Publication No. 74-e82

WA-22-4010

September 16, 1974

Memo to: Ron Robinson

From: Shirley Prescott

Subject: STP Efficiency Study, Camp Grisdale

A routine efficiency study was conducted on July 17, 1974. This is a small plant which serves the Simpson logging camp of about 160 people.

The plant is housed in a small building; the area is not fenced nor has anything been done with the surrounding area. There was little or no lab equipment visible and no regular records are kept or any testing done on a regular basis.

Ray Charles of Ray Charles Co., the engineering firm who installed the plant, called after our visit there to tell me that Loren Hoard, the Camp Grisdale Superintendent, was putting in a request for some lab equipment and log books so he could start a regular program of testing and logging information. Assuming that this does happen, they would almost be forced to do something with the building interior in the way of facilities to accomplish this.

Field testing showed effluent pH as low as 4.8. This was attributed to low flow in the plant and a resulting chemical imbalance. When this was pointed out, caustic was added and pH readings increased with each subsequent sampling.

Along with the regular report form and lab analysis, there is a schematic drawing and a magazine article which describes the plant in some detail. Also a copy of a letter to Mr. Hoard from Grays Harbor-Pacific Health District which is most complementary.

SP:jmh

STP Survey Report Form

Efficiency Study

City Camp Grisdale Plant Type Chemical Pop. Served [illegible] Design Capacity [illegible]

Receiving Water Ground Dispersion Perennial ______ Intermittent ______

Date 7/11/74 Survey Period 1100 - 1630 Survey Personnel S. Prescott, [illegible]

Comp. Sampling Frequency hourly Sampling Alequot 1000 mls.

Weather Conditions (24 hr) Rain Are facilities provided for complete by-pass of raw sewage? X Yes ____ No/Frequency of bypass very infrequent

Reason for bypass ______ Is bypass chlorinated? ____ Yes [illegible] No

Was DOE Notified? ______ Discharge - Intermittent ______ Continuous ______

Plant Operation

Total flow 14 GPM How measured Totalizing Meter

Maximum flow 20,000 GPD Each of 2 plants Time of Max. Mess Hall & Family Housing

Minimum flow ______ Time of Min. Early morning, 1 A.M.

Pre Cl_2 None #/day Post Cl_2 kept @ 1 ppm. #/day

Field Results

Determinations	Influent Max.	Influent Min.	Influent Mean	Influent Median	Effluent Max.	Effluent Min.	Effluent Mean	Effluent Median
Temp °C	17.0	17.0		17.0	17.0	17.0		17.0
pH (Units)	7.0	6.8		6.9	6.3	4.8		5.0
Conductivity (µmhos/cm^2)	550	425		475	1150	1000		1050
Settleable Solids (mls/l)	2.5	.4	1.63		0	0	0	0

Laboratory Results on Composites

	Influent	Effluent	% Reduction
Laboratory No.	74-2966	74-2967	
5-Day BOD ppm	170	82	52%
COD ppm	321	149	54%
T.S. ppm	411	481	
T.N.V.S. ppm	134	404	
T.S.S. ppm	96	16	83%
N.V.S.S. ppm	20	8	60%
pH (Units)	7.2	5.2	
Conductivity (µmhos/cm^2)	450	900	
Turbidity (JTU's)	60	5	

Laboratory Bacteriological Results

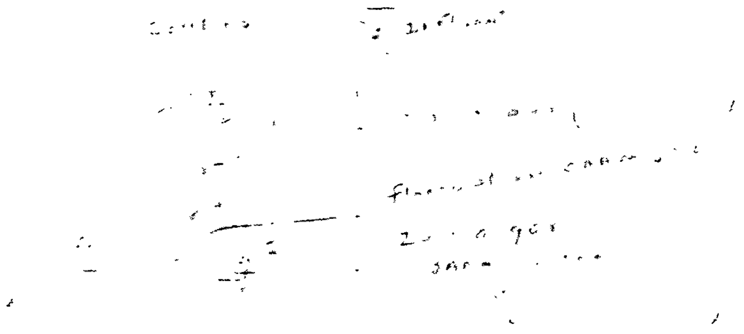
Lab No.	Sampling Time	Colonies/100 ml (MF) Total Coliform	Fecal Coliform	Fecal Strep	Cl_2 Residual 15 sec	[illegible]
74-2962	1245	<20	<10		.3	[illegible]
2963	1430	<20	<10		.5	[illegible]
2964	1500	<20	<10		.75	[illegible]
2965	1600	<20	<10		.5	1.0

Additional Laboratory Results

NO_3-N ppm -	.01	
NO_2-N ppm -	N.D.	
NH_3-N ppm -	.33	
T. Kjeldahl-N ppm -	33.5	
O-PO_4-P ppm -	.7	
T-PO_4-P ppm -	.34	

Operator's Name Loren Hoard Phone No. ____________

Furnish a flow diagram with sequence and relative size and points of chlorination.



