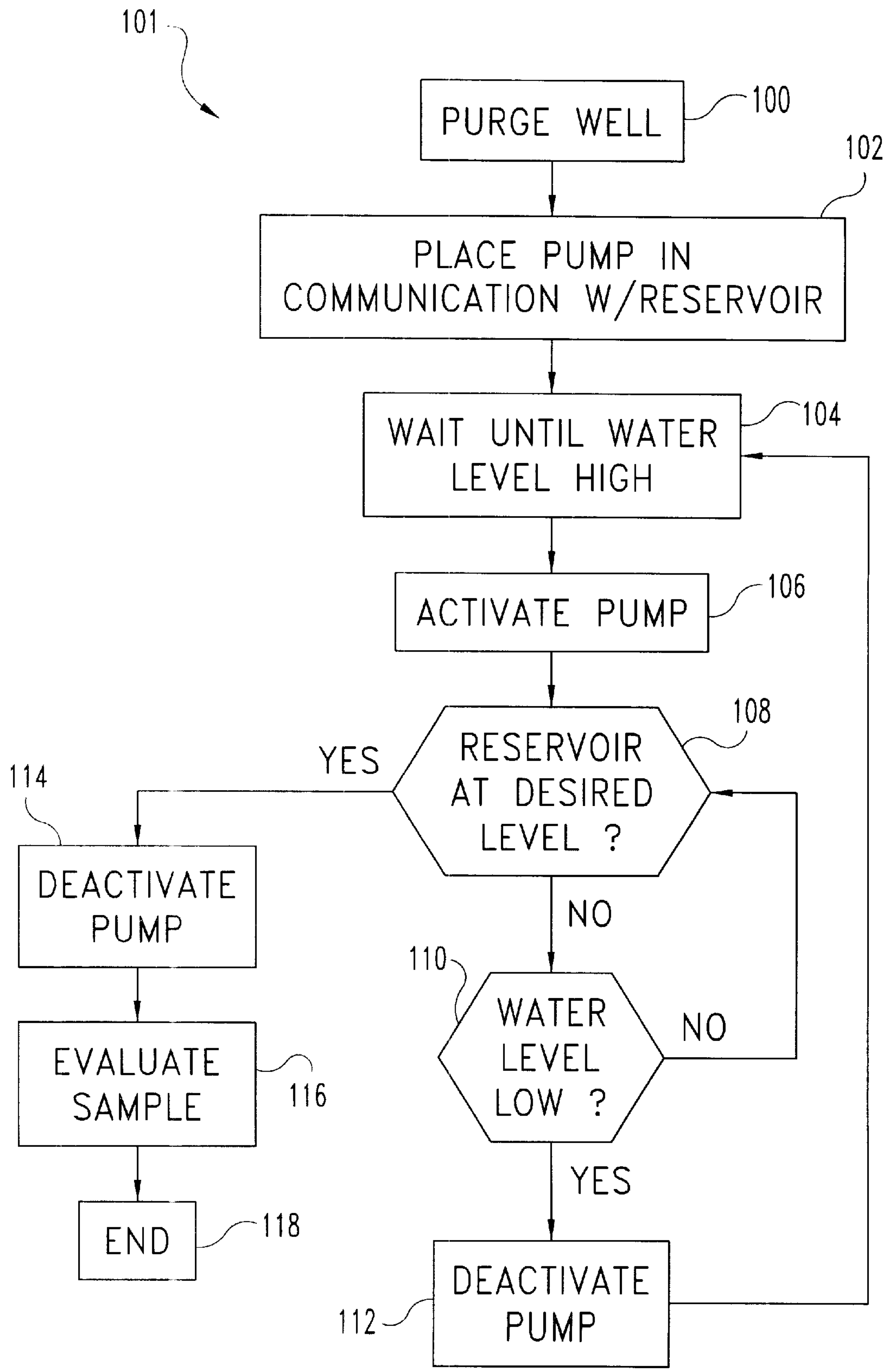
101
PURGE WELL
100
PLACE PUMP IN COMMUNICATION W/RESERVOIR
102
WAIT UNTIL WATER LEVEL HIGH
104
ACTIVATE PUMP
106
RESERVOIR AT DESIRED LEVEL ?
108
YES
NO
114
DEACTIVATE PUMP
110
WATER LEVEL LOW ?
NO
YES
EVALUATE SAMPLE
116
END
118
DEACTIVATE PUMP
112

