PHOTOS, PLANS AND SPECIFICATIONS

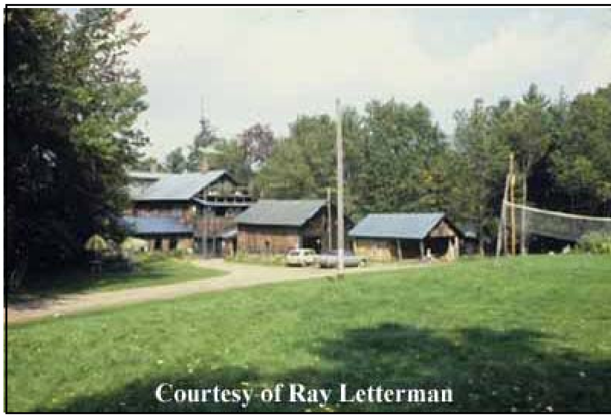
(A) PHOTOS

i. *Photos of Limestone Contactor in U.S.:*

a) Limestone contactors installed at a resort in the Adirondack Mountains, New York:

The following photos show a column-type contactor and a box-type contactor installed at a resort in the Adirondack Mountains, New York (on Big Moose Lake). The owner of the resort had problems with corrosion especially pin-holes in copper pipe.

- **Covewood Lodge**



Covewood Lodge is owned and managed by C. V. "Major" Bowes. It is located on Big Moose Lake in the Adirondack Mountains of New York State. The gravity-fed water supply for the lodge and cabins includes covered in-ground, cistern-like structures constructed on two natural springs. The springs are located on the forested mountainside above the property.

- **Column-type limestone contactor being carried into a Covewood Lodge cabin**

This is a column-type limestone contactor being carried into the basement of a Covewood Lodge cabin. This unit was tested as an alternative to the large box contactor unit that was installed in one of the mountainside springs. This column-type unit is no longer used because it leaked excessively.

- **Installation of a column-type limestone contactor in the basement of a Covewood Lodge cabin**

This is the column-type limestone contactor (in the previous photo) installed in the basement of the cabin.

- **Construction of a box-type limestone contactor in the mountain side springs at the Covewood Lodge**

This is a box-type limestone contactor. It is made of ¾-inch plywood covered with thin sheets of plexiglass. Plexiglass baffles are used to direct the flow through the compartments in the unit to minimize headloss and maximize utilization of the limestone. In this photo, the empty unit has just been installed in a mountainside spring at the Covewood Lodge. The spring has been drained and the box is about to be filled with 1 cm effective-diameter limestone. When the spring is refilled, the water will flow into and through the contactor and into the pipeline that supplies water to part of Covewood Lodge.

- **Installation of the cover on the spring where the box-type limestone contactor was installed**

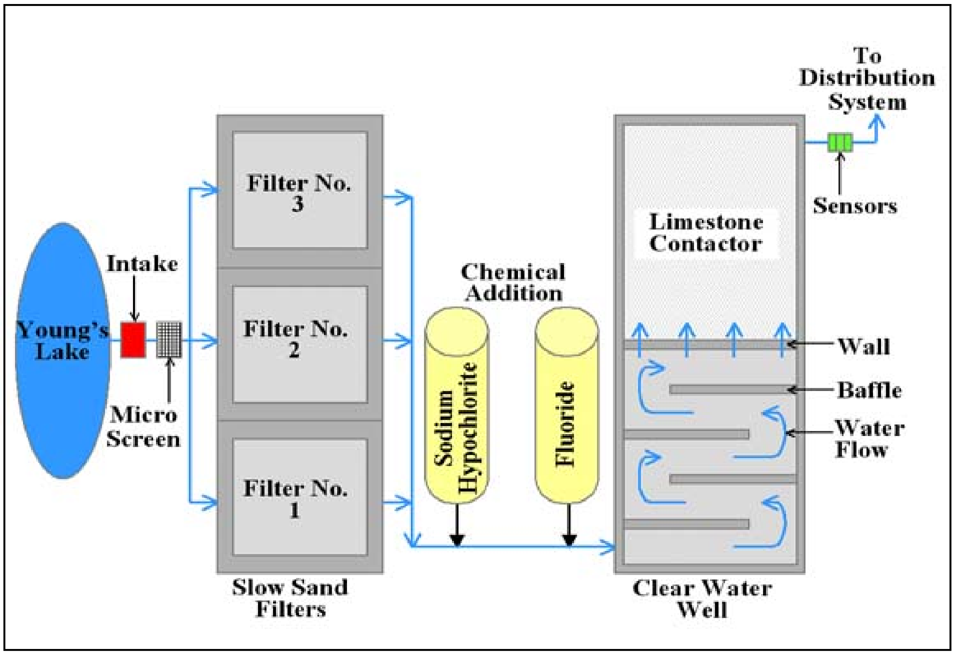
This shows the cover on the spring where a box-type limestone contactor has been installed. The limestone has been put in the box and the cover was about to be reinstalled on the spring.

b) **Limestone contactor facility in Mars Hill, Maine:**

Mars Hill Blaine Water Co. Filter Plant is located in Westfield, Maine. It is approximately 7 miles from Mars Hill, Maine where the office of Mars Hill Utility District, that owns and manages the plant, is located.