Type of Collection System

__ Combined __ Separate __ Both

Estimate flow contributed by surface or ground water (infiltration)

15% higher during wet weather MGD

Plant Loading Information

Annual average daily flow rate (mgd)

Dry 20,000 GPD

- 15% additional

Peak flow rate (mgd)

Dry 40,000 capacity

Wet + 15% 35,000 GPD [illegible]

[illegible]: ____________

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

WATER QUALITY LABORATORY

ORIGINAL TO: S. Prescott

COPIES TO:

DATA SUMMARY

Source: Camp Grisdale

Collected By: S.P.

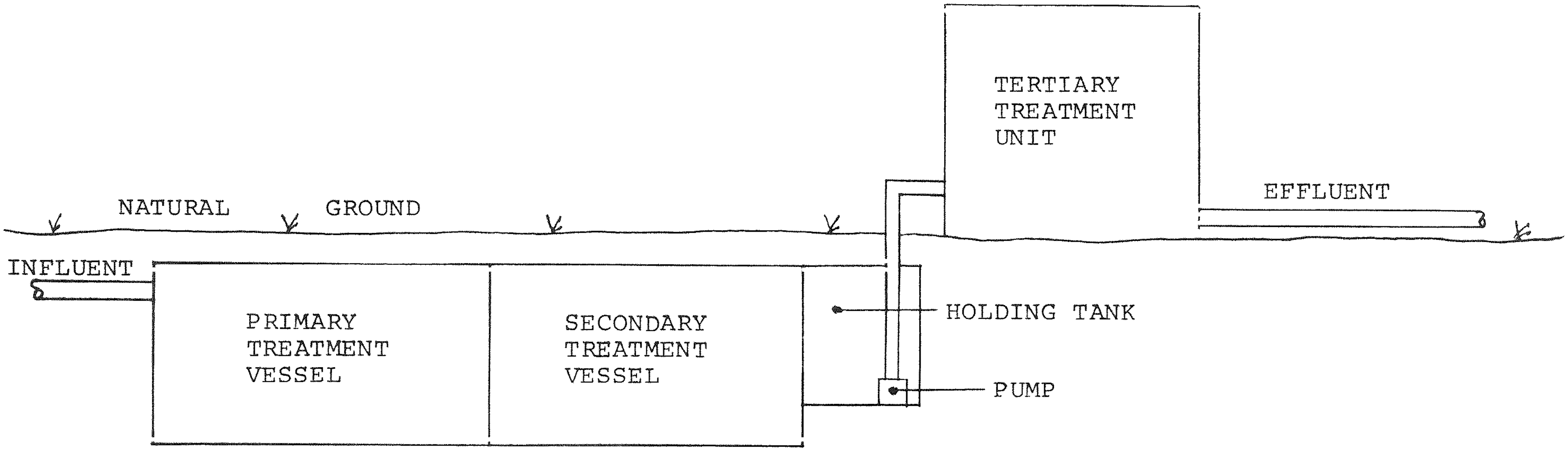
Date Collected: 7-17-74

Log Number: 74- 2966 62 64 63 6 65

Station:	INF	Eff	1245	1430	1500	1600					STORET
pH	7.2	5.2									
Turbidity (JTU)	60.	5.									00070
Conductivity (umhos/cm)@25°C	450.	900.									0095
COD	321	149									00340
BOD (5 day)	170	82									00310
Total Coliform (Col./100ml)	-	-	<20	<20	<20	<20					31504
Fecal Coliform (Col./100ml)	-	-	<10	<10	<10	<10					31616
NO3 N (Filtered)		.01									00620
NO2-N (Filtered)		ND									00615
NH3-N (Unfiltered)		33.									00610
T Kjeldahl-N (Unfiltered)		33.5									00625
O-PO4-P (Filtered)		0.7									00671
Total Phos -P (Unfiltered)		.34									00665
Total Solids	411	481									00500
Total Non Vol. Solids	134	404									
Total Suspended Solids	96	16									00530
Total Sus. Non Vol. Solids	20	8									

Note: All results are in PPM unless otherwise specified. ND is "None Detected"
Convert those marked with a * to PPB (PPM X 10^3) prior to entry into STORET