Fig. 4

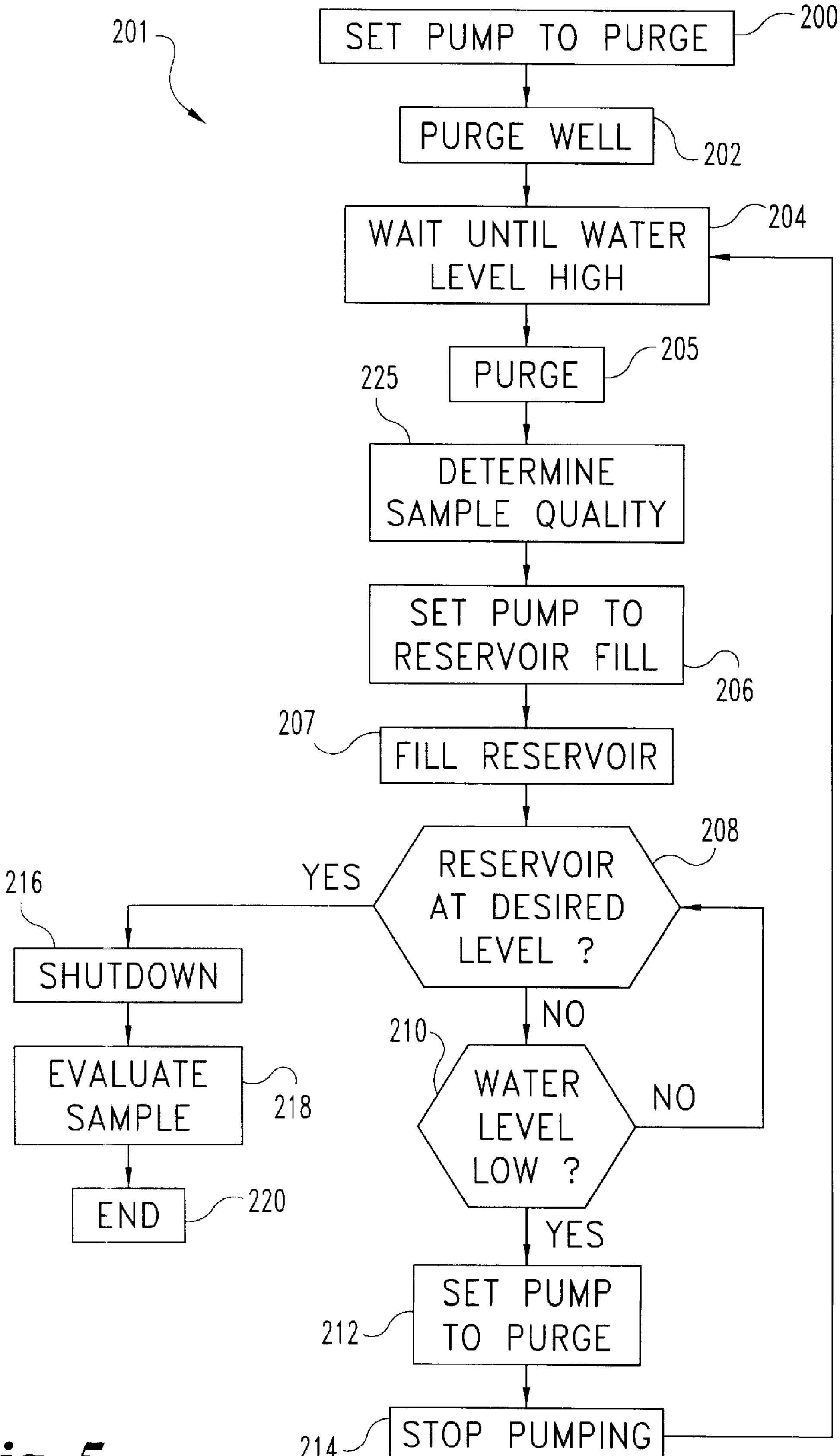
201
SET PUMP TO PURGE
200
PURGE WELL
202
WAIT UNTIL WATER LEVEL HIGH
204
PURGE
205
225
DETERMINE SAMPLE QUALITY
SET PUMP TO RESERVOIR FILL
206
207
FILL RESERVOIR
208
RESERVOIR AT DESIRED LEVEL ?
YES
216
SHUTDOWN
EVALUATE SAMPLE
218
END
220
NO
210
WATER LEVEL LOW ?
NO
YES
SET PUMP TO PURGE
212
STOP PUMPING
214

Fig. 5

METHOD AND APPARATUS FOR SAMPLING LOW-YIELD WELLS

GOVERNMENT RIGHTS

This invention was made with Government support under Contract Number DE-AC0676RLO1830 awarded by the U.S. Department of Energy. The Government has certain rights in the invention.

TECHNICAL FIELD OF THE INVENTION

The present invention relates to ground water sampling instruments and techniques. More particularly, but not exclusively the invention relates to sampling instruments and techniques for low yield aquifers and perched groundwater zones.