Mars Hill Blaine Water Co. Filter Plant

The plant was built in 1993 with microfiltration, slow sand filtration, sodium hypochlorite disinfection and fluoride addition as the treatment processes. A limestone contactor was added to the plant in 1996 when corrosion control treatment was required. The plant was designed to treat an average of 300,000 gallons/day (1,100 m^3/day) and a maximum of 430,000 gallons/day (1,600 m^3/day) (Spencer, 2000). It serves approximately 1,480 people in the Westfield, Blaine and Mars Hill areas (Kearney, 2003).



Mars Hill Blaine Water Co. Filter Plant's Schematic

Young's Lake

	
Young's Lake (Photo 1)	Young's Lake (Photo 2)

Mars Hill Blaine Water Co. Filter Plant obtains raw water from Young's Lake. The lake's water quality varies seasonally and before the limestone contactor was designed in 1996, the raw water pH ranged from 6.74 to 8.08 and alkalinity ranged from 45 to 83 mg/L as $CaCO_3$ (Spencer, 2000). The lake is rich with humic acid due to organic materials. The flow of water to the treatment plant is gravity fed and no pumping is needed since the lake is at a higher elevation compared to the plant.

Intake

			
Building for the intake valves (Photo 1)	Building for the intake valves (Photo 2)	Building for the intake valves (Photo 3)	Building for the intake valves (Photo 4)

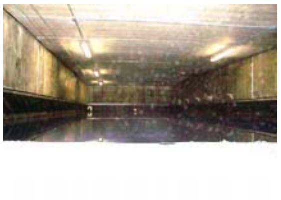
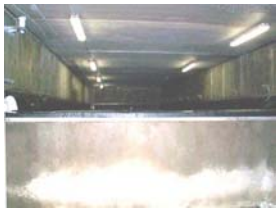
The intake is located at Young's lake, approximately 1 mile from the water treatment plant. The flow of the water from the intake to the treatment plant is gravity fed, so no pumping is needed. The following photos show the building where the intake valves are kept.

Microscreen

		
Microscreen (Photo 1)	Microscreen (Photo 2)	Microscreen (Photo 3)

The raw water from Young's Lake is filtered through microscreens to remove algae.

Slow Sand Filters

	
Slow sand filter (Photo 1)	Slow sand filter (Photo 2)

The water from the microscreens flows through slow sand filters to remove suspended solids. There are three filter beds in the plant, with two in operation at any time and one on standby. Prior to 1996, the pH of the raw water was stabilized unintentionally by contacting the under layer gravels in the filter beds (which consist of limestone materials) and the concrete basin walls (Spencer, 2000). However, when the filter beds were having problems in 1996, the existing under layers were replaced with new gravels and the concrete basins were lined with hypalon liners. Stabilization of pH could no longer occur in the filter beds and the plant exceeded the Lead and Copper Rule in the first sampling event in 1996. Corrosion control treatment was required to be installed in the plant. A cost study showed that a limestone contactor was the most attractive option on a long term basis compared to soda ash. Due to the ease of the process, it was deemed more suitable for the plant considering the size of the plant. Therefore, limestone contactor was chosen as the corrosion control treatment method for the plant.

Disinfection using Sodium Hypochlorite

		
Sodium hypochlorite mixing tank and dosing pump	Sodium hypochlorite and sodium fluoride injection points in the filter pipe gallery (Photo 1)	Sodium hypochlorite and sodium fluoride injection points in the filter pipe gallery (Photo 2)

Sodium hypochlorite is added to the water for disinfection. In the photo above, sodium hypochlorite powder is mixed with water in the yellow tank. The saturated solution of sodium hypochlorite is pumped from the mixing tank and injected into the water in appropriate dose. Since addition of sodium hypochlorite tends to reduce the pH of water, the limestone contactor in this plant was placed after hypochlorite addition. Chlorine residual in the water is monitored after the final stage of treatment in the plant, which is the limestone contactor.

Addition of Sodium Fluoride

		
Sodium fluoride mixing tank and dosing pump	Sodium hypochlorite and sodium fluoride injection points in the filter pipe gallery (Photo 1)	Sodium hypochlorite and sodium fluoride injection points in the filter pipe gallery (Photo 2)

Sodium fluoride is added to the water for prevention of dental carries. The sodium fluoride powder is mixed with water in the yellow tank as shown in the photo above. The saturated solution of sodium fluoride is pumped from the mixing tank and injected into the water in appropriate dose.

Clear Water Well


Location of the clear water well in the plant

The original capacity of the clear water well when it was first installed in this plant was 30,000 gallons. When the plant needed a limestone contactor as a corrosion control treatment method in 1996, half of the clear water well was modified into a limestone contactor. Baffles were installed to prevent short circuiting of the flow to the limestone contactor. A 12 inch wide wall was built to separate the clear water well from the limestone contactor and it is submerged with weir to ensure uniform flow of water to the limestone contactor. The water from the clear water well can bypass the limestone contactor if the contactor requires maintenance.

