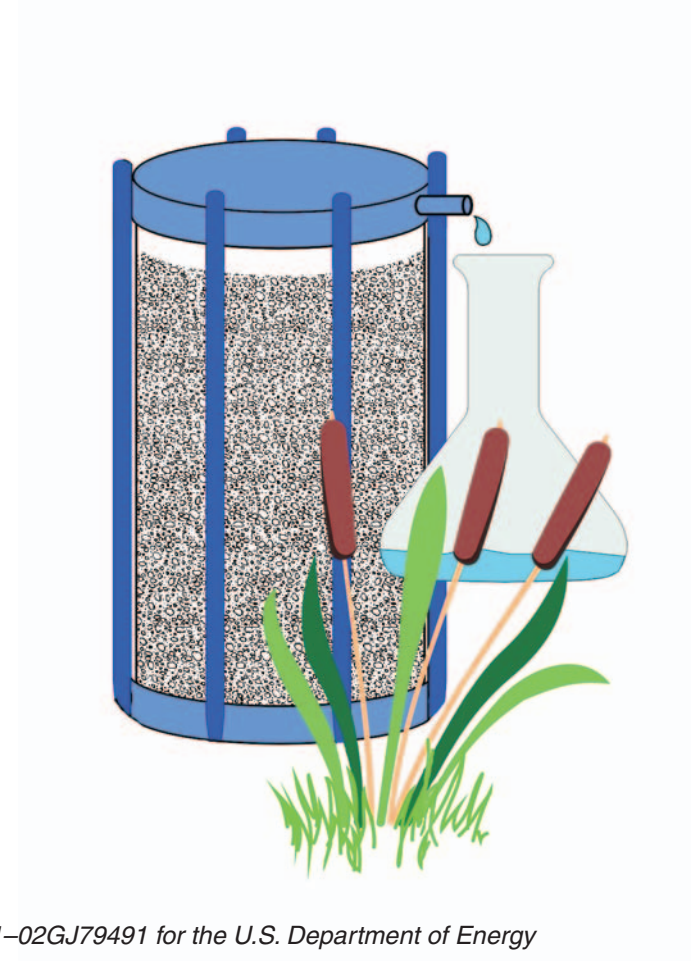
GJO–2004–589–TAC
ESL–RPT–2004–02

Environmental Sciences Laboratory

Diffusion Multilayer Sampling of Ground Water in Five Wells at the Tuba City, Arizona, Site

February 2004



Prepared for
U.S. Department of Energy
Grand Junction, Colorado

Work Performed Under DOE Contract No. DE–AC01–02GJ79491 for the U.S. Department of Energy
Approved for public release; distribution is unlimited.

ESL–RPT–2004–02

Office of Legacy Management

Diffusion Multilayer Sampling of Ground Water in Five Wells at the Tuba City, Arizona, Site

February 2004

Work Performed by S.M. Stoller Corporation under DOE Contract No. DE-AC01-02GJ79491
for the U.S. Department of Energy, Grand Junction, Colorado

U0195900

Signature Page

Office of Legacy Management

Diffusion Multi-Layer Sampling of Ground Water in Five Wells at the Tuba City, Arizona, Site

February 2004

Prepared By: _____
Mark Kautsky, Project Hydrologist

Reviewed By: _____
Stan Morrison, Manager
Environmental Sciences Laboratory

Contents

Page

Tables

Page

Figures

Page

Appendixes

End of current text

Acronyms

DMLS	Diffusion Multilayer Sampler
DOE	U.S. Department of Energy
EC	electrical conductance
LM	Legacy Management
ORP	oxidation reduction potential
UMTRA	Uranium Mill Tailings Remedial Action

End of current text

Executive Summary

Passive samplers were used to collect depth-specific ground water samples from five monitor wells at the U.S. Department of Energy Tuba City Legacy Management site in north central Arizona. Diffusion Multi-Level Sampler (DMLS) methodology was used to collect the ground water samples from wells 938, 934, 935, 944, and 932 between May 6, 1998 and February 25, 1999. Each DMLS tool is 5 feet long and contains 12 equally spaced ports that are separated by flexible rubber seals that contact the inside of the well casing. Two DMLS instrumentation setups were used in this study. The four DMLS tools were either directly joined together to obtain continuous samples from wells having 20-foot-long screen intervals, or they were connected with a length of cable to sample screen intervals up to 45 feet long at discreet locations. Each probe was equipped with a 14-mL sample cylinder capped with a dialysis membrane. The assembly of probes was lowered into each well for a period of at least 2 weeks and then retrieved. At well 938, the sample collection was repeated using a longer equilibration period (120 days) to determine if the 2-week period was sufficient. Upon retrieval from the well, samples from three probes were composited into a single 40-mL glass vial, cooled, and transported to the analytical laboratory for analysis of molybdenum, selenium, nitrate, sulfate, and uranium. Samples from a fourth probe were measured in the field for pH, redox potential, alkalinity, and electrical conductance.

Results of the sampling show that the concentration profile was constant over the depth that was sampled. This indicates that either the concentration profile in the well was constant over the sample depth, or that vertical flow within the well yielded an equal concentration. Replicate sampling of well 938 showed that the concentrations obtained from a 14-day equilibration were reproduced with a 120-day equilibration. Assuming that the 120-day equilibration yielded a representative sample implies that the 14-day equilibration was also adequate.

The DMLS sampling method could potentially be used in the future to monitor wells with longer screens. Analytical results from such monitoring should be viewed with caution at the Tuba City site because significant vertical hydraulic gradients could induce preferential flow within the screen interval. Quantitative assessments of the concentration profiles could be improved by first determining if concentrations collected with the sample probes match those measured outside the probe.

End of current text

1.0 Introduction

One of the uncertainties during the design phase of the Tuba City remedial action was the depth of the contamination plume (Kautsky 1999). There were few monitoring wells within the area of the plume that actually tapped deeper portions of the aquifer, and those were situated outside the plume area. Wells inside the plume area tapped the upper part of the aquifer, and few wells within the plume area had long screen intervals. Because of the lack of wells that could be used to define the depth of the plume, passive samplers were used within the plume area to project its depth. This report describes the passive sampling conducted at the Tuba City site and the concentration profile data that were collected. Deployment of the passive samplers described in this report was conducted as part of the UMTRA Ground Water Project. The presentation of results from those efforts is being done under the Environmental Sciences Laboratory subtask of the Legacy Management task order.