BACKGROUND OF THE INVENTION

The quality of naturally occurring water is a matter of increasing concern. Various toxic pollutant substances derived from, for example, industrial effluents, human wastes, or natural factors of geological weathering, aging, and erosion often find their way into aquifer systems. Since aquifer systems may involve interconnected bodies of water, it is important to monitor associated groundwater at numerous locations, and because the characteristics of the groundwater usually varies with time, repetitive sampling is usually necessary. While certain characteristics of water can be monitored by detectors placed in a well which provide continuous monitoring, in most instances, more complete data is needed which can more effectively be obtained by the transport of groundwater samples to a full service laboratory.

Prior to obtaining a reliable sample, a well typically must be purged of at least the stagnant water in the well. For many groundwater wells, an operator can travel to a site and both purge the well and collect the necessary sample without delay. However, there are other wells, known as low yield wells, that do not produce a large enough volume of water to satisfy the demand of both purging and sampling without requiring a significant amount of time to accumulate water from the aquifer after being purged. The water that does accumulate in a low yield well stagnates as time passes, further compounding the problems of sample collection. For example, certain low yield wells may never accumulate enough water at any one time to obtain an adequate sample volume. In certain rather extreme situations, a well in a perched aquifer might only produce about 1 liter of water a day when about 4 liters of water are required for a full laboratory sample.

Accordingly, an operator is required to purge low yield wells in one trip and then return to take at least a partial sample after a sufficient time has passed for the accessible well water volume to recover. Depending on the volume of water accessible in the well and the required purging and sampling volumes, this may require multiple and/or extended trips to the well, driving up the time and cost of monitoring the aquifer. Moreover, in the most extreme cases, the water capacity of a single well can be so low that both purging and sampling can each require multiple trips to the well.

Therefore, there is a need for groundwater sampling techniques that reduce the time and effort involved in obtaining individual groundwater samples from perched or low yield aquifers. There is also a need for groundwater sampling techniques that reliably collect and store a sample for later retrieval without disturbing important measurable

characteristics of the sample. There is also a need for a device that can automatically collect and hold a groundwater sample without requiring continual operator attendance.

These and other objectives are realized through various embodiments of the present invention.

SUMMARY OF THE INVENTION

A novel sample collection apparatus and method are disclosed for automatically collecting a fluid sample from a well.

In one embodiment the present invention provides a method of monitoring groundwater in a low-yield aquifer comprising, providing a pump, at least one water level sensor, and a controller responsive to the at least one sensor for automatically activating the pump; activating the pump when the water level reaches a first threshold as indicated by the at least one sensor; and deactivating the pump when the water level reaches a second lower threshold as indicated by the at least one sensor. The method can also include continuously activating and deactivating the pump until a desired volume of water is provided to a sample container where the sample container is initially substantially devoid of air.

In a second embodiment, an apparatus for collecting a groundwater sample from a low-yield well is provided comprising: a reservoir, a pump for removing water from the low yield well and providing the water to the reservoir; at least one sensor; and a controller for activating and deactivating the pump, the controller activating the pump to fill the reservoir at a flow rate less than about 500 ml/min in response to signals received from the sensor; wherein the controller activates the pump when the water level in the well reaches a first level as indicated by the at least one sensor, and the controller deactivates the pump when the water level in the well reaches a second lower level as indicated by the at least one sensor. The reservoir can be substantially devoid of air and adapted to receive a predetermined volume of groundwater from the pump.

In a third embodiment, an apparatus for collecting a sample from a low-yield well is provided comprising: a pump; a sample reservoir substantially devoid of air for receiving a volume of liquid for subsequent monitoring; a controller for automatically activating the pump to fill the reservoir; at least one fluid level sensor adapted to sense the level of fluid in the well and output at least one signal; wherein the controller sequentially activates and deactivates the pump in response to the at least one signal until the reservoir is filled with a predetermined volume of fluid.

In a further embodiment there is provided an apparatus for collecting a sample from a well comprising a sample reservoir for receiving a volume of liquid for subsequent monitoring; a sample bypass conduit; a pump for removing liquid from the well and providing the liquid to the sample reservoir, a multiway valve having a first position placing the pump in fluid communication with the sample reservoir and a second position placing the pump in fluid communication with the bypass conduit, a controller for automatically activating the pump and the multiway valve, at least one fluid level sensor adapted to sense the level of liquid in the well and output at least one signal, wherein the controller sequentially activates and deactivates the pump in response to the at least one signal until the reservoir is filled with a predetermined volume of liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a sampling instrument according to an embodiment of the present invention.

FIG. **2** is a schematic of the FIG. **1** sampling instrument in a well.

FIG. **3** is a schematic of the lower portion of the FIG. **1** sampling instrument showing fluid being pumped into the reservoir.

FIG. **4** is a flowchart depicting a method of collecting a groundwater sample from a low yield aquifer.