Summary By: Stephen D. Roll   Date: 8-19-74



PRIMARY TREATMENT

A. Removes settleable solids.

B. Removes oils & greases.

C. Solids are decomposed by anaerobic action.

SECONDARY TREATMENT

A. Intensified anaerobic bacterial activity.

B. Reduces BOD to required level.

TERTIARY TREATMENT

A. Removes suspended solids by chemical flocculation.

B. Removes phosphates.

C. Reduces nitrogen.

D. Disinfects.

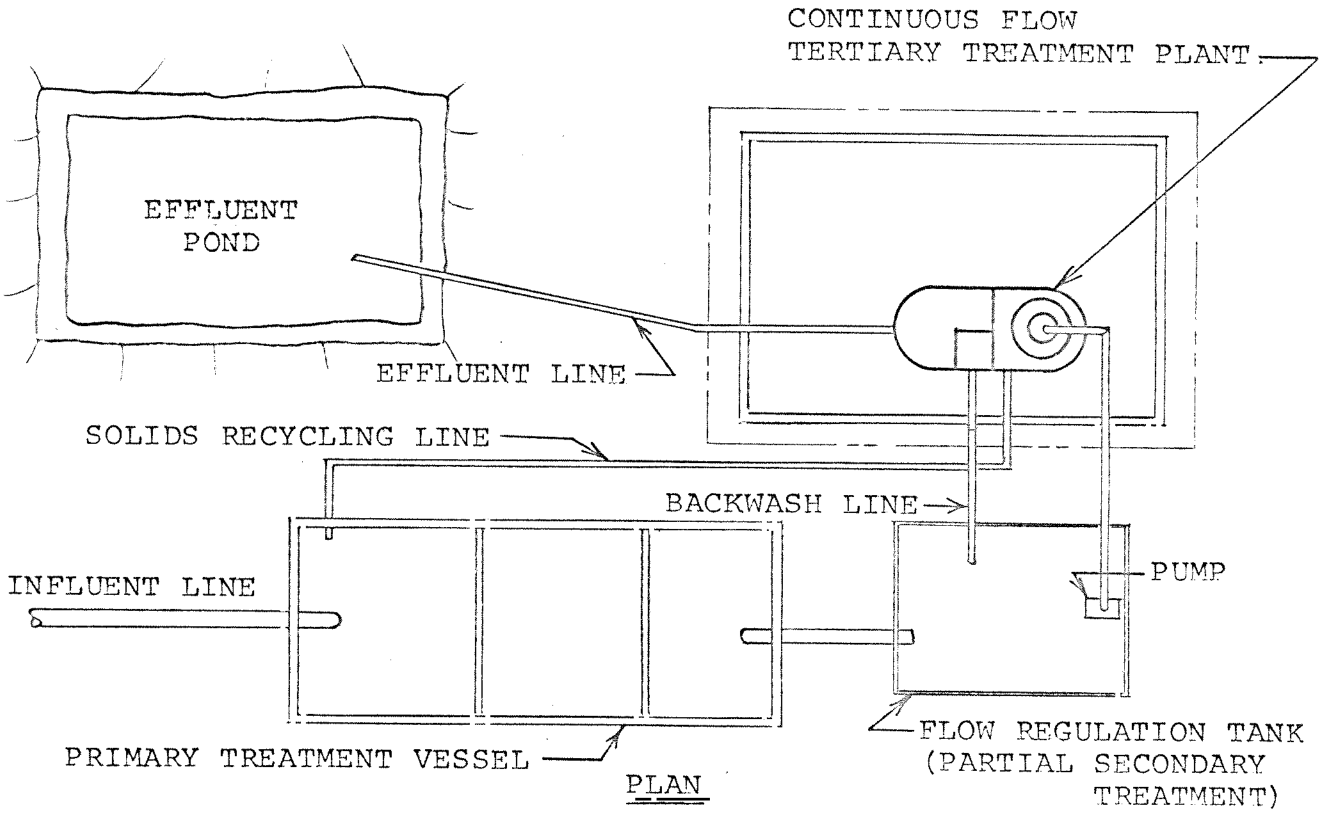
EFFLUENT DISPOSAL

To conform with local standards.

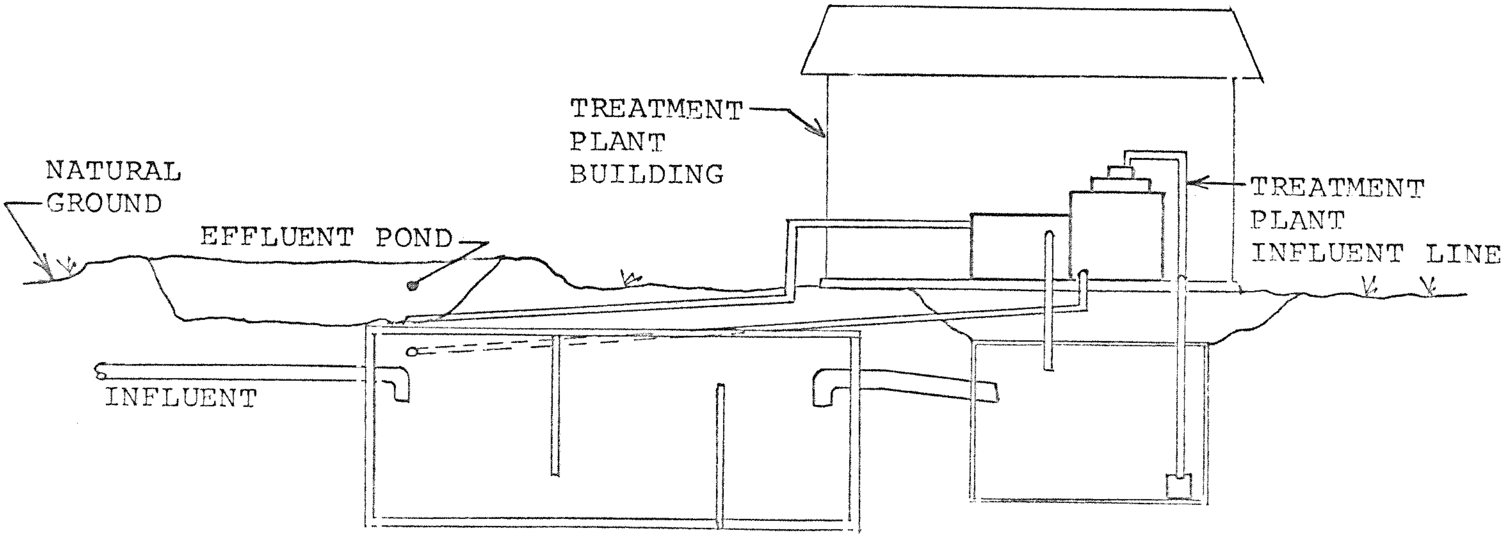
ENVIRONMENTAL SYSTEMS, INC.