End of current text

2.0 Background

Diffusion Multi-Level Sampler (DMLS) methodology employs dialysis cell technology to passively collect water samples at various depths in a well and to vertically profile the chemical composition of an aquifer. Scientists at the Weizmann Institute of Science in Israel developed the sampling methodology as a research tool and introduced it to the science community in 1985. In 1996, U.S. Filter/Johnson Screens became the exclusive North American distributor for DMLS (recent inquiries conducted as part of this report were unsuccessful at locating the current U.S. distributor). Appendix A contains a reprint of the DMLS installation and maintenance manual furnished by U.S. Filter.

The sample cell used in the DMLS technique is a polypropylene vial filled with deionized water and capped with a permeable dialysis membrane. When the cell is exposed to well water, ground water solutes diffuse into the cell until concentrations inside the cell equal the concentrations outside the cell. The diffusion occurs across the semipermeable membrane. Up to 12 dialysis cells are installed along a 5-foot (ft)-long rod, and each cell is isolated from its neighbor with flexible rubber seals that fit loosely against the inside of the well screen. Turbulence and mixing of ground water occurs as the DMLS sampler is lowered into a well; therefore, sufficient time must be allowed to permit natural flow to replace the water inside the well with formation water and to achieve equilibrium within the dialysis cell. Approximately 7 to 10 days are required before the DMLS can be retrieved; however, in low-flowing wells the period might be longer.

End of current text

3.0 Methods

Between May 6, 1998, and February 25, 1999, ground water concentration profiles were obtained from wells 938, 934, 935, 944, and 932 at the Tuba City site (see Figure 1). The profiles were collected using a series of four DMLS sampling rods suspended within the screen interval of each well. If a screen interval was 20 ft in length, four 5-ft-long DMSL rods were attached end-to-end to accomplish the sampling. If the screen intervals were longer than 20 ft, the DMLS rods were connected together with cables of equal length. In both cases, a weight was attached to the lowermost rod to pull the assembly of rods down the hole. For convenience, the rods were labeled A, B, C, and D; A was the uppermost and D the lowermost rod in each installation. Each rod is capable of housing up to 12 sampling probes along its length. If the ports on the upper half of the rod were being used, the samples were labeled U; if the lower half of the rod was being used, then the sample was designated L. Table 1 summarizes the depths that the DMLS tool was placed in each well. The designation 938-A-U indicates that the sample was from the upper half of the uppermost sampling rod and was collected from well 938.

The DMLS assembly was lowered into the well using a cable reel attached to a standard marine winch with a counter (see Figure 2). The cable was passed through a pulley affixed to the apex of a large tripod. The D rod was lowered into the well first, followed by the C, B, and A rods, until the entire sampling string was lowered into the well. As shown in Table 1, the first three installations equilibrated for a period of about 14 days. The remaining installations equilibrated for 13, 22, and 120 days, respectively. The 120-day installation was a repeat of an earlier 14-day installation in well 938 to evaluate if the 14-day equilibration was sufficient.

Each dialysis cell contains 14 milliliters (mL); consequently, the contents of 3 cells were needed to fill a 40-mL glass vial. A fourth cell was used for field measurements at each depth. Each 40-mL composite sample was analyzed for molybdenum, nitrate, selenium, sulfate, and uranium. Field measurements included alkalinity as $CaCO_3$, electrical conductance (EC), oxidation reduction potential (ORP), and pH.

End of current text

4.0 Results and Discussion

Analytical results for the DMLS sampling are summarized in Table 2 and are also summarized graphically in Figures 3 through 7. Except for samples 938-A-U, 934-A-U, and 934-A-L, the sample results show qualitatively that the DMLS method collects credible samples. The three exceptions occurred presumably because the uppermost ports in wells 938 and 934 were not completely submerged in the ground water. This would explain why the resulting concentration is higher than deionized water and lower than the expected ground water concentration.

Well 938 was sampled twice with the DMLS tool; the first sample was extracted on May 20, 1998, and the second sample was extracted on February 25, 1999. The results are not entirely comparable because the uppermost sampler was not immersed completely; however, nitrate, sulfate, and uranium concentrations from the three lower samplers B, C, and D, at 56.5, 78.0, and 94.5 ft, respectively, appear to be comparable (Table 2). The reproducibility of the results from these depths suggests that 14 days was sufficient time for the samples to equilibrate with the well water from that interval. However, these data do not necessarily show that the dialysis cells yield the same concentration as the ground water.

End of current text

5.0 Conclusions and Recommendations

Results from this investigation suggest that the DMLS method can be used to gather chemical profile data from wells at the Tuba City site. The method is best suited to sites where the vertical hydraulic gradient is negligible, because the well itself could become a pathway for vertical migration of ground water if the vertical gradients were important. If the vertical hydraulic gradients were significant and vertical flow was taking place within the well, the resulting concentration profile measured with the DMLS method would probably show little change with depth. The absence of large variations in the concentration in well 938, which has the longest screen interval of the wells tested in this investigation, might indicate that the well itself is serving as a conduit for vertical flow.

The five wells in which the DMLS samplers were installed had relatively short screens and tapped only a small portion of the total depth of the contaminant plume at the Tuba City site. Extrapolating the total contaminant depth based on these limited DMLS results would introduce considerable error; consequently, no such estimate is presented in this document. However, 25 extraction wells installed in the summer of 1999, after the DMLS sampling was complete, have much longer screen lengths and penetrate deeper sections of the plume. Three of these extraction wells have 100-foot long screens. The remaining twenty-two wells have 150-foot long screens that span the 4,820 to 4,970-ft elevations. Applying the DMLS sampling technique to these latter wells may yield a better estimate of the concentration profile in the plume.

Although results from the DMLS sampling show that the method can be used to collect reproducible ground water samples at the Tuba City site, no specific tests were conducted to compare the concentrations in the dialysis cells to those in the surrounding well water. Laboratory testing could be used to compare the equilibrated concentrations in the dialysis cells to the concentration of the reference liquid in which the cell is immersed.

Questionable results from samples 938-A-U, 934-A-U, and 934-A-L indicate that the depth to water and the depth of the sample cells must each be measured with utmost care to ensure that each probe is completely immersed. The installation procedures must also be carefully followed.

End of current text

6.0 References

Kautsky, Mark 1999. "Hydrogeologic Uncertainty and the Design of a Remedial Well Field" in *Proceedings of the Sixth International Conference on Tailings and Mine Waste'99, Fort Collins, Colorado, USA, 24−27 January 1999,* A.A. Balkema, Rotterdam, Brookfield.