FIG. **5** is a flowchart depicting an alternative method of collecting a groundwater sample from a well.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

Turning now to FIG. **1** a groundwater sampling apparatus **70** is shown. Apparatus **70** includes pump **60**, reservoir **52**, and bypass tube **62** adjacent reservoir **52**. Power supply **40** and controller **50** power and control pump **60** respectively, and three way valve **64** is operable to selectively place pump **60** in fluid communication with either reservoir **52** or bypass tube **62**.

Reservoir **52**, bypass tube **62**, and pump **60** are together sized and configured to be insertable into a preexisting conventional well, for example a 2 inch well casing, such that pump **60** can fill reservoir **52** with fluid from the well. Controller **50** can be any analog or digital controller such as a conventional microprocessor, and controller **50** is programmed to activate and deactivate pump **60** in response to signals from sensors **56** and **58**. Sensors **56** and **58** are disposed on the exterior of reservoir **52** and connected by signal lines to controller **50**.

When placed in the well, sensors **56** and **58** provide indications of the fluid depth in the well to controller **50**. Controller **50** also communicates with sensor **54** inside reservoir **52**. Sensor **54** provides controller **50** with an indication of fluid depth in the reservoir **52**, and as will be described in more detail below, controller **50** is programmed to deactivate pump when the fluid depth in the reservoir reaches a desired level.

Turning now to FIG. **2** and with continued reference to FIG. **1**, apparatus **70** is shown secured in well casing **30** to a fixed depth by any conventional method. In the illustrated embodiment, well casing **30** can be screened as is known in the art and depends from a well vault **32** for housing controller **50** and power supply **40** below ground level. Alternatively, controller **50** and power supply **40** could be located above ground. Pump **60** extends into well into operative contact with the well fluid. Sensors **58** and **56**, which can be adjusted along the exterior length of reservoir **52**, are fixed relative to the location of pump **60** to indicate high and low well fluid levels **34** and **36** respectively.

In operation, the well is first purged. Three way valve **64**, through manual manipulation or automatically in response to a signal from controller **50**, places pump **60** in communication with bypass **62** to purge well fluid into a purge container **74**, some other receptacle (e.g. storm sewer) or onto the ground. Purging continues, for example in a manner equivalent to the automatic filling of reservoir **52** described below, until a predetermined criteria is met. This criteria can be the purging of a predetermined volume of fluid, purging a predetermined number of purging cycles (as described below with reference to filling reservoir **52**), and/or the attainment of a predetermined fluid characteristic.

The predetermined fluid characteristic can relate, for example, to geochemical stability and can be either a fixed criteria or the relative stabilization of a measured value, for example fluid turbidity, conductivity, or pH. As shown in FIG. **3**, apparatus **70** is equipped with turbidity sensor **78**, which sends a signal to controller **50** indicating the turbidity of the water exiting pump **60**. In addition to or in place of sensor **78**, other sensors or probes for measuring fluid characteristics may be located at any appropriate location, for example at the inlet, outlet, or along the length of the bypass tube **62**, in the bypass fluid container **74**, or along or in pump **60**.

After purging, three way valve **64** is operated to place pump **60** in communication with reservoir **52**. When controller **50** determines that fluid level **38** has reached the high level **34**, controller signals pump **60** to begin pumping. Pump **60** provides fluid to reservoir **52** thereby depleting fluid in well **30**. When controller determines that fluid level **38** has reached the lower level **36**, controller **50** signals pump **60** to discontinue pumping.

Controller **50** determines the relative fluid level **38** by analyzing the output of sensors **56** and **58** which are placed at relatively fixed predetermined locations along the length of apparatus **70**. Sensors **56** and **58** send signals to controller **50** that depend on the relative level of fluid in the well. Sensors **56** and **58** can be any sensor from which controller **50** can determine the relative fluid level. In one embodiment, sensors **56** and **58** output a signal indicative of contact with water or any similar fluid. In other embodiments sensors **56** and **58** are combined into a single sensor (such as a pressure transducer) that outputs a signal that varies continuously with the level of fluid in the well.

Controller **50** also receives a signal from sensor **54**. Sensor **54** outputs a signal indicative of the level of fluid in reservoir **52** from which controller **50** can determine when a desired volume of fluid has been collected from well **30**. In the illustrated embodiment, sensor **54** is inside reservoir **52** and has a signal response that varies with contact with reservoir fluid. When the reservoir **52** contains the predetermined volume of fluid, which can be a variable amount dependent on the particular application, controller **50** signals pump **60** to discontinue pumping. Controller **50** can also signal a communications member (not shown) to signal an operator, for example by radio or cellular phone, that the sample is ready to be collected and analyzed.