SCHEMATIC DIAGRAM--SEWAGE TREATMENT SYSTEM

TYPICAL SYSTEMS ARRANGEMENT FOR RESIDENTIAL COMPLEX USING CONTINUOUS FLOW TREATMENT



PLAN



ELEVATION

ENVIRONMENTAL SYSTEMS, INC.
SEATTLE, WASHINGTON

W.M. | 12-3-70

GRAYS HARBOR-PACIFIC HEALTH DISTRICT

223 Finch Bldg. - LEnox 2-8631
Aberdeen, Washington 98520

LAUREN H. LUCKE, M.D., M.P.H
HEALTH OFFICER

February 18, 1972

Mr. Loren Hoard
Maintenance Supervisor
Grisdale Logging Camp
Route 1, Box 1301

Re: Package Treatment Plant

Dear Loren:

It's been awhile since I've corresponded with you, but I presume things are under control.

Finally, here are the results of the tests I took in November:

	Plant Inlet	Outlet
BOD (biochemical oxygen demand)	72.8 ppm	25.8 ppm
Phosphate	5.0 ppm	0.4 ppm
Sulfate	45 ppm	180 ppm
Chlorine residual	-	0.6 ppm
Coliform count	-	0

These results are all good. If the maintenance of the system is kept up, it appears there shouldn't be too many problems.

The Department of Ecology will be working with you in the future in continuing to iron out any problems you may have.

Also, continue to take regular water samples from your water supply, to keep an eye on it.

Sincerely,

Paul E. Guenther, RS

Paul E. Guenther, R.S.
District Sanitarian

PEG:jr
cc: Mike Price, Department of Ecology

Chitin & chitosan

Continued

available today. Today's shellfish industry could support more than 50 times the chitosan production that it could have 15 years ago.

Some applications require either chitin or chitosan, while others require blends. Here is a list of known and potential uses of chitin and chitosan:

- as a papermaking additive to improve the wet and dry strength properties of newsprint and other paper
- as an additive to improve the wet strength properties of other wood products, such as paper towels, grocery bags, and disposable baby diapers, and of nonwoven fabrics
- as an aid in increasing the efficiency of wood fiber beating processes
- as a coagulant and coagulant aid in the treatment of water supplies, domestic sewage, and industrial wastewater
- as an additive to baby food formulations
- as an additive to stomach anti-acids
- in the treatment of wounds
- as a substrate for controlled, long-term release of herbicides and insecticides
- in textile finishes and shoe polish
- in water-base paint emulsions
- as a water clarifier during undersea explorations and exercises, search and recovery operations, diving expeditions, TV monitoring and photographic operations, and repairs of underwater installations
- as a new synthetic fiber
- in fiber modification, such as treatment of glass fibers to make them accept and hold dyes
- as a food thickener
- in the encapsulation of pharmaceuticals
- for biodegradable, moisture-proof packaging and coatings, such as cigarette box wrappings
- in making stable gels
- as an agent for cold stabilization of fruit juices
- in the manufacture of specialty adhesives
- in the manufacture of films

In most cases, chitin and chitosan are not now in use for these purposes because they have been in scarce supply for many years.

The ultimate applications of chitin and chitosan depend on their prices relative to those of competing materials. A major task at the pilot plant is to determine production costs. These costs are expected to be different from past experience because the FCRL process permits the recovery of by-products and recycling of chemicals.

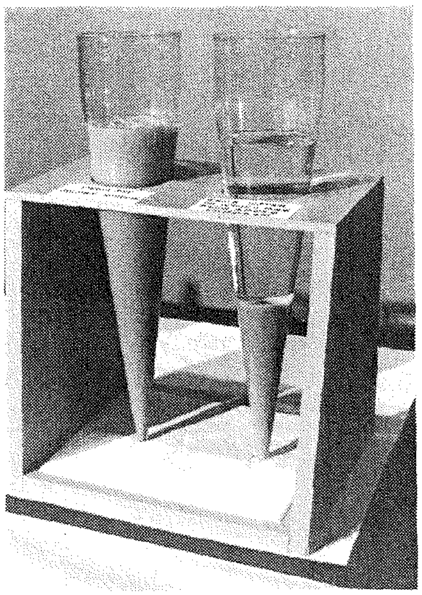
Some applications, such as those in domestic sewage treatment and papermaking, already have been made or tested within Washington state.