End of current text

Table 1. Installation Depths and Equilibration Periods for DMLS Samples at the Tuba City, Arizona, Site

DMLS Sample No.	DMLS Depth (ft BTOC)	Screen Interval (ft BTOC)	Installation Date	Extraction Date	Equilibration Period (days)
938-A-U	44.5	43.3−98.3	May 06, 1998	May 20, 1998	14
938-A-L	48.5				
938-B-U	56.5				
938-B-L	60.0				
938-C-U	78.0				
938-C-L	81.5				
938-D-U	94.5				
938-D-L	98.5				
934-A-U	47.5	46.7−91.7	May 20, 1998	June 03, 1998	14
934-A-L	51.5				
934-B-U	58.0				
934-B-L	62.0				
934-C-U	69.5				
934-C-L	73.5				
934-D-U	81.0				
934-D-L	85.0				
935-A-U	54.0	52.7−92.7	June 03, 1998	June 17, 1998	14
935-A-L	58.0				
935-B-U	65.5				
935-B-L	69.5				
935-C-U	77.5				
935-C-L	81.5				
935-D-U	89.0				
935-D-L	93.0				
944-A-U	88.0	87.1−107	June 17, 1998	June 30, 1998	13
944-B-U	93.0				
944-C-U	98.0				
944-D-U	103				
932-A-U	116	115−135	June 30,1998	July 22, 1998	22
932-B-U	121				
932-C-U	126				
932-D-U	131				
938-A	44.5	43.3−98.3	October 28, 1998	February 25, 1999	120
938-B	56.5				
938-C	78.0				
938-D	94.5				

ft BTOC = ft below top of casing.

Table 2. Analytical Results of DMLS Sampling

DMLS Sample No.	Depth (ft)	Alk (mg/L) $CaCO_3$	EC (µmhos/cm)	Eh (mV)	pH	Mo (µg/L)	NO_3 (µg/L)	Se (µg/L)	SO_4 (µg/L)	U (µg/L)
938-A-U	44.5	2	0.051	145	5.74	<01.0	442	<1.0	554	<1.0
938-A-L	48.5	NA	NA	117	5.03	1.1	827000	48.0	328000	229
938-B-U	56.5	662	6010	151	6.69	<1.0	1410000	50.0	1910000	164
938-B-L	60.0	NA	6120	130	6.67	<1.0	1320000	41.5	1940000	196
938-C-U	78.0	801	6150	120	6.74	<1.0	1270000	36.2	1990000	214
938-C-L	81.5	813	6130	114	6.70	<1.0	1260000	35.7	2030000	218
938-D-U	94.5	822	6100	110	6.69	<1.0	1260000	35.9	2020000	215
938-D-L	98.5	803	6120	97	6.74	<1.0	1270000	36.0	2020000	211
934-A-U	47.5	0	1061	94	4.99	<1.0	244	<1.0	509	<1.0
934-A-L	51.5	0	NA	63	4.81	<1.0	325	<1.0	522	<1.0
934-B-U	58.0	1244	12670	40	6.63	2.1	2440000	10.8	7520000	262
934-B-L	62.0	1236	12510	1	6.73	1.7	2320000	10.6	7750000	288
934-C-U	69.5	1292	12720	−9	6.80	2.3	2330000	10.8	7850000	288
934-C-L	73.5	1289	12610	−13	6.81	2.1	2320000	10.5	7770000	284
934-D-U	81.0	1353	12630	−28	6.91	3.4	2330000	10.8	7800000	283
934-D-L	85.0	1342	12690	−26	6.87	3.1	2310000	10.6	7850000	279
935-A-U	54.0	493	576	125	6.26	<1.0	537000	19.7	2830000	157
935-A-L	58.0	526	5960	119	6.38	<1.0	556000	23.0	2860000	149
935-B-U	65.5	552	5830	119	6.49	<1.0	574000	25.6	2950000	141
935-B-L	69.5	556	6100	112	6.47	<1.0	586000	25.1	2960000	151
935-C-U	77.5	559	6020	104	6.42	<1.0	588000	25.6	2930000	150
935-C-L	81.5	564	5970	102	6.26	<1.0	588000	25.8	2950000	147
935-D-U	89.0	575	6060	86	6.42	<1.0	585000	26.1	2930000	149
935-D-L	93.0	494	6000	75	6.46	<1.0	587000	26.0	2940000	149
944-A-U	88.0	524	6840	121	6.42	<1.0	50800	31.6	2020000	648
944-B-U	93.0	524	8510	119	6.86	<1.0	53200	45.5	2010000	1010
944-C-U	98.0	548	8460	100	6.62	<1.0	53900	46.5	1940000	1020
944-D-U	103	549	5600	104	6.98	<1.0	36500	47.2	1940000	1060
932-A-U	116	91	364	55	6.98	2.5	17500	1.3	24400	6.2
932-B-U	121	98	344	31	7.21	1.2	9830	<1.0	23700	7.7
932-C-U	126	99	339	40	7.24	2.4	8010	<1.0	21500	5.9
932-D-U	131	119	573	35	7.32	<1.0	64400	<1.0	66000	6.9
938-A	44.5	470	7650	216	6.97	<1.0	2070000	154	2610	190
938-B	56.5	709	6330	201	6.81	<1.0	1520000	64.4	2090000	193
938-C	78.0	786	6170	165	6.86	1.4	1420000	51.6	2140000	222
938-D	94.5	810	6170	146	6.89	<1.0	1410000	51.6	2050000	226