In operation, an operator may not know or be available to collect the sample as soon as it is collected in reservoir **52**. In addition, it may require several minutes, hours, or even days to fill reservoir **52** when several on/off cycles of pump **60** and consequently several cycles of waiting for the well to reach level **34**, are required. Therefore, to prevent deterioration of the sample, for example by reaction with oxygen in the atmosphere, the sample is preferably kept out of contact with air. This can be accomplished by providing reservoir **52** with an inert atmosphere or as an evacuated bladder.

When reservoir **52** is filled with an inert gas, for example nitrogen, reservoir **52** includes check valve **66** to release the gas as fluid fills reservoir **52**. Alternatively, reservoir **52** can include an evacuated liner or bladder that receives sample fluid. When configured with an evacuated bladder, reservoir sensor **54** can be configured to sense a predetermined change in the volume of the bladder type reservoir. Other mechanisms to maintain a near zero head-space in the sample collection member could also be used.

Reservoir **52** contains a sample valve **68** for withdrawing the sample to be analyzed. Sample valve **68** can be located anywhere along reservoir **52**. When, as illustrated in FIG. **2**, valve **68** is at the lower portion of reservoir **52**, reservoir **52** is removed from well **30** to conveniently access the sampled fluid. Once removed, apparatus **70** can also be cleaned and redeployed at a different sampling site.

In other embodiments, apparatus **70** can be more permanently installed at a single site for multiple sampling operations at the same site. When more permanently installed, rather than removing the entire apparatus **70**, an operator can remove only the bladder or reservoir **52**, which can be contained in a housing and separately removable therefrom. To be separately removable from the housing, a bladder could include an internal check valve and a quick release or breakaway coupling connection to pump **60**. Alternatively the sample can be transferred from reservoir **52** by a pump (for example pump **60** or a second pump) either through appropriate modifications to bypass **62** or through a separate sample recovery conduit (not shown).

In still other embodiments, apparatus **70** can include multiple sample collection reservoirs **52**, for example as a series of evacuated bladders. When one reservoir is filled, controller **50** can purge the well (if necessary) and then select the next reservoir to be filled with fluid, for example by operation of a series of fluid valves and/or a single multiway valve. With each such reservoir selectively removable, a single installation can produce multiple contained samples for removal on a defined schedule.

Each time a well pump cycles on, the well fluid is agitated resulting in, among other things, undesirable turbidity. Thus, the number of cycles of pump **60** necessary to fill reservoir **52** can adversely affect the quality of the collected sample. Also, the length of time that fluid stagnates in a well can adversely affect the quality of the sample. Therefore, the number of cycles required to fill the reservoir **52**, and correspondingly the amount of time between cycles, can be adjusted by moving sensors **56** and **58** closer or farther apart to strike an optimum balance as required by the hydrodynamics or other factors of any particular well. Controller **50** can include conventional data processing equipment, such as a timer and memory, for logging and analyzing data, such as the time between successive pump activation and deactivation cycles, to assist in optimizing the operation for each sampling apparatus **70**.

In addition, controller **50** can be configured to selectively activate three way valve **64** to direct turbid water to bypass **62** and more optimal water to sample reservoir **52**. In one embodiment, controller **50** activates valve **64** to direct initial water from the beginning of a pumping cycle (that may be turbid) to the purge chamber or bypass tube **62**. After a predetermined volume or upon the attainment of a desired minimum turbidity level, for example as indicated by sensor **78**, controller **50** then activates three way valve **64** to direct water back to sample reservoir **52**. At the end of a pumping cycle, controller can then activate valve **64** to select bypass tube **62** to await the next cycle and to prevent any unintended flow of fluid from the well into reservoir **52**.

In addition to increased turbidity, fluid agitation, for example caused by a high fluid flow rate, can cause volatile organic compounds (VOC) to be lost from a groundwater sample, for example by partitioning of VOC's to the gas phase upon excessive agitation. Thus, while pump **60** can be any pump sufficient to remove groundwater from a well, preferably pump **60** is a low flow pump that gradually pumps the fluid at a low volumetric flow rate. In addition, gradual startup and shut down can help to preserve the integrity of the well and a groundwater sample through successive activations and deactivations of pump **60**. Preferably pump **60** pumps at a volumetric flow rate of less than about 500 ml/min, more preferably less than about 400 ml/min. and most preferably between about 100 and 200 ml/min. In one embodiment pump **60** is a pump known as a WHALE® Purge Pump, made by Munster Simms Engineering, based in Bangor, Northern keland. In other embodiments, apparatus **70** can utilize appropriately modified components of the MICROPURGE® Basics system market by QED Environmental Systems, Inc., having a place of business in Ann Arbor Mich., such as the WELL WIZARD® Bladder pump. A sampling of other pumps useful in the present invention are detailed in Table 1.