Limestone Contactor

			
Location of the limestone contactor in the plant	Limestone contactor viewed from one of the access hatches (Photo 1)	Limestone contactor viewed from one of the access hatches (Photo 2)	Limestone contactor viewed from one of the access hatches (Photo 3)

			
Sample of limestone media used in the contactor	Limestone contactor under construction in 1998	Hole on the wall of the limestone contactor for piping	Piping from the clearwell and the limestone contactor
			
The floor of the limestone contactor being rebarred (Photo 1)	The floor of the limestone contactor being rebarred (Photo 2)		

Limestone contactor in this plant has been operational since 1998. The media in the contactor consists of a top layer of 4 feet of limestone media and a bottom layer of 1 foot of supporting gravels (washed stone). The limestone used in the contactor is supplied by Graymont (NB) Inc., New Brunswick, Canada.

The water flows downward in the contactor through the media into a 4 inch underdrain pipe and then to the distribution system. The lower the flow rate, the longer the contact time of water with the limestone, resulting in a higher pH and vice versa.

The contactor is equipped with access hatches and a ladder to allow access for maintenance or cleaning work. A flow sensor is placed in the contactor to sense the level of water. pH is monitored after the water leaves the contactor.

The maintenance procedure consists of flushing the media to waste at a high rate once or twice a year. In the last 3 years that the limestone contactor has been in operation, only 6 inches of limestone have been dissolved from the top surface and total replacement of the media has not yet been required.

Since the limestone contactor in this plant is underground, it may be best to view the drawing and specifications of the contactor as well to better understand the process.

pH, Turbidity and Chlorine Residual Sensors

			
pH meter, turbidity meter and chlorine analyzer	pH meter measures the effluent pH after water flows through the limestone contactor	Chlorine analyzer measures the residual chlorine in the finished water	Turbidity meter measures the turbidity of finished water
			
Chart recorders record the flow in the filter beds and the effluent turbidity data	Chart recorder records the effluent pH data	Chart recorders	

Sensors are placed inside the pipe after the limestone contactor to enable monitoring of pH, turbidity and chlorine residual in the finished water. The sensors send a sample of water to the monitoring unit where the water is automatically tested for pH, turbidity and chlorine residual and the values of each are displayed on the monitor. The effluent pH data are recorded on a chart recorder.

The pH of treated water before limestone contactor was installed ranged from approximately 7.2 to 7.6 (Spencer, 2000). The lead and copper concentrations exceed the action level in several sampling points in August 1993 (before the slow sand filters went online) and in August 1996 (after the concrete basins in the filter beds were lined with liners and the under layer containing limestone gravels was replaced with new gravels). After limestone contactor was installed, the pH was increased to about 7.65 to 8.1 and the lead and copper levels constantly stay below the action levels. Refer to the following Lead and Copper Test Results for Mars Hill Water Co. (Courtesy of Jay Peavey) to view the detailed performance of the limestone contactor in this plant.

Lead and Copper Test Results for Mars Hill Water Co.
(Courtesy of Jay Peavey)

**The values in the table below represents the lead and copper concentrations at different sampling locations on the date indicated on the top column. Various modifications to the water treatment plant occured at dates in the table below which impacted the lead and copper results.*

Time period	*Plant status*
Aug 1993 and Mar 1994	*Before the new plant (with the slow sand filters) was constructed.*
Dec 1994 and May 1995	*After the new plant went online on June 1994. Water was unintentionally stabilized in the slow sand filters by contacting the filter walls and the underlayer gravels.*
Aug 1996	*The underlayer gravels containing limestone was replaced with new gravels. The filter walls were lined preventing water to contact lime in the concrete.*
Jun 1999	*After limestone contactor was constructed. Limestone contactor was online in 1998.*

** Each row in the table below represents a different sampling location.*
** The circled numbers show either the lead or copper content exceeds the action level of 0.015 mg/L of lead and 1.30 mg/L of copper.*

Lead and Copper Test Results for Mars Hill Water Co.