Chitosan used in sewage treatment

In July 1970, an ESI Model 100 waste treatment plant was installed at Grisdale, Washington, a company logging camp owned by the Simpson Timber Co. Grisdale consists of about 50 residential units and other camp facilities. Located northwest of Olympia in the Olympic National Forest, its population varies from about 130 to 160.

The ESI Model 100 was engineered by the Ray Charles Co., a consulting engineering firm, and manufactured by Environmental Systems, Inc. of Seattle. Its capacity is 20,000 gallons of wastewater per day. A second unit has since been added as a standby plant which automatically turns on in case of failure or overload of the first plant.

The Ray Charles Co. has researched this field for about 10 years. In 1969, Charles learned of FCRL's work with chitosan and became so convinced of its superiority over other polyelectrolytes that he formed ESI to market a domestic sewage treatment system which specifies the exclusive use of chitosan.



Chitosan solution used as a coagulant. Left: ordinary muddy water. Right: same water to which chitosan solution was added.

Prior to installation of the first ESI Model 100, two septic tanks serviced Camp Grisdale.

A major problem with septic tanks is that they do not remove all the suspended solids and bacteria from wastewater, Charles said.

"Either of these can plug up a drainfield and did so at Grisdale," he said. "In fact, the drainfield is the most vulnerable part of a waste treatment system."

Charles said the Grisdale system typically reduces the B.O.D. (biological oxygen demand) by 80 to 85%. It virtually eliminates all colloidal material. Phosphates are reduced to 0.5 parts per million or less. Chlorinization sterilizes the effluent, and the coliform (a bacterial group) count is normally near zero. The effluent is consistently free from color and odor. By minimizing change to the percolation characteristics of a drainfield, the ESI system prolongs its useful life, he said.

What part does chitosan play? One major function is to make coagulation occur two or three times faster than it would otherwise, Charles said.

Chitosan is a marine polymer which carries a positive electrical charge and hence is one of many cationic polyelectrolytes.

Polyelectrolytes are commonly used in wastewater treatment as coagulant aids. They cause colloids (very small particles which ordinarily remain suspended in a liquid) to settle out. Domestic wastewater particles are typically anionic (carrying a negative charge).

Generally accepted theory is that the polymer molecules attach themselves to the surfaces of suspended particles at one or more sites. Part of the long chain, however, extends into the bulk of the solution. When contact is made with another suspended particle, the free end adsorbs onto it, thus forming a bridge or link between two particles of suspended solids. Progressive linking results in an ever increasing cluster of particles that finally settle out.

The effectiveness of any polymer as a coagulant aid is determined by the size, density, and ionic charge of the colloids to be coagulated, pH (relative acidity or alkalinity) of the water, the coagulant used, and techniques and equipment for dissolution of the polyelectrolyte.

In other words, all wastewaters exhibit their own individual properties and may require slightly different treatment processes, ingredients, or concentrations of ingredients. Their effluents, too, are as unique as human fingerprints.

For each combination of coagulant and wastewater, there is an optimum pH range for coagulation and an optimum dosage of coagulant. Hence, these two parameters must be controlled in advanced waste treatment systems.

The treatment plant at Grisdale uses alum as a coagulant. Sodium hydroxide, an alkaline reagent, is added to control the pH. Alum reacts chemically with the natural colloidal constituents in the wastewater and with the sodium hydroxide to form solids heavy enough to settle out.

Chitosan reacts electrically with those particles to do the same thing. If needed, bentonite clay is added as a weighting agent. These additives increase the sedimentation rate, thereby decreasing detention time in the tanks and increasing the capacity of the sewage treatment plant.

Some cationic polyelectrolytes produce excellent clarification of raw wastewater when used in high dosages even without a coagulant such as alum.

Based on field and laboratory investigations, Charles believes that by increasing the chitosan dosage from 1.7 parts per million to somewhere between 10 and 20 parts per million, both the alum and the sodium hydroxide could be eliminated from the ESI Model 100 at Grisdale.

Fred Snelgrove, logging engineer at Simpson Timber Co. in Shelton, said the company would prefer to eliminate the logistic problem of handling alum.

Alum is irritating to the skin and mucous membranes due to its acidic nature. It can cause serious eye injury.

Since chitosan is non-synthetic and biodegradable, the sediments formed from a plant using only chitosan would be less of a disposal problem than they are now, Charles said. At Grisdale the sludge is pumped every two or three months and dumped as land fill in a nearby garbage pit.

Snelgrove said the company would like to divert the sludge and backwash water into a septic tank for further decomposition before final disposal. This may be done in 1973.