µmhos/cm = micromhos per centimeter

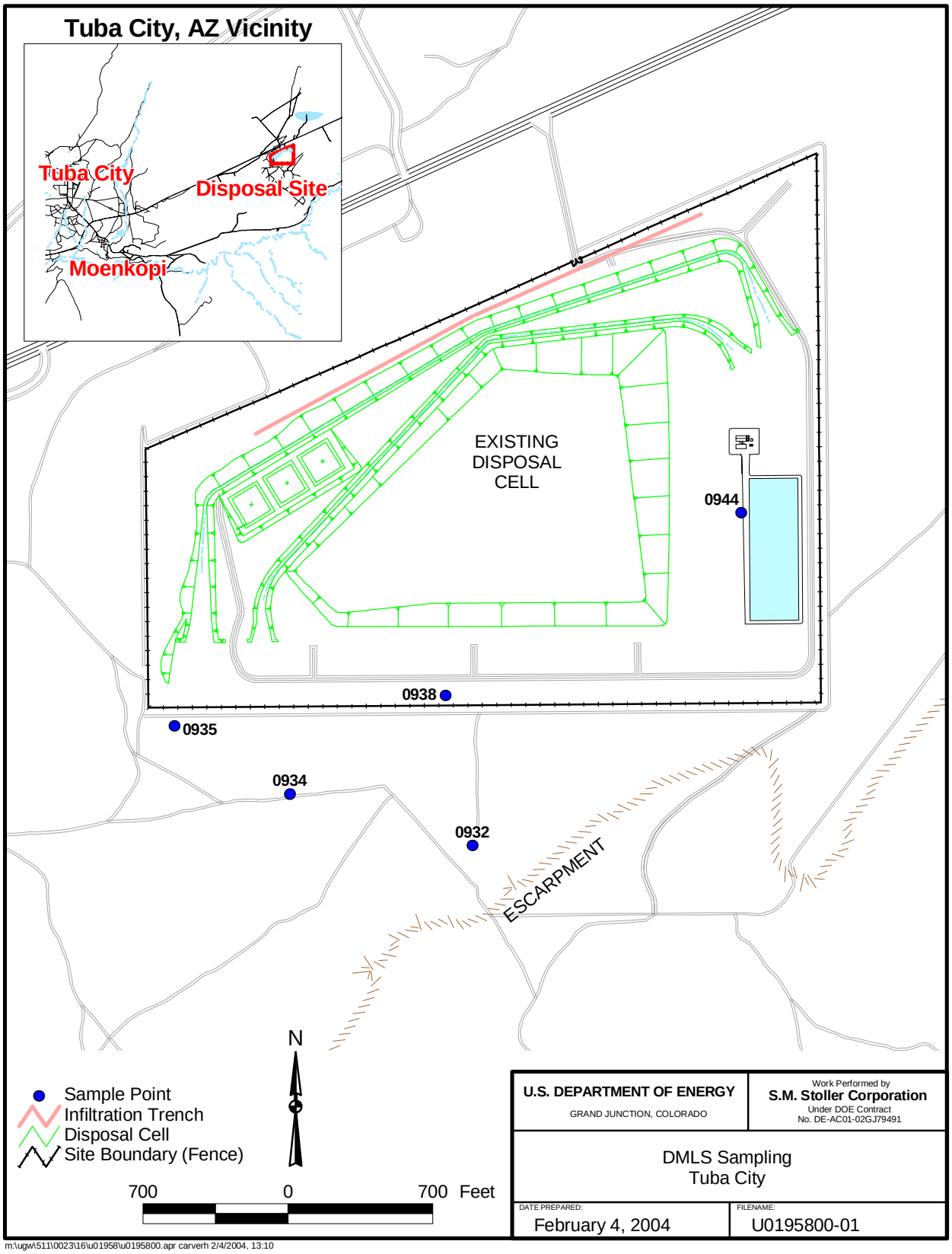


Figure 1. Well Location Map

Figure 2. DMLS Assembly

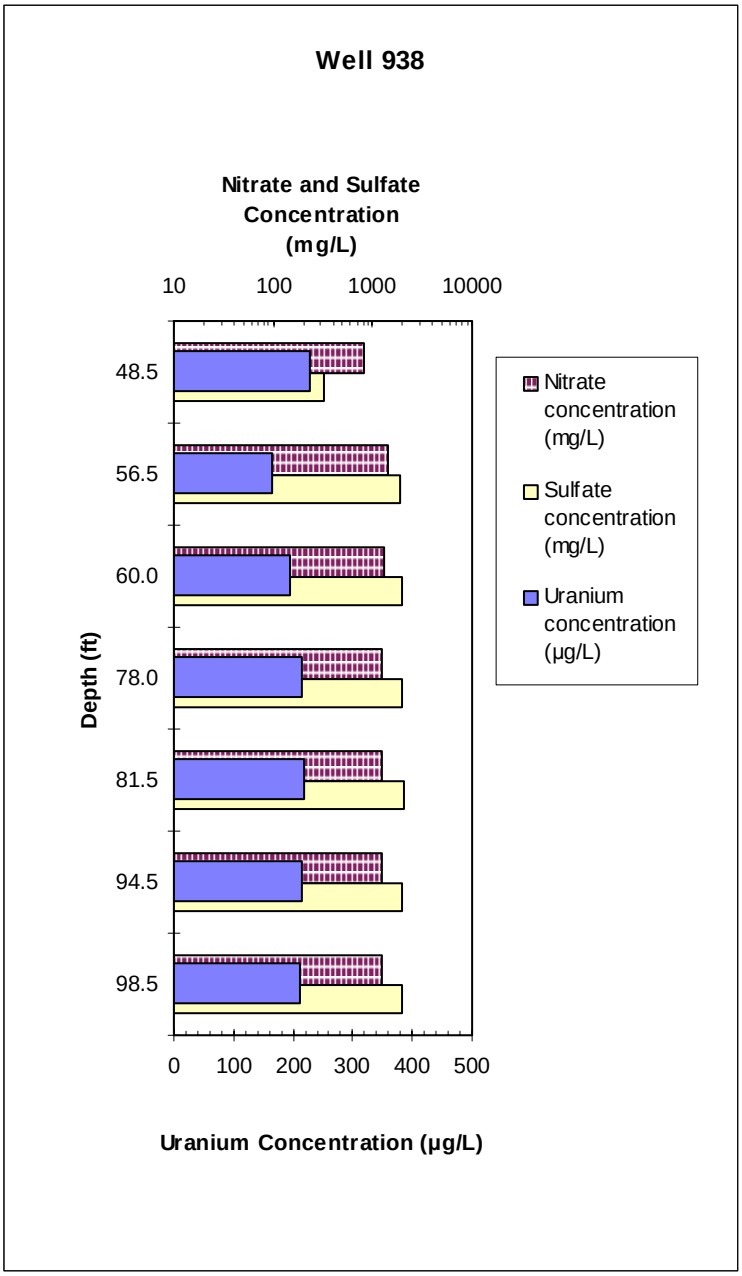


Figure 3. Concentration of Selected Constituents versus Depth at Well 938

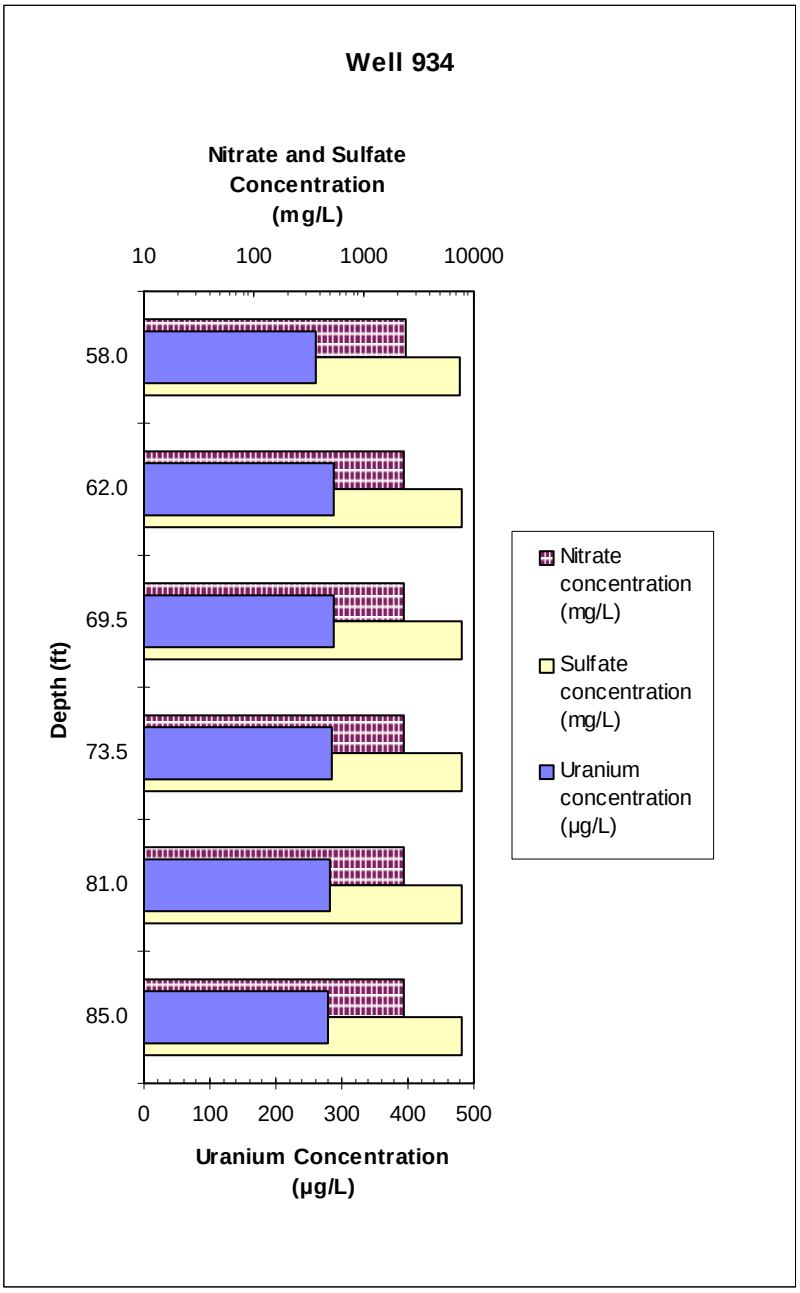


Figure 4. Concentration of Selected Constituents versus Depth at Well 934