TABLE 1

Operational Characteristics of Small Pumps for Purging and Sampling

	Rediflo 2 Submersible Pump	QED Bladder Pump	Keck Helical Rotor Pump	Fultz SP300 Gear-Drive Pump	Waterra Inertial Lift Pump
Approximate Diameter (inches	1.81	1.5	1.75	1.75	1.0
Maximum Lift (feet)	250	1000	150	200	175
Maximum Design Flow Rate (gpm)	9.0	1.5	1.2	2.4	2.5
Typical Flow Rate @ 100 ft of Lift L/min (gpm)	29 (7.7)	2 (0.5)	2 (0.5)	8 (1.9)	8 (2.1)
Minimum Flow Rate Ml/min (gpm)	100 <0.026	100 <0.026	400 0.1	100 <0.026	NA NA
Function & Power	Electric 110-volt	Pneumatic Compressor	Electric 12 to 14.5 volt	Electric 36 or 110 volt	Electric 110 volt

Apparatus **70** also includes a number of check valves for preventing cross contamination of fluids when cycling the pump or when switching from bypassing to filling the reservoir **52** and vice versa. As shown in FIG. **3**, three separate one way check valves **80, 82, 84** may be used. With valve **64** configured to direct water to reservoir **52**, as indicated by the arrows, check valve **64** prevents fluid from bypass tube **62** from contaminating the collected sample. Likewise, valve **82** operates to prevent fluid from draining out of reservoir **52** between pumping cycles.

While apparatus **70** has been illustrated with a separate pump and reservoir, the reservoir and pump can be combined, wherein purging could be accomplished by any known method. These configurations could utilize a bladder pump, a syringe type sampler, or an evacuated (vacuum) cylinder. Any such combined pump/reservoir can be disposed in the well and sequentially operable by controller **50** as described above.

In addition, apparatus **70** has been illustrated with an in-well pump and an in-well reservoir. Apparatus **70** could also be construed with an external pump, for example the pump marketed as a GEOPUMP® by Geotech Environmental Equipment, Inc., of Denver, Colo. or those disclosed in U.S. Pat. No. 5,611,671 to Tripp, Jr. which is hereby incorporated by reference. In addition to or in place of the external pump, reservoir **52** can be located outside of well **30**, for example in vault **32**. Where reservoir **52** is external to well casing **30**, it is understood that sensors **56** and **58** can be provided to sense the fluid level of the well by alternative means, for example by being disposed on the fluid conduit between the well and the sample reservoir.

Turning now to FIG. **4**, a flowchart for a process of obtaining a groundwater sample from a well is illustrated. The illustrated method **101** is particularly, though not exclusively, applicable to low yielding wells or perched aquifers. More particularly method **101** is applicable to those wells producing less than about a few liters of water over a typical 8 hour shift (those producing about 0.5 liters/hour) when about 4 liters of water are required for a full laboratory sample.

Activity **100** recites purging the well. The purging can be by any known means and generally involves using a pump to remove stagnant water from the well. Purging can occur by cyclic operation of the pump according to the procedure for obtaining the fluid sample described more fully below. Preferably, substantially all the stagnant fluid is removed from the well in the purging operation. Alternatively, purging can occur until a predetermined criteria is met such as indicated by an appropriate purge criteria sensor.

After purging, a pump, for example the same pump used for purging and preferably a low flow pump, is placed in operable relation to fill a reservoir with well water in activity **102**. Since the purging likely substantially depleted the entire volume of fluid in the well the process proceeds to action **104** which calls for a wait until the water level reaches a high level. The high level is determined by an appropriate sensor(s) in the well and can be preestablished prior to purging or determined by monitoring the water level as a function of time as it rises after being depleted for the first time.

Upon attainment of a high water level the pump is automatically activated in action **106**, though a predetermined delay could also be inserted after attainment of the high water level. Next the process **101** continually cycles through a decision loop until a breakout condition is satisfied. Decision **108** asks whether a reservoir is filled to a desired level and decision **110** asks whether the water level in the well is at a low level. As long as neither decision block yields a yes answer, as determined by an automated analysis of the appropriate sensors, the pump keeps pumping water to the reservoir, allowing the reservoir to be filled automatically without an operator in attendance.

When either decision **108** or **110** is yes, the pump is automatically deactivated. If the reservoir is not yet at the desired level, indicating that action **112** was taken because the water level was at the low level, process **101** cycles back to action **104** to wait until the water level is high. Otherwise, the pump is deactivated by action **114** and no further pumping is necessary to fill the reservoir.

Action **116** calls for an evaluation of the sample. This may occur by action of an operator, who can have been automatically notified of the completion of the sampling, where the operator physically takes the sample contained in the reservoir to an external lab. Alternatively or in addition, automated analysis could be performed.