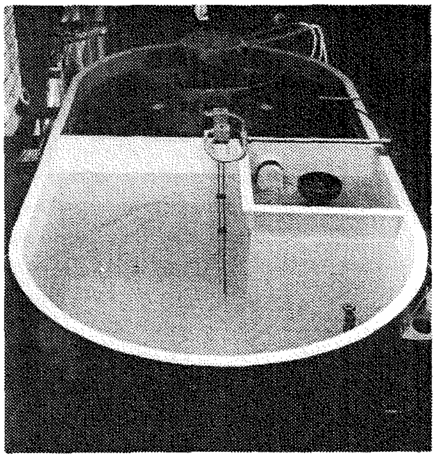
Mike Price, district supervisor for the Department of Ecology in this region, said the quality of effluent from the plant at Grisdale is as high as could be expected from a package plant.

"The ESI design is pretty straightforward and incorporates tried and true methods of waste treatment," he said. "There are a number of such package plants which also reduce the B.O.D. and remove suspended solids. One which we investigated, however, does so while adding from 1000 to 1500 parts per million of sulfate. Which is worse, the before or after?"

Price said the department recently approved a permit application for another installation near Ocean City on the Pacific Coast.

Charles said this installation will be served by an ESI Model 100, which is continuous flow, and also by an ESI Model 300, which is batch flow.

They will service 105 homes and 50 condominium units. The two units (including the prefabricated primary treatment vessel but excluding the collection system) should cost less than would be expected if individual septic tanks were used, Charles said.



The ESI Model 100 domestic sewage treatment plant at Grisdale has a capacity of 20,000 gallons per day. When wastewater enters this plant, it already has been through primary treatment, where the heavier solids settle out. Alum (a coagulant), sodium hydroxide (a caustic), and chitosan (a coagulant aid) are mixed with the wastewater in the three flocculation chambers (in circular structure, top center) in quantities of 264, 18 and 1.7 parts per million, respectively. Detention time in the chambers is 25 minutes. Detention time in the settling tank, which surrounds the flocculation chambers, is 50 minutes. The water then passes through a 14" sand filter supported by gravel (right center). Next, the clear water is chlorinated in the clearwell (foreground), where detention time is 62 minutes. The nominal flow through the plant is 14 gallons per minute. (Courtesy of Ray Charles Co.)

He believes there is a good market for waste treatment plants which are designed to fill the gap between small, isolated septic tank systems and large, municipal systems.

"Our plans to service this market are based on our confidence that chitosan will continue to be available at an acceptable cost," he said. "If it becomes unavailable or costs too much, we'll get out of the domestic sewage treatment business. Chitosan is so good we wouldn't use anything else."

Charles said chitosan should work just as well in a small municipal treatment plant as in the ESI models. He believes it has equal or better market potential in clarifying industrial effluents such as washwater from grain and gravel operations.

In Japan chitosan is used as a clarifier in breweries.

Chitosan used in papermaking

Drs. G. Graham Allan and Kyostvi V. Sarkanen of the College of Forest Resources, University of Washington, and a team of graduate students have been investigating the utilization of marine polymers in papermaking since 1968.

This research indicates that chitosan may offer papermakers several advantages. By improving interfiber bonding, chitosan increases the wet and dry strength of paper. If the treatment also improves internal bonding in the sheet, its "pick resistance" may be increased; i.e., during printing, the tendency for machines to pick up fibers would be reduced, the paper surface would remain smooth, and printability would improve.

Also, since chitosan increases paper strength, the papermaker who uses it could probably use other fibers which are weaker and cheaper without any loss in quality.

Since chitosan is cationic, it may improve the electrical conductivity of special papers such as those used in photocopying machines made by Xerox and other companies. Polymers analogous to chitosan are now used in these papers. A French scientist has had encouraging experimental results using chitin as an additive to improve the

Continued on page 12

Chitin & chitosan

Continued

electrical qualities in capacitor tissue.

Gerald D. Crosby, a U.W. graduate student in the final months of a Ph.D. program which he plans to complete by next September, has shown on a laboratory scale that chitosan might eliminate up to 90% of the pulp beating process with comparable or better properties obtained.

Dr. Allan discussed this work in a paper entitled "New Bonding Systems for Paper" at the 1972 Symposium on Man-Made Polymers in Papermaking at Helsinki.

He said there that the strength of a sheet of paper is determined by the strength of the fibers and the interfiber bonds. In conventional paper made of cellulose, the fibers are primarily held together by hydrogen bonds. One way to improve paper strength would be to supplement these low-energy bonds with more energetic ionic linkages. Groundwood fibers already have an abundance of anionic sites by virtue of their lignin content.

"In principle," he said, "the preferred spanning entity should be a high molecular weight, linear, film-forming, polycationic polymer with the additional capability of forming hydrogen bonds with nonionic areas of the fiber surface."

Chitosan meets all these criteria. In film form it is about as strong as a sheet made of well-beaten kraft pulp.

"The addition of chitosan," said Dr. Allan, "cannot then be expected to significantly improve the physical properties of a well-beaten kraft pulp since the fiber breakage is already the predominant mode of failure [in tensile strength tests] . . . On the other hand, for a lightly beaten kraft pulp the full potential of the fibers is not realized, and the addition of 1% chitosan increases [its strength almost to that] of the highly beaten fibers.