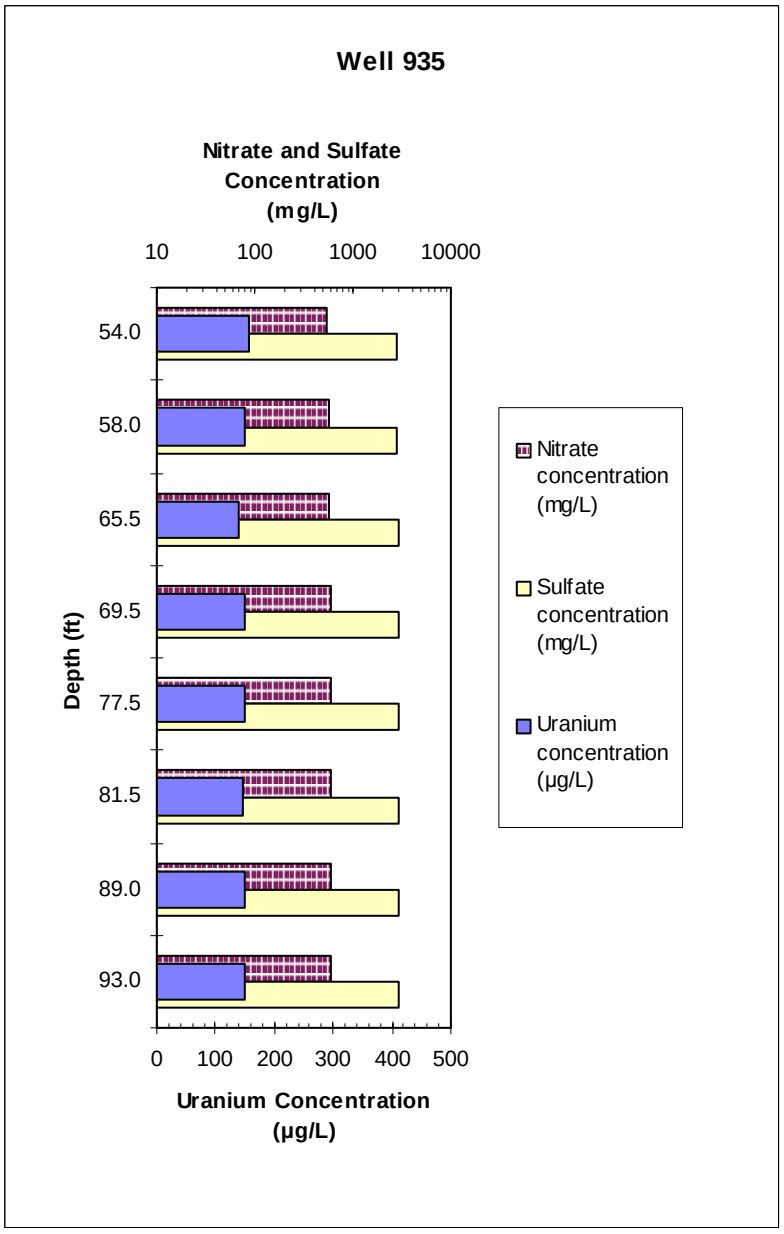


Figure 5. Concentration of Selected Constituents versus Depth at Well 935

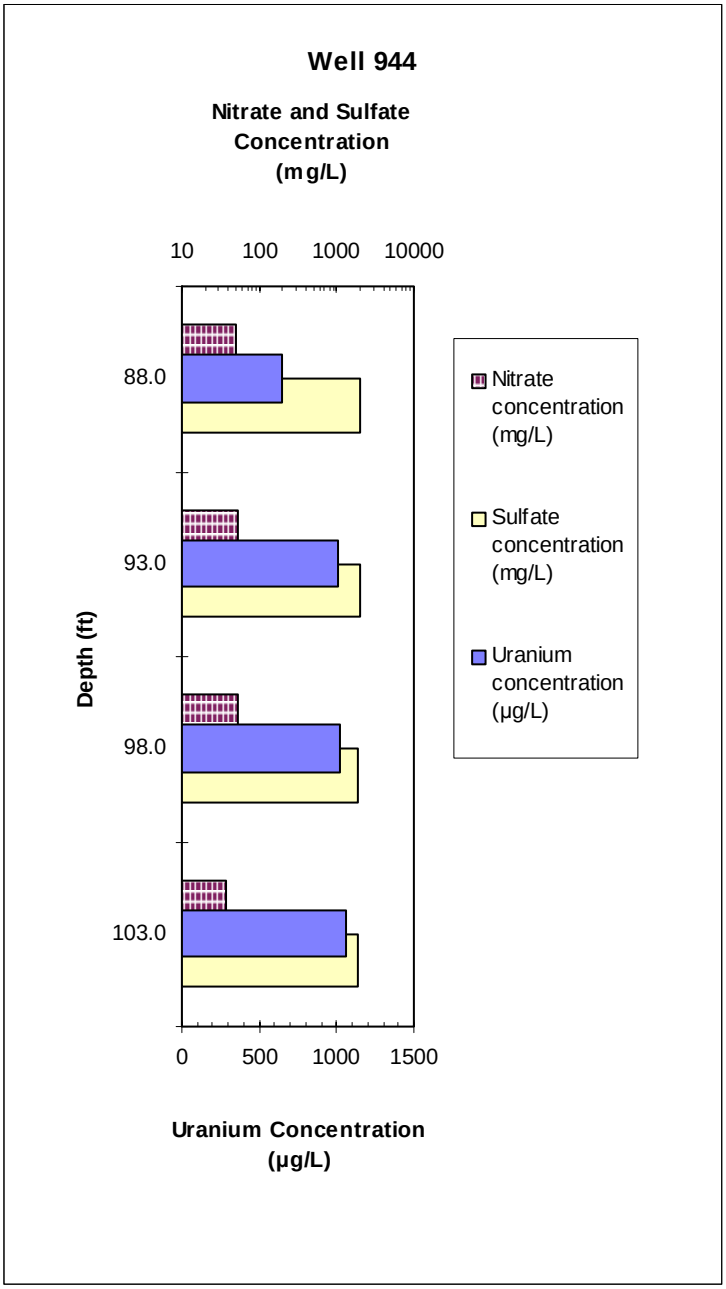


Figure 6. Concentration of Selected Constituents versus Depth at Well 944

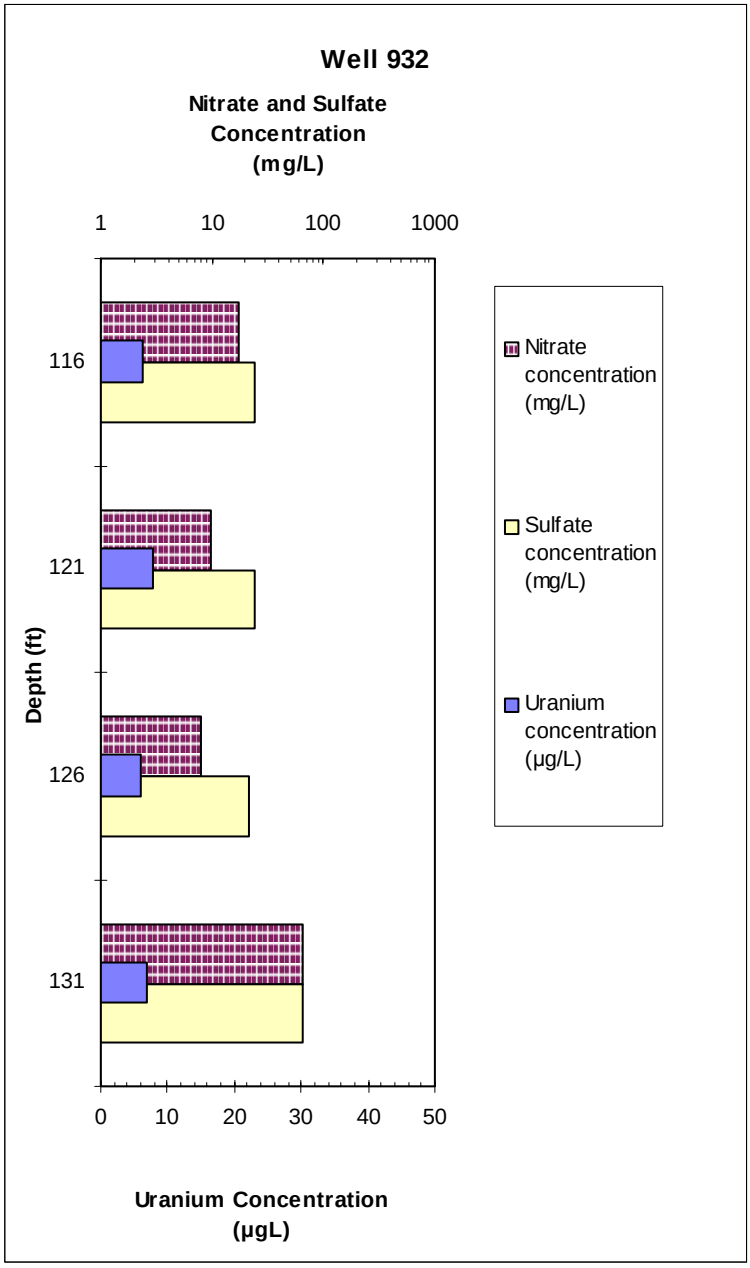


Figure 7. Concentration of Selected Constituents versus Depth at Well 932

End of current text

Appendix A

DMLS Installation and Maintenance Manual
(U.S. Filter)

U.S. Filter / Johnson Screens™

DMLS™

Installation & Maintenance Manual

Tel: 800-VEE-WIRE, Fax: 612-638-3171 E-mail:hansonga@jfs.mhub.com
P.O. Box 3118, St. Paul, Minnesota 55164, U.S.A.