The process ends at action **118** at which point the apparatus used to take the sample, including the reservoir, pump, and sensors can be cleaned and deployed at another groundwater site. The device, such as device **70** discussed above, can also be configured to allow for drainage of the purge water and/or sample water back into the aquifer after sampling and/or automated analysis has been completed.

Turning now to FIG. **5** a method of collecting a groundwater sample is provided where a single pumping apparatus is configured to both purge a well and fill a sample container. Method **201** is also particularly though not exclusively applicable to low yield wells, and method **201** is particularly applicable where a high quality/low turbidity fluid sample is desired. In one embodiment method **201** is a method of using apparatus **70** discussed above.

Method **201** begins by inserting a pumping apparatus into a well. Action **200** calls for setting the apparatus to purge the well. The apparatus can be set to purge the well by way of a valve assembly, such as three way valve **64** in apparatus **70** discussed above. The well is then purged in action **202**.

After purging, action **204** calls for a wait until the water level in the well reaches a high level. Once the water level reaches the high level, the pump is activated in action **205** and begins to purge more water from the well. However, unlike activity **202**, purging activity **205** only continues for a brief period during which activity **225** calls for a determination of sample quality. The sample quality can be determined to be acceptable to proceed to the next activity in several ways. The purging of a predetermined volume of fluid or the attainment of a desired low turbidity value (for example as indicated by sensor **78** in apparatus **70**) are two possible methods of determining that the sample is of adequate quality to proceed. In the first method, it is assumed that the initial water pumped after a substantial waiting period will be of low quality. In the second method the actual quality of the water is measured. Other determination methods could also be used. In any case, operations **205** and **225** serve to divert initially pumped water (which can be of low quality) from entering the sample reservoir.

Method **201** proceeds to actions **206** and **207** by switching the pump to now fill the sample reservoir and filling the reservoir. Preferably the switching and filling occurs by activating a valve assembly without otherwise disrupting the flow of fluid from the well which began in action **205**. In this way one can further ensure that the collected sample is of adequate quality.

Method **201** proceeds to decisions **208** and **210** which correspond to decisions **108** and **110** in method **101**. When the water level in the well has been determined to be too low yet the sample reservoir is not at the desired level, actions **212** and **214** call for setting the pump to purge and stopping the pump. Method **201** then calls for a return to action **204** to wait until the level of water in the well reaches a high level.

When the sample reservoir is determined to be at the desired level, action **216** calls for the pump to be shut down, which can also include selecting the pump to purge. Next, the sample is evaluated by any known method (for example as described above with respect to method **101**) in action **218** and method **201** ends.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

What is claimed is:

1. A method of monitoring groundwater in a low-yield aquifer comprising:

(a) operating a pump to remove water from a well in a low-yield aquifer and to provide the water to a sample container substantially devoid of air;

(b) providing at least one sensor to monitor the level of water in the well;

(c) providing a controller responsive to the at least one sensor for automatically activating and deactivating the pump;

(d) activating the pump when the water level reaches a first threshold as indicated by the at least one sensor; and

(e) deactivating the pump when the water level reaches a second lower threshold as indicated by the at least one sensor.

2. The method of claim **1** further comprising:

(f) repeating actions (d) and (e) at least once until a desired volume of water is provided to the sample container.

3. The method of claim **2** wherein the actions (d) and (e) are repeated at least once without a human operator in attendance.

4. The method of claim **3** wherein the pump fills the sample container at a volumetric flow rate less than about 500 ml/min.

5. The method of claim **2** further comprising:

(g) deactivating the pump when a predetermined volume of water fills the sample container.

6. The method of claim **1** further comprising switching the pump to fill the sample container after (d) activating the pump.

7. The method of claim **1** wherein the at least one sensor is a pair of contact sensors in spaced apart relation for sensing the first and second thresholds respectively.

8. The method of claim **7** wherein the pair of sensors are placed at adjustable positions along the length of a member extending into the well.

9. The method of claim **1** wherein the well produces less than about 0.5 liters of water per hour.

10. The method of claim **1** further comprising performing water quality analysis on the collected sample.

11. The method of claim **10** further comprising collecting a sample from the sample container after the deactivation for water quality analysis.

12. An apparatus for collecting a groundwater sample from a low-yield well comprising:

a reservoir substantially devoid of air;

a pump for removing water from a well in a low-yield aquifer and providing the water to the reservoir;

at least one sensor;

a controller for activating and deactivating the pump, the controller activating the pump at a flow rate less than about 500 ml/mm in response to signals received from the sensor;

wherein the controller activates the pump when the water level in the well reaches a first level as indicated by the at least one sensor, and the controller deactivates the pump when the water level in the well reaches a second lower level as indicated by the at least one sensor.