"For stronger fibers, therefore, the addition of chitosan may well substitute for part of the beating cycle," he said.

"The beating step, in which fibers are mechanically agitated to develop bonding surfaces, is very inefficient (less than 1%) and is the most costly in paper manufacturing," said Dr. Allan.

None of chitosan's commercial competitors, either polyethylenimines or polyacrylamides, compare to chitosan as a film-former, Dr. Allan said.

In March, Crosby made about 200 pounds of newsprint paper in tests at the facilities of the Central Research Division of Crown Zellerbach Corp. in Camas, Washington. Using their experimental paper machine, he used about 10 pounds of chitosan in testing the effects achieved by adding it (1) in various concentrations, (2) by various methods, and (3) at various steps in the papermaking process.

For example, he sprayed a chitosan solution on a wet sheet before it went into the dryer; he precipitated it onto the fibers in the stock chest before making a sheet; and he applied it to the paper at the size press.

"The last method was the most successful," Crosby said.

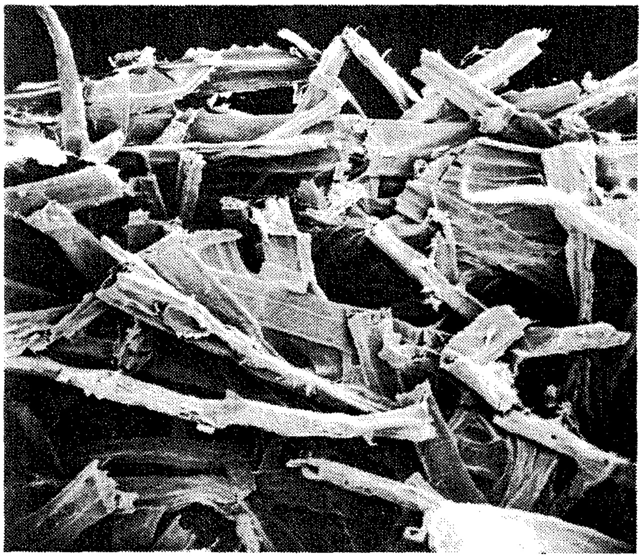
Newsprint is about 80% groundwood and 20% chemical pulp. This chemical pulp, however, represents about 40 to 50% of the cost of the newsprint. If chitosan were used to replace all or most of the chemical pulp, the newsprint would be about 95 to 98% groundwood and two to five per cent chitosan. Whether or not this would be more economical will, of course, depend on the price of chitosan. Price is one of the most important questions for the pilot plant to answer.

Sea Grant research and support

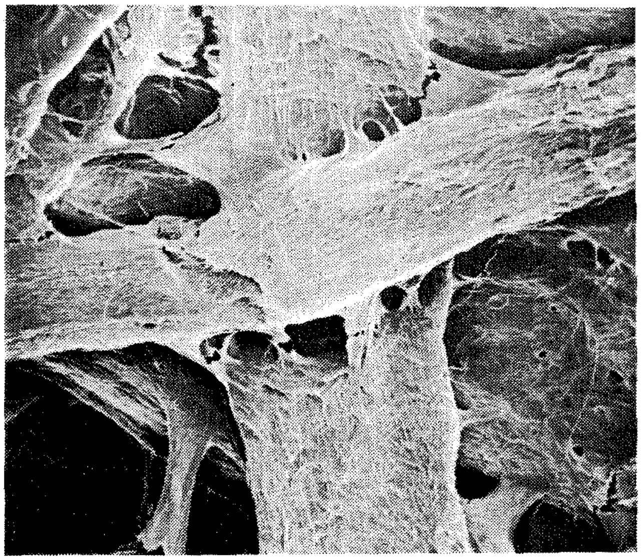
Much of U.W.'s research into the utilization of chitosan and other marine polymers has been supported through the Washington Sea Grant Program, administered by the Division of Marine Resources, University of Washington.

The National Sea Grant Program, through the University of Washington and the Oceanographic Institute of

Continued on page 15



This scanning electron photomicrograph shows the edge of a handmade sheet of paper, magnified 131 times, after it ruptured during a tensile strip test. The paper was made of unbeaten, unbleached kraft treated with chitosan. Note that almost all the fibers broke; there was essentially no fiber pullout. (Courtesy of the University of Washington)



Two fibers, magnified 640 times in this scanning electron photomicrograph, cross in this kraft handsheet containing 25% chitosan. Bridges of chitosan film merge almost imperceptibly with the fiber surfaces; some have cracked under the intense heat associated with making this photomicrograph. (Courtesy of the University of Washington)

Operations for the National Weather Service's Western Region in Salt Lake City. "Eastern Washington will have a state agricultural weather service office. It will be headed by an advisory agricultural meteorologist who will coordinate his combined specialty with other agencies and universities. Also, teletype communication to mass media will relay weather information consistently and more rapidly."