				Aug-93		Mar-94		Dec-94		May-95		Aug-96		Jun-99	
Name	Address	Home	Work	Lead	Copper	Lead	Copper	Lead	Copper	Lead	Copper	Lead	Copper	Lead	Copper
[redacted]				0.032	0.90	0.025	0.87	0.013	0.61	0.009	0.38	0.017	1.27	0.008	0.47
				0.011	0.61	0.008	1.35	0.004	0.29	0.004	0.48	0.058	0.85	0.009	0.29
				0.005	0.50	0.005	1.58	0.004	0.92	0.004	0.68	0.006	0.66	0.003	0.40
				0.006	0.59	0.008	1.24	0.003	0.63	0.004	0.51	0.007	0.25	0.006	0.46
				0.007	0.59	0.012	1.17	0.005	0.68	0.006	0.40	0.005	0.59	0.000	0.52
				0.007	0.69	0.005	1.25	0.000	0.85	0.003	0.48	0.003	0.82	0.000	0.32
				0.008	1.18	0.011	2.04	0.004	0.86	0.003	0.64	0.008	1.33	0.006	0.31
				0.008	0.45	0.014	1.05	0.007	0.52	0.003	0.15	0.003	0.30	0.000	0.18
				0.007	0.79	0.008	1.46	0.000	0.50	0.003	0.40	0.004	0.73	0.005	0.40
				0.005	0.67	0.003	1.19	0.000	0.66	0.003	0.52	0.003	0.41	0.003	0.28
				0.006	0.86	0.005	1.05	0.000	0.32	0.003	0.42	0.003	1.08	0.000	0.30
				0.006	0.67							0.017	0.95	0.004	0.57
				0.003	0.69	0.005	1.36	0.004	0.32	0.003	0.25	0.005	0.96	0.003	0.23
				0.007	0.82	0.008	1.29	0.004	0.72	0.006	0.43	0.008	0.83	0.004	0.26
						0.011	1.27	0.007	0.71	0.004	0.20	0.003	0.53	0.009	0.47
						0.005	0.48	0.003	0.44	0.003	0.22	0.005	0.74	0.005	0.61
				0.009	0.98	0.007	1.88	0.000	0.68	0.006	0.60	0.044	1.30	0.005	0.58
				0.003	0.80	0.003	1.09	0.000	0.71	0.004	0.65	0.005	1.07	0.003	0.25
				0.010	0.52	0.003	0.18	0.000	0.14	0.005	0.18	0.004	0.56	0.005	0.29
												0.008	1.520	0.007	0.60
				0.019	1.10	0.015	1.00			0.003	0.33	0.019	1.1		
				0.016	0.93	0.025	1.59					0.016	0.93		
								0.004	0.87						
								0.014	0.9	0.008	0.29				
90th Percentile				0.017	1.004	0.016	1.619	0.006	0.873	0.006	0.641	0.019	1.297	0.008	0.582

Alkalinity and hardness are also tested once a month.

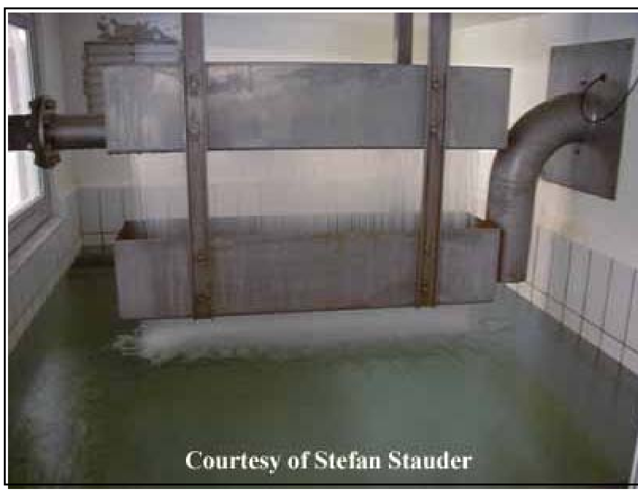
The following photo shows the staff at the Mars Hill & Blaine Water Co. Filter Plant.

Mars Hill Blaine Water Co. Filter Plant's Personnel
(L to R: Jay Peavey, Frank Kearney)

ii. Photos of Limestone Contactor in Germany:

The following photos show typical limestone contactors in Germany. In Germany, limestone contactors are commonly called calcium carbonate filters (Stauder, 2002). These types of contactors have been used by nearly every village in the mountains in Germany for decades. The typical spring water characteristics treated by these contactors are pH of 5.5-6.5, CO_2 of 0.2-0.5 mmol/L and HCO_3^- of 0.1-0.7 mmol/L (Stauder, 2002).

- **2-step cascade of carbon dioxide stripping above the limestone contactor's surface**



Carbon dioxide stripping is sometimes useful to minimize the amount of $CaCO_3$ (Stauder, 2002). The picture shows a simple but effective method for this purpose. It is a 2-step cascade of carbon dioxide stripping above the limestone contactor's surface. It removes 30 to 40% of carbon dioxide.

- **Example of an open limestone contactor**

This is an example of an open limestone contactor. It is similar to the sand filters in the United States except the filtration media is replaced with calcium carbonate. It is rectangular and the wall is protected from corrosion using ceramic tiles.

- **Example of a closed limestone contactor**

This is an example of a closed limestone contactor. It is in a pressurized tank. It is used when pumping is needed. Typically, the tank is made of steel and lined with epoxy coating to protect the wall from corrosion.

- **Example of a closed limestone contactor**

This photo shows another example of a closed limestone contactor.

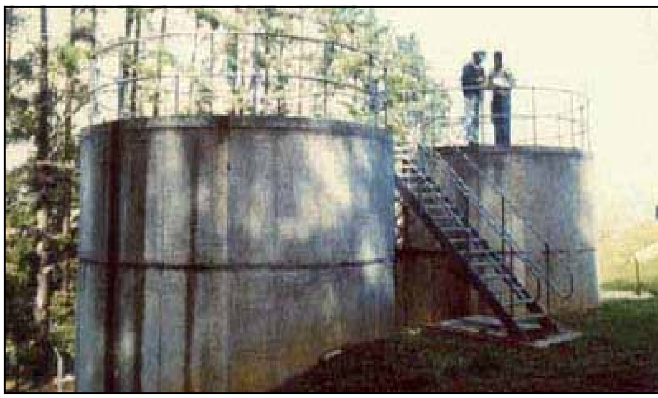
iii. Photos of Limestone Contactor in South Africa:

The following photos show examples of limestone contactors in South Africa.