13. The apparatus of claim **12** wherein the reservoir is an evacuated bladder.

14. The apparatus of claim **12** wherein the reservoir contains a substantially inert atmosphere.

15. The apparatus of claim **12** wherein the controller deactivates the pump when a predetermined volume of liquid is transferred to the reservoir.

16. The apparatus of claim **15** further comprising a reservoir sensor for determining when the predetermined volume has been transferred to the reservoir.

17. The apparatus of claim **12** wherein the at least one sensor comprises a pair of contact sensors in spaced apart relation for sensing the first and second levels respectively.

18. The apparatus of claim **17** wherein the well normally has an accessible water volume of less than about 4 liters.

19. The apparatus of claim **12** wherein the well produces less than about 0.5 liters of water per hour.

20. The apparatus of claim **19** further comprising:

a multiway valve in fluid communication between the pump and the reservoir and controlled by the controller for selecting between purging the well and providing the water to the reservoir.

21. The apparatus of claim **20** wherein the controller switches the multiway valve to cause water to be provided to the reservoir after activating the pump when the water level in the well reaches the first level.

22. An apparatus for collecting and storing a sample from a low-yield well for subsequent analysis comprising:

a sample reservoir substantially devoid of air for receiving a volume of liquid for subsequent monitoring;

a pump for removing liquid from a low yield well and providing the liquid to the sample reservoir;

a controller for automatically activating the pump to fill the reservoir;

at least one fluid level sensor adapted to sense the level of liquid in the well and output at least one signal;

at least one reservoir sensor to sense the volume of liquid in the reservoir;

wherein the controller sequentially activates and deactivates the pump in response to the at least one signal until the reservoir is filled with a predetermined volume of liquid as indicated by the at least one reservoir sensor.

23. The apparatus of claim **22** wherein the pump operates at a flow rate of less than about 500 ml/min.

24. The apparatus of claim **22** wherein the reservoir comprises an evacuated bladder.

25. The apparatus of claim **22** wherein the controller activates the pump when the liquid level in the well reaches a first level as indicated by the at least one sensor, and the controller deactivates the pump when the liquid level in the well reaches a second lower level as indicated by the at least one sensor.

26. The apparatus of claim **25** wherein the at least one sensor comprises a pair of sensors in spaced apart relation for sensing the first and second levels respectively.

27. The apparatus of claim **22** further comprising a multiway valve in fluid communication between the pump and the reservoir and controlled by the controller for selecting between purging the well and providing the liquid to the reservoir.

28. The apparatus of claim **27** wherein the controller switches the multiway valve to cause liquid to be provided to the reservoir while the pump is activated.

29. An apparatus for collecting a sample from a well comprising:

a sample reservoir for receiving a volume of liquid for subsequent monitoring;

a sample bypass conduit;

a pump for removing liquid from the well and providing the liquid to the sample reservoir;

a multiway valve having a first position placing the pump in fluid communication with the sample reservoir and a second position placing the pump in fluid communication with the bypass conduit;

a controller for automatically activating the pump and the multiway valve;

at least one fluid level sensor adapted to sense the level of liquid in the well and output at least one signal;

wherein the controller sequentially activates and deactivates the pump in response to the at least one signal until the reservoir is filled with a predetermined volume of liquid.

30. The apparatus of claim **29** wherein the reservoir is substantially devoid of air.

31. The apparatus of claim **30** wherein the controller activates the pump when the liquid level in the well reaches a first level as indicated by the at least one sensor, and the controller deactivates the pump when the liquid level in the well reaches a second lower level as indicated by the at least one sensor.

32. The apparatus of claim **31** wherein the well is a low yield well.

33. The apparatus of claim **31** wherein the controller switches the multiway valve from the second position to the first position while the pump is activated.

34. An apparatus for collecting a groundwater sample comprising:

a reservoir;

a pump for removing water from a well and providing the water to the reservoir;

at least one sensor operable to sense the level of water in the well;

a controller for activating and deactivating the pump in response to signals received from the at least one sensor wherein the controller activates the pump when the water level in the well reaches a first level as indicated by the at least one sensor and the controller deactivates the pump when the water level in the well reaches a second lower level as indicated by the at least one sensor; and

a multiway valve in fluid communication between the pump and the reservoir and controlled by the controller for selecting between purging the well and providing the water to the reservoir.

35. The apparatus of claim **34** wherein the controller switches the multiway valve to cause water to be provided to the reservoir after activating the pump when the water level in the well reaches the first level.

36. The apparatus of claim **34** wherein the reservoir is substantially devoid of air.

37. The apparatus of claim **34** further comprising at least one reservoir sensor for sensing the volume of water in the reservoir wherein the controller sequentially activates and deactivates the pump until the reservoir is filled with a predetermined volume of water as indicated by the at least one reservoir sensor.

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