 12/13/96

A). Background

DMLS (Diffusion Multi-Layer Sampler) is a passive, multi-layer sampling device based on dialysis cell technology. It was developed as a research tool by a group of scientists at the Weizmann Institute of Science in Israel who studied ground water processes in the saturated zone. Since its introduction in 1985, the DMLS has been incorporated into many studies throughout the world, providing information never before available. In 1996, U.S. Filter / Johnson Screens became the exclusive North American distributor for DMLS.

B). The DMLS principle

1). A dialysis cell is a polypropylene vial that is filled with distilled water and covered by permeable membranes at both ends. When a dialysis cell is exposed to ground water having concentrations of solutes different from inside the cell, a natural process of diffusion of solutes from higher concentrations to lower concentrations occurs. This occurs through the membrane until a dynamic equilibrium is reached. At this point and beyond, the contents of the cell will be representative of the water surrounding the cell. The process is dynamic and the concentration of solutes inside the cell will change as the concentration outside the cell changes. There will be a lag period (the equilibration period) which varies from one solute to another.

2). The DMLS is comprised of a rod on which dialysis cells are placed and which are separated by seals loosely fitting the inner diameter of the well. When lowered into a well, these seals form layers. Therefore, each dialysis cell represents the layer formed by the seals.

3). While being lowered into the well, the DMLS mixes the water column inside the well. Therefore, it must be left in the well for the minimum period of time required for the natural flow of the aquifer to change at least one volume of water and to re-establish the natural stratification of the solutes of the aquifer. This period of time depends on the nature of the aquifer and the diameter of the borehole. No purging is required when using the DMLS.

4). After the DMLS is retrieved from the well, the cells are capped and sent to the lab, or analyzed in the field. The results form a vertical profile of the chemical composition of the water at a 3" or greater vertical sequence.

5). The DMLS is modular and flexible in use. Its units can be connected to fit most sampling programs.

C). Storage conditions

1). When not in use, store the DMLS rods and parts under room temperature conditions in a well ventilated storage area. DMLS parts should not be exposed to heat greater than 110 degrees F (45 degrees C).

   a). Remove the seals, clean, and store them in a box or a plastic bag.

   b). Store the DMLS rods horizontally and fully supported along the body of the rod. Do not store them resting on their ends only.

2). For short term storage of the rods with seals attached, store them horizontally and fully supported along the body of the rod. Do not store them resting on the seals.

3). Do Not expose the DMLS to excessive or continuous sunlight or heat. When working in the field, store it in a shaded location.
4). Transportation to the field should be done in a heat isolated package (wood, carton, etc.).

D). Tools required but not provided

1). Cable & winch for lowering the DMLS into the well
2). Gloves: protective and surgical
3). Screwdriver - large (preferable battery powered)
4). Safety helmet
5). Safety goggles
6). Waterproof marking labels
7). Metal stopper - assembly tool *
8). Assembly stand/sawhorses

* Accessory items available from Johnson Screens

E). Safety rules

1). Always wear protective gloves, helmet, and goggles.
2). Keep all objects away from the lip of the well. If any object falls in, the well may be damaged and possibly contaminated.
3). It is recommended that a manual or hydraulic winch be used when lowering or retrieving the DMLS.
4). Always comply with local, state and federal laws and requirements.

WARNING:
1). Do Not lower the DMLS into or out of the well by hand.
2). Do Not overload the DMLS. The following are load recommendations:
   a). For Standard Product: maximum load is four (4) connectable rods (20 feet) plus weights.
   b). For Engineered Product: maximum load is twenty (20) connectable rods (100 feet) plus weights.
3). Do Not expose the DMLS to excessive or continuous sunlight or heat. When working in the field, store it in a shaded location.
4). Transportation to the field should be done in a heat isolated package (wood, carton, etc.).

F). Checking the inventory list

Unpack the DMLS from its packaging. Compare the contents with the packing list provided. Special attention should be paid to the integrity of the seals and all other parts of the DMLS. Note: Do not use any damaged parts. Notify your distributor or Johnson Screens if damaged parts are received.

G) Preparing the dialysis cell

Each dialysis cell has 4 parts:

1. The cell body (1 pc.)
2. Membrane in membrane holder (2 pcs.)
3. Membrane screw cover (2 pcs.)
4. Dialysis cell cap (2 pcs.)

1). The membrane has a convex side and a concave side.
   a). Wear surgical latex gloves.
   b). Insert one membrane into one of the membrane screw covers. Note: Cell cap will not snap in place if membrane is improperly inserted.
   c). Screw the membrane screw cover to the cell body.
   d). Repeat this procedure for each cell to be used.

2). Add the desired number of partially assembled cell bodies, membranes, and membrane screw covers into a bucket filled with distilled water. The bucket should be large enough to contain all cells and membranes and allow convenient cell filling under the water.

3). Insert a membrane into a membrane screw cover and screw it (under water) to the open end of a partially assembled cell body.

4). Avoid air bubbles in the cells.

5). Leave the filled cells in the bucket during transportation to the field. Air bubbles and unnecessary opening and capping of the cells later can be avoided.

Important Remarks:

1. Each membrane should be used for **only one** sampling procedure.
2. Avoid touching the membranes with greasy or oily hands as grease and dirt may block the pores of the membrane and decrease the diffusion area. Wear latex surgical gloves while installing membranes and filling the cells.
3. Do not use torn or broken membranes
4. Check the cells for air bubbles and proper membrane installation prior to placing them in the rod.

The dialysis cells are now ready to use.

H). Assembly of the DMLS

1). Put the two half parts of the centralizing guide in the wide slot at the center of the rod (only for 4" wells - not required for 2" wells) with each end against the other. Insert the screws in their location and screw tight with a screw driver. Do not use excessive force.

2). The standard rod has 14 seal slots and the engineered rod has 20. The seals should be assembled into the slots from each side of the rod (seals for 2" wells are preassembled). Attach the seals by stretching one gently and pulling it over the DMLS rod until it reaches the slot closest to the centering guide. Slip the inner side of the seal into the slot. Make sure that the seal is properly positioned by rotating it around the rod. Repeat this process until a seal occupies each slot. Note: Wetting the rod provides a smoother seal installation.

I). Loading the cells on the DMLS

Set up a clean stand (i.e. sawhorses about 5 ft. apart) on level ground. Place the DMLS rod on the stand. The standard product rod has 12 holes for 12 cells (Engineered product has 18 holes for 18 cells). If previously capped, remove both caps from each cell and insert a cell into each hole of the rod until the cell clicks into place.