- **Limestone contactor in Jonkershoek, Stellenbosch, South Africa**

This limestone contactor treats 2 MLD of water. It obtains raw water from a mountain catchment. The water is chlorinated before it flows to the contactor.

- **Limestone contactor in Rozendal, Stellenbosch, South Africa**



This limestone contactor treats 6 MLD of water. The raw water source is from a mountain catchment. The water is chlorinated before it flows through the contactor.

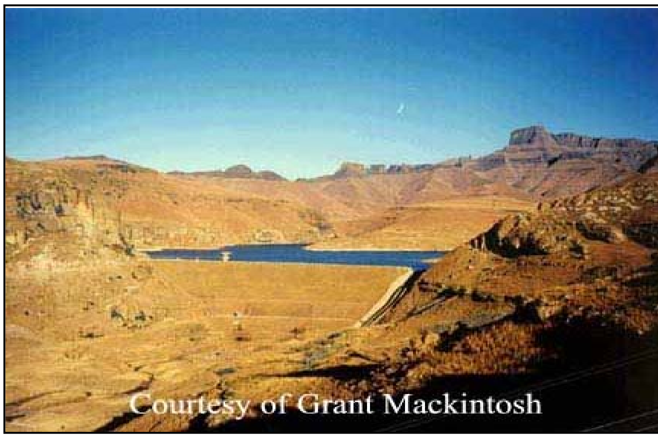
- **Limestone contactor outlet**

This shows the outlet of a limestone contactor. In this photo, the water flows upward through the limestone media and then flows out of the contactor through the outlet in a downward direction.

- **CSIR Spraystab I Unit**

This shows a Spraystab I unit installed by CSIR at a farm in Stellenbosch, South Africa.

- **Mountain catchment area**



This is an example of a mountain catchment area in South Africa typically used as the source of raw water for some of the limestone contactor facilities in Stellenbosch such as in Jonkershoek, Rozendal and Idas Valley.

- **Limestone loading gantry facility**

This shows limestone being loaded into a limestone contactor using a gantry.

iv. Photos of Limestone Contactor in the Canary Islands, Spain

The following photos show examples of the limestone contactors designed by the Canary Islands Water Center. It is used to treat desalinated water from the reverse osmosis plants in the Canary Islands. The salinity and CO_2 content of the desalinated water vary from one reverse osmosis plant to another but the typical characteristics are pH = 5.6 to 6, CO_2 = 30-45 ppm and EC=600-1500 µS/cm (Hernández, 2003). The limestone contactors use 98% calcium carbonate with media size of 3 mm (Hernández, 2003). Due to variation in desalinated water quality from plant to plant, recommendations are to carry out pilot test to define accurate design parameters. The contactor may be easily added to an existing plant or custom-built for each installation and type of water (Centro Canario del Agua, 2003).

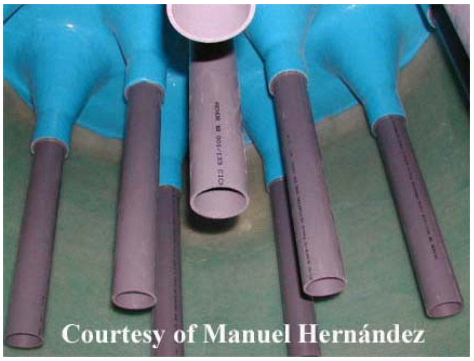
- **Three-dimensional drawing of the limestone contactor (Courtesy of Manuel Hernández)**

This photo shows the three-dimensional drawing of the limestone contactor used to treat desalinated water in Canary Islands. Important feature of these contactors is the feeding cones for the contactor bed.

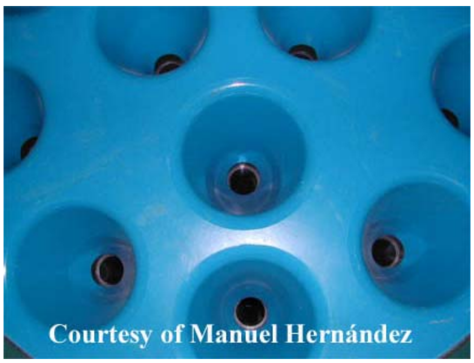
- **Water distribution system (Courtesy of Manuel Hernández)**

This photo shows the distribution system located at the bottom of the limestone contactor. The distribution system allows water to flow upward in this limestone contactor to avoid risk of clogging (Centro Canario del Agua, 2003).

- **Calcium carbonate feeders (Courtesy of Manuel Hernández)**

	The feed system allows continuous dosing of calcium carbonate into the water without turbulence (Centro Canario del Agua, 2003).