The specialized service has been a boon to farmers thus far in other parts of the country. NOAA's survey of the program's value in the 12 U.S. areas where it is now used shows savings that ranged from $152, saved by a farmer in spraying 50 acres of soybeans, to as much as $100,000, saved by a corporate farm in scheduling men and equipment for mechanical harvesting operations. For an annual expenditure of $1.7 million in weather services, an estimated saving of more than $62.1 million was reported.

Long Range Forecasting

Long range weather forecasting would of course save the most time, money and effort. Still in early stages, the answer to this type of forecasting lies out in the Pacific where it all starts.

"Any success in long range forecasting—for a month, season, or year ahead—is likely to come from understanding the interactions between atmosphere and ocean," says Dr. Mike Wallace, associate professor of atmospheric sciences at the University of Washington. "Air-sea interaction is a field of more and more interest to oceanographers and meteorologists."

Wallace explains some of the basics of air-sea interaction: wind patterns at the sea surface make the ocean temperature change. These changes are integrated gradually into sea surface patterns over long periods, for a resulting weather trend.

"In other words," he says, "the sea surface on a given day reflects an average surface wind pattern which has existed over the last few months—an effect something like the stock market, whose market value on a particular day reflects events over the past few months or years."

The specific measurements derived from the NOAA data buoys and weather satellites will help in air-sea studies. "With more data from the ocean available," he says, "we can build a base for understanding this interaction. Weather satellites will soon be equipped with infra-red sensors to measure sea surface temperature. This information will be valuable for interpreting just how the ocean influences the atmosphere—which is one-half of the air-sea interaction. To understand the other half—how the atmosphere influences the ocean—measurements have to be made not only of temperatures at the sea surface but also through the first 1000 feet of ocean. This is the depth through which most of the atmospheric effects are felt."

Some air-sea studies indicate a correspondence between sea surface anomalies in certain parts of the ocean and weather anomalies over certain parts of the United States. Lengthy records will be necessary to finally prove this true, but if there is a match-up between sea surface patterns and climates, long-range prediction may become a reality.

All of this meteorological and oceanic research translates into practical language for coastal and inland areas of the Northwest. With forewarning of long-range weather trends, ski resort operators can prepare for the upcoming winter season or fuel companies in urban areas can stock the proper amounts of oil.

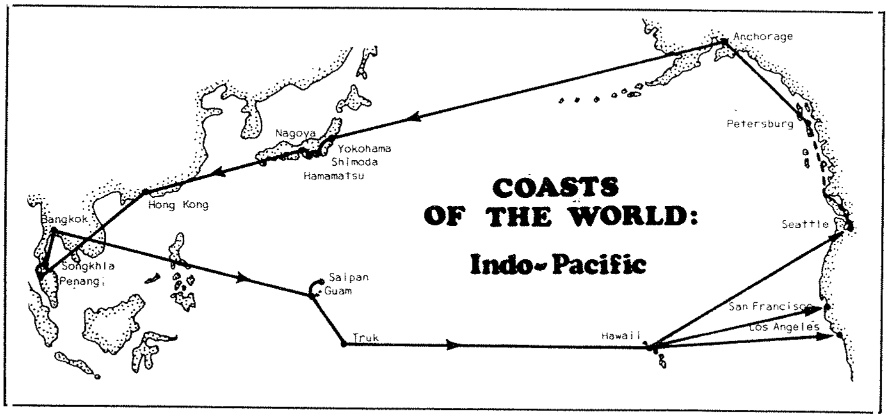
Maybe even someday *The Farmer's Almanac* will be replaced by weather information which, though it may not be as interesting, will be much more reliable.

Chitin & chitosan

Continued

Washington, is guaranteeing FCRL a market for chitin and chitosan by purchasing $48,000 worth of chitin and chitosan during 1972-74. The grant is to OIW, which functions as a procurement and distribution agent, supplying these materials to those qualified researchers throughout the country and abroad who request samples. This arrangement also permits FCRL to have a modest revenue during this development period to support market research and sales promotion. FCRL bears the entire capital cost of the pilot plant.

Instructions on how to obtain FCRL chitin and chitosan are on page 7.



Public Invited to Tour World Coasts

For the fifth year, three University of Washington oceanographers will escort laymen (18 to 80 years) on a tour of several coasts of the world. This year U.W. extension credits are offered for the first time. The course begins in Seattle on 13 July and ends at Truk on 7 August 1973.

Those who make the trip will attend lecture and discussion sessions by Drs. Joe S. Creager, Dora P. Henry, Richard W. Sternberg, and local biologists and geologists from the areas visited.

Field trips at principle sites offer on-site observation and study of intertidal and near-shore environments, coastal evolution, marine biology, coral reefs, volcanoes, beaches, and fjords.

The registration fee of $250, which covers instruction and course materials, is due by 15 May. Travel costs are $1945 (subject to change).

For more information, write Office of Short Courses & Conferences, University of Washington DW-20, Seattle, Washington 98195, telephone (206) 543-5280.