J). DMLS unit connection method

All DMLS units are connected by using quick lock connectors and a screwdriver.

1). Unscrew the connector screws.
2). Bring the flat ends of the units (rods) to be connected together.
3). Close the connector over them.
4). Screw the connector closed.
NOTE: The plastic screws are not exposed to any stress or force while lowering the DMLS or retrieving it. Do not use excessive force while screwing or unscrewing.

K). Preparing the DMLS for operation

NOTE: The order in which the DMLS units and weights are placed is determined by the sampling program. Weights can be placed anywhere along the DMLS. Generally, if the sampling procedure allows, it is preferable to start with at least one weight to keep the cable taut.

Make note of the rod serial numbers (stamped toward the top of each rod) in the order they will be used. Each rod is stamped (every other cell) with cell location numbers. This will help in identifying the exact depth location of each cell.

Connect the cable to the hook. Be sure the cable and the connection are strong enough so they will not break inside the well.

L). Lowering the DMLS into the well

1). Join the base and first unit (i.e. weight and DMLS rod) using a quick lock connector.
2). Connect the free end of the first unit to the hook and cable using a connector.
3). Lift the cable and insert the base and first unit into the well. When the first unit's top hole is a few inches above the lip of the well, stop the cable and insert the metal stopper/assembly tool into the hole. If there is a cell in the hole then remove it temporarily.
4). Lower the cable until the first unit is held by the stopper at the lip of the well and the cable is slack.
5). Open the connector between unit and cable. Connect the cable to the second unit using the same method.

6). Lift the second unit with the cable and connect its base to the top of the first unit (which is already in the well).
7). Lift up the apparatus and extract the stopper. Replace the stopper with the cell (if taken out).
8). Repeat the same process for every connectable unit.
9). Using free-fall method, lower the DMLS into the well. Release as much cable as is necessary. When DMLS reaches the desired depth location, carefully tie the cable to the lip of the well. Pay attention to the cable, keeping it taut during the entire lowering process.

M). Determining the duration of stay in the well

The process of lowering the DMLS will mix the water in the well, so the DMLS should be left long enough to allow the well to re-stratify. Normally, a period of 7 - 10 days is enough, but in low-flow wells, this period may need to be longer. In most cases, there is no limitation to the length of time the DMLS may stay in the water.

N). Retrieving the DMLS from the well

1). Connect the end of the cable to the tower or tripod; then disconnect the cable from the lip of the well or the cable lock.
2). Gradually start lifting the DMLS by pulling the cable up. The power required during retrieval depends upon various factors such as: water above DMLS, seal friction, hydraulic conductivity of the various layers, and the sediments that may have settled on the DMLS during its sampling time interval. Therefore, starting motion upwards could be difficult. If you use a mechanical lifting device, slowly increase the rate of ascent.

NOTE:
1. Applying an uncontrolled sudden force, an assertive force, or a greater speed than required during ascent, may result in a broken cable or instrument.
2. The DMLS may become stuck during ascent. If this happens, try to release it by gently lowering and lifting the unit.

3). Stop pulling the cable when the top hole of the second unit is above the lip of the well. If there is a cell in that hole, remove and insert the metal stopper/assembly tool.
4). Lower the DMLS unit until it is resting on the stopper and the cable is slack.
5). Open the connector between the first and the second units and disconnect the first unit from the cable.
6). Lower the cable and connect it to the top of the now uppermost unit.
7). Lift the cable and extract the metal stopper. Replace a cell if it has been extracted.
8). Pull the second unit out of the well, and repeat the entire procedure for each unit to be dismantled.

O). Retrieving the cells

1). Each rod has a unique serial number and a cell numbering scheme (see Section K).
2). Place the dismantled rod on a clean stand.
3). Cap each cell with cell caps.
4). Mark or label each cell in a way that defines the rod it was extracted from and its location on the rod.
5). Place the cells in a box and send to the lab or analyze in the field.

Note: For water samples containing volatiles,

1. Cap the cells while they are still on the rod during the DMLS retrieval process. Be careful not to drop caps into well.
2. Then follow steps 2) and 4) above.
3. Wrap each end of the capped cell with parafilm in a way that it covers the caps and entire cell cover.
4. Place the cells on ice and rush them to the lab. These samples should be analyzed within 24 - 48 hours. Consult with your lab if questions.

Johnson DMLS Sampler
Parts List

Ref No.	Part No.	Description
1	80728	DMLS–SP 2"x5' Sch40 Well Assy
	80729	DMLS–SP 4"x5' Sch40 Well Assy
	85292	DMLS–SP 4"x5' Sch80 Well Assy
	80736	DMLS–EP 4"x5' Sch40 Well Assy
	85294	DMLS–EP 4"x5' Sch80 Well Assy
2	80718	DMLS–SP 4" Sch40 Centering Guide
	84524	DMLS–SP 4" Sch80 Centering Guide
	80722	DMLS–EP 4" Sch40 Centering Guide
	85288	DMLS–EP 4" Sch80 Centering Guide
3	80714	DMLS–SP 2" Sch40 Seals (14 attached to Rod)
	80717	DMLS–SP 4" Sch40 Seals (Pkg of 16)
	84523	DMLS–SP 4" Sch80 Seals (Pkg of 16)
	80752	DMLS–EP 4" Sch40 Seals (Pkg of 22)
	85287	DMLS–EP 4" Sch80 Seals (Pkg of 22)
4	80716	DMLS– SP Connector
	80721	DMLS– EP Connector
5	81293	DMLS–2" (0.2 micron) Cells (Pkg of 12)
	81294	DMLS–4" (0.2 micron) Cells (Pkg of 12)
	81295	DMLS–4" (0.2 micron) Cells (Pkg of 18)
6	N.A.	DMLS–Cell Cap
7	N.A.	DMLS–Membrane Screw Cover
8	80727	DMLS–Membranes 0.2 micron (Pkg of 24)
	81360	DMLS–Membranes 10 micron (Pkg of 24)
9	N.A.	DMLS–Cell Body
10	80725	DMLS–SP 5KG Weight
	80959	DMLS–EP 5KG Weight
	80723	DMLS–EP 10KG Weight
11	80726	DMLS–SP Hook
	80724	DMLS–EP Hook
12	81507	DMLS–SP Assy Tool
	81509	DMLS–EP Assy Tool