- **Calcium carbonate feeders view from the top (Courtesy of Manuel Hernández)**

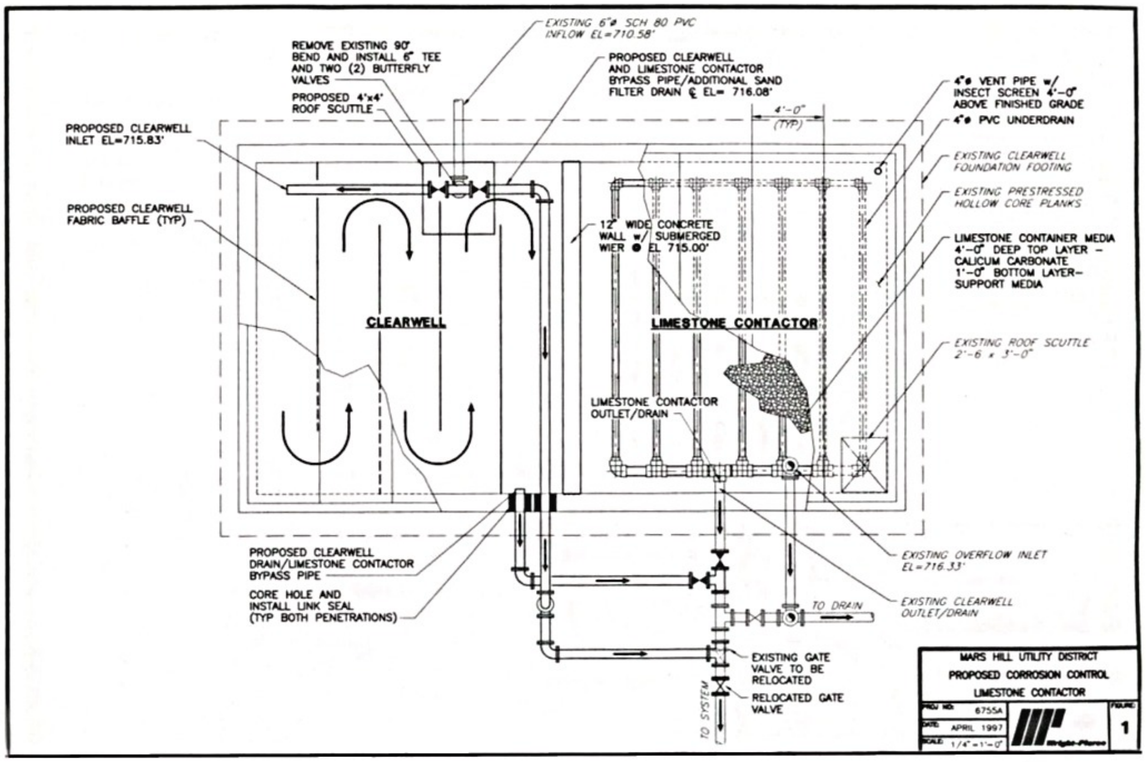
	This photo shows the calcium carbonate feeders viewed from the top of the limestone contactor.

- **Limestone contactor installation (Courtesy of Manuel Hernández)**

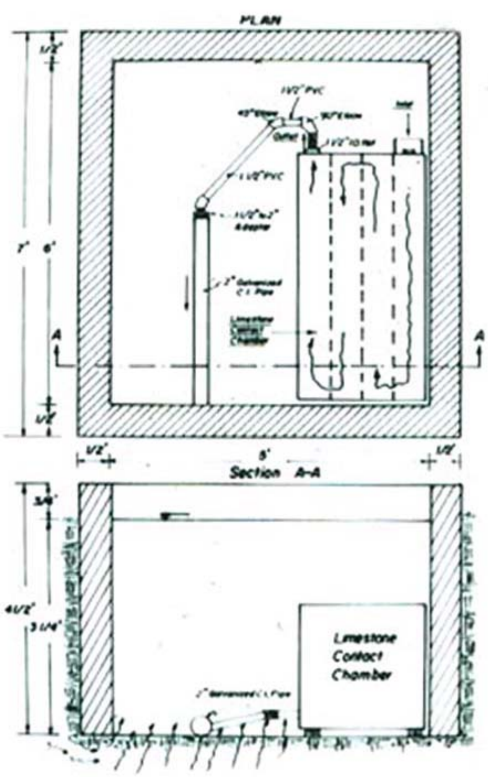
	This photo shows limestone contactor being installed on a site in a desalination plant in Southern Tenerife, Canary Islands.

- **(B) EXAMPLES OF PLANS**

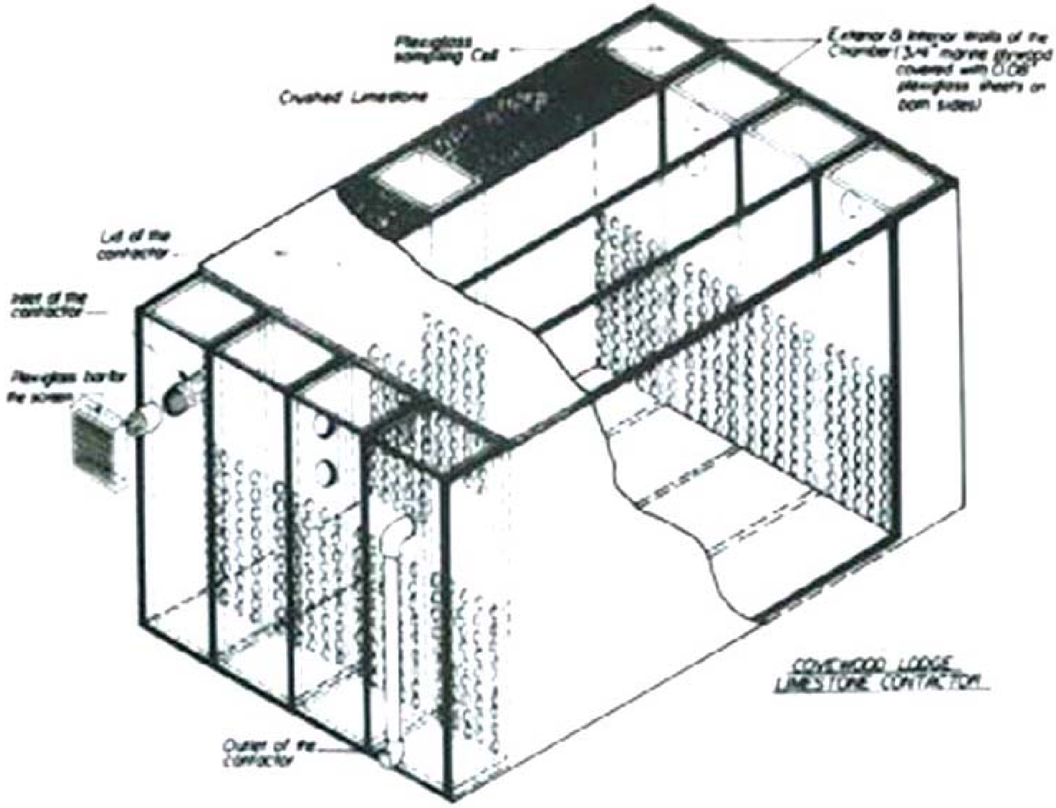
1. Plan of Limestone Contactor Installed in Mars Hill Blaine Water Co. Filter Plant, Maine (Courtesy of Wright Pierce)



2. Plan of Limestone Contactor Installed in a Resort in Adirondack Mountains, New York (Drawing 1) (Courtesy of Ray Letterman)



3. Plan of Limestone Contactor Installed in a Resort in Adirondack Mountains, New York (Drawing 2) (Courtesy of Ray Letterman)



(C) EXAMPLES OF SPECIFICATIONS

1. Specification of Limestone Contactor in Mars Hill Blaine Water Co. Filter Plant (Courtesy of Wright Pierce)

SECTION 11800A

LIMESTONE CONTACTOR

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish all labor, equipment, materials required for the supply and installation of limestone media and gravel support layer as specified herein and as shown on the Drawings.

B. Description of System:

1. The limestone media and support gravel shall work as a complete and coordinated system. The gravel provides support for the limestone and allows water to flow to the underdrains. The limestone layer above the gravel provides the intended treatment.

1.2 QUALITY ASSURANCE

A. Standards:

1. Support gravel shall comply fully with AWWA B100-89, Filtering Material.
2. Test method for organic impurities in gravel - ASTM C40.
3. Acid solubility test of gravel as per AWWA B100.
4. Limestone shall comply with ASTM C51 definition of a High Calcium Limestone.
5. Limestone constituents shall be tested by ASTM C25-92.
6. Sieve sizes shall comply with ASTM E11-87.

B. Supply Source:

1. All support gravel shall be furnished from a single supplier regularly engaged in processing and supplying gravel.
2. All limestone shall be furnished by a single supplier regularly engaged in processing and supplying limestone.

C. Acceptable Limestone Suppliers:

1. Havelock Lime, Fredericton, New Brunswick Canada (506) 534-2311
2. Greybec Calc Inc., Boucherville, Quebec, Canada (514) 449-2262

1.3 TESTING

A. Prior to shipment a representative sample of media shall be submitted to the Owner. Sample size and method of sampling shall be as outlined in AWWA B100.

B. The gravel supplier shall collect representative samples as per AWWA B100 and perform testing as follows:

1. Acid solubility test
2. Specific gravity
3. Sieve Analysis
4. Organic impurities test as per ASTM C40.

C. The limestone supplies shall collect representative samples as per AWWA B100 and perform testing as follows:

1. Chemical analysis of limestone as per ASTM C25-92.
2. Specific gravity
3. Sieve analysis
4. Bulk density

D. At its option, Owner will collect and analyze media samples prior to placement. Contractor shall assist in the collection of these samples.

1.4 SUBMITTALS

A. Submit gradation test results, material certificates and laboratory test results as specified.

B. Provide affidavit of compliance stating that filter materials comply with applicable portion of AWWA B100, ASTM Standards and this specification.

1.5 DELIVERY, STORAGE AND HANDLING

A. All media shall be thoroughly washed at the pit just prior to shipment. Medium shall not be washed and stored where it may be contaminated by fines and other airborne debris.

B. All media shall be handled with clean equipment and in such a manner as to prevent contamination.

C. Media transported in bulk by truck shall be in clean, tight enclosures to prevent contamination. Impermeable plastic liners shall be used.

D. All media shall be stored on the project site in a location protected from contamination. Stockpiled media shall be covered.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Support Gravel:

1. Support gravel shall consist of clean, washed coarse aggregate in which a large proportion of the particles are rounded and tend towards a general spherical shape.
2. Support gravel shall have a saturated-surface-dry specific gravity not less than 2.50.
3. Not more than 25 percent, by weight, of particles shall have more than one fractured face.
4. Not more than 2 percent by weight of the particles shall be flat or elongated to the extent that the longest axis of the circumscribing rectangular prism exceeds five times the shortest axis.
5. The gravel shall be free of clay, shale and other impurities. Not more than 1.0 percent finer than 1/4 inch sieve.
6. Acid solubility shall be less than 5 percent for particles less than No. 8, 17.5 percent for No. 8 particles through 25.4 mm, and 25 percent for particles larger than 25.4 mm.
7. The effective size shall be between 25 mm to 30 mm and the uniformity coefficient shall not exceed 1.6.
8. Depths as shown on the Drawings.

B. Limestone Media:
1. Limestone media shall consist of clean, washed high calcium limestone.
2. Limestone shall have a specific gravity greater than 2.50 and a loose bulk density of 1400 kg/m^3 (87 lb/ft^3).
3. The effective size shall be between 8 mm and 10 mm and the uniformity coefficient shall not exceed 1.6. Upper and lower gradations shall be as follows:

Sieve Size	Percent Passing
22.4 mm (7/8 in.)	100
16 mm (5/8 in.)	75
11.2 mm (7/16 in.)	50
8 mm (5/16 in.)	10

4. Calcium carbonate must exceed 95% of the total chemical composition.
5. Depth as shown on the Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Placement of the contactor underdrains and media shall only be done after the concrete work is accepted and the contactor basin is tested for leakage.
B. The basin shall be thoroughly cleaned before any contactor materials are placed.
C. Suitable bench mark shall be set within each basin to mark the elevation of the underdrains and each media layer.

3.2 PLACEMENT
A. Install underdrains and bottom layer of support gravel. Maintain elevations, slopes and gravel thickness as shown on the Drawings.
B. Carefully place gravel to avoid damaging and displacing the underdrains.
C. Each layer shall be completed before the next layer above is begun. Each layer shall be placed in uniform thickness.
D. The elevation of the top surface of each layer shall be checked for levelness by filling the filter with water to the level line previously marked on the inside of the filter.
E. The filter media may be placed by hand, by conveyor or other acceptable means.
F. Use of mechanical equipment that may compact the media shall not be used.

3.3 CLEANING
A. After all filter gravel is placed, and before any limestone is placed, the filter may be washed.
B. Once limestone is placed, the contactor shall be filled with water from below through the underdrains. The rate of filling shall be less than 0.05 gpm/ft^2.
C. Wash media until upflow through the bed is clean.
D. Any residual fines (No. 50 sieve or finer) on the surface of the limestone layer after washing shall be removed by scraping.
E. Repeat as needed until surface is free of fines.
F. Replace limestone as needed to provide full depth after cleaning.

3.4 DISINFECTION

A. The basin and media shall be disinfected as per AWWA C653 prior to placing into service.

B. Bacteriological samples shall be taken as per AWWA C653 prior to placing the contactor in service.

C. This work shall be coordinated with the Owner.

3.5 WASTE DISPOSAL

A. Wash water shall be conveyed to a location acceptable to Owner (Drainage System). Rates and amounts of discharges shall be coordinated with the Owner.

END OF SECTION

2. Specification of Limestone Media used in Mars Hill Blaine Water Co. Filter Plant (Courtesy of Graymont (NB) Inc.)

MAGEE QUARRY

REP No. NOV9106.R99
Customer Havelock Lime Works
Attention Rob Camm
Reference PO 10235
Project 9903161
Samples Routine Pulp
Chemist Roch Marion, B.Sc., C.Chem.

Title 4.2 ICP-OES Strong Acid Digest Package
Date 22.11.99

Type

Sample ID	*Al	*As	*Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t
Limestone	1200	< 20	180	< 2.0	370000	< 5.0	< 5.0	< 5.0	< 5.0	440	< 600
Calcium Hy	1500	< 20	200	< 2.0	510000	< 5.0	< 5.0	7	< 5.0	600	< 600

Sample ID	La	Mg	Mn	Mo	Na	Ni	P	Pb	Sb	Se	*Sn
	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t
Limestone	< 50	830	870	< 10	36	< 5.0	< 20	< 30	< 20	< 50	< 10
Calcium Hy	< 50	1300	1600	< 10	340	< 5.0	48	< 30	< 20	< 50	< 10

Sample ID	Te	Y	Zn
	g/t	g/t	g/t
Limestone	< 20	< 5.0	38
Calcium Hy	< 20	< 5.0	65

The extraction used above may be incomplete for those elements marked with an asterisk.
Detection limits may vary due to sample matrix. Lower limits may be obtained