OMYA INC.
VERPOL PLANT TAILINGS PRODUCT
Pittsford, Vermont

SITE CHARACTERIZATION REPORT

Revised June 15, 2006

HEINDEL AND NOYES

Consulting Hydrogeologists, Engineers, and Environmental Scientists

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Prepared by:

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EXECUTIVE SUMMARY

- Omya generates a tailings product at its Verpol plant in Florence. Tailings are generated by Omya's calcium carbonate processing operation, and consist principally of the minerals that are separated from the marble ore that Omya processes. The tailings product contains calcium carbonate, mineral impurities, and approximately 0.4% of processing compounds.
- The tailings product are similar to sandy silt in texture, and contain water because water is used in the production process. Tailings at Omya are typically 70% to 90% solids.
- Omya is proposing to place its tailings product in two Tailings Management Areas (TMAs) on site under interim certification: the Dolomite Quarry and the Kane & Drake Quarry. The Loveland (or Dogleg) Quarry, and settling cells that are part of the production process, also have been studied during site characterization.
- Site characterization involved extensive testing of the physical and chemical properties of the tailings product, and of the geology, hydrogeology, and geochemistry of the site. Site testing included geologic mapping, fracture trace analysis, rock outcrop observation, field geophysical reconnaissance by VLF and geomagnetics, well installation and monitoring, testing of public and private off-site wells, well borehole video inspection, water elevation contouring, well pumping tests, streamflow gauging along groundwater discharge zones, and chemical analysis of groundwater and surface water samples.
- Testing of the tailings product has determined that the tailings have a low

permeability and do not generate significant quantities of leachate.

- Tailings do not contain elevated levels of metals or inorganic contaminants; barium and phosphorus are present in tailings at levels typically found in natural soil and bedrock.
- Tailings contain volatile organic compounds and semi-volatile organic compounds; the range of variation of the substances in tailings, tailings pore water, and tailings "leachate" extract have been identified. The levels of these substances in tailings do not present a risk to public health and safety or the environment.
- The analysis of over 190 groundwater samples from on- and off-site, and the analysis of over 20 surface water samples from on and off-site has shown that all groundwater and surface water are in compliance with Vermont's Groundwater Enforcement Standards, Drinking Water Standards, and Water Quality Standards. With Omya's tailings and TMAs having been in place at the site for over 25 years, these water quality tests confirm that the tailings have had no adverse environmental impact.
- Fate and transport modeling has verified that the groundwater and surface water monitoring results are consistent with the expected environmental fate and transport of the flotation reagent used in the production of the tailings product.
- The TMAs are compliant with the siting standards from the Vermont Solid Waste Management Rules (section 6-502), and meet the general performance standard (section 6-503(a)).
- The TMAs, which are unlined, conform to the liner waiver requirement: the tailings are not the source of leachate harmful to public health and safety or the environment, and do not create nuisance conditions. As documented by groundwater and surface water testing and the fate and transport model, all Water Quality standards, Drinking Water Standards, and Groundwater Enforcement Standards are met and are expected to continue to be met at the design management zone (as well as at all locations at the site). Any emission of leachate that conceivably may have originated from the unlined TMAs is having the least possible impact on the environment.
- The tailings management operation at the Omya Verpol plant in Florence, Vermont has been investigated via characterization of the tailings, study of the site geology and hydrology, and water quality monitoring. Extensive testing of groundwater and surface water on and off the Omya property, including public and private wells, has confirmed that the tailings do not cause an adverse environmental impact.
- The TMAs at Omya comply with the regulatory requirements for Interim Certification.

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SITE CHARACTERIZATION REPORT

June 15, 2006

I. INTRODUCTION

The Omya Inc. Verpol plant is located in an industrial zone within the community of Florence, in the Town of Pittsford, Vermont. The Verpol plant produces fine ground calcium carbonate. Quarried marble ore is ground at the plant and processed to remove natural mineral impurities via the process of beneficiation. Beneficiation involves the use of a flotation process by which the impurities are floated out of a mixture of water, ground ore, and processing compounds. Tailings consist primarily of the mineral impurities separated from the calcium carbonate via the plant's beneficiation process, mixed with calcium carbonate lost due to the efficiency limits of the current flotation technology. To a much lesser extent, tailings also may consist of calcium carbonate derived from other portions of the production process. Tailings also contain water from the flotation process and small amounts of processing compounds.

Omya's Verpol plant tailings product is placed in three Tailings Management Areas (TMAs) at the plant site. The TMAs are former rock quarries into which the tailings have been placed, either directly from the flotation system or after settling in a cell to remove some of the process water. TMAs which are proposed for the Interim Certification are the Dolomite Quarry and the Kane & Drake Quarry. The Loveland Quarry TMA (also called Dogleg Quarry) has been used for tailings management since 1979 and therefore has been studied during the site investigation. However, the Loveland Quarry is not presently being proposed as a TMA for the Interim Certification. The settling cells that are located to the east of the Loveland Quarry are part of Omya's production system and are not considered TMAs. The tailings in-place are typically 70% to 90% solids.

This Site Characterization Report evaluates the physical, topographic, geologic, and hydrologic aspects of the Verpol plant site. In order to address the potential affects of

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the tailings product to the environment, groundwater and surface water hydrogeology have been studied in detail.

The location of the site is shown on pages 1 and 2 of appendix 1, on a USGS topographic map and a Vermont 1:5000 orthophoto, respectively.

A. Tailings Production Process

Flotation refers to the process of separating impurities from the calcium carbonate. During the flotation process, impurities are floated out of a mixture of water and ground ore by means of a flotation reagent and air bubbles. In order to do their job, the flotation reagents must bind to the mineral impurities, and create a hydrophobic layer so that the impurities will separate from the mixture of water and calcium carbonate. Those minerals with the flotation agent bound to them are skimmed from the top of the aerated mix of water and calcium carbonate. The floated minerals are removed to various settling cells, where they are allowed to settle, and the settled solids are removed for deposition in the tailings management areas. Some portion of solids, mainly consisting of calcium carbonate, from rail car wash water and floor wash water also have been settled on-site, and thus comprise a portion of the tailings product placed in the past. It is these settled solids, and associated process compounds and water, that are identified as the “tailings product.”

II. TAILINGS CHARACTERIZATION METHODS

The composition of the tailings was determined by reviewing the materials involved in the plant operation, and by analyzing samples of tailings product and the pore water contained within the tailings. Samples were obtained from the tailings management areas, from the tailings settling cells, and from the flotation system prior to settling. Additional samples were used to perform laboratory extraction tests to determine the composition of the “leachate” extracted from the tailings.

Samples of tailings and pore water were analyzed for RCRA metals, TCLP extraction for herbicides and pesticides, EPA methods 8260 and 8260B for volatile organics, EPA methods 8270 and 8270C for semi-volatiles, method AG-24 for the TOHI-based flotation reagent, EPA method 8032 for acrylamide, EPA method 8015 for methylamine, and standard method 4500 CI-G for free chlorine. For a few substances, related to Omya's flocculants and dispersants, no laboratory tests exist that can detect them in the low concentrations that may be expected in the tailings. To assume a worst-case scenario, we have presented the highest quantities of those non-detectable substances that might be present in the tailings, based on a mass balance analysis. The mass balance calculations are confidential and contain and rely on proprietary trade secret information; therefore they will be submitted under seal by separate cover to the State for review.

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Initial rounds of tailings testing indicated the absence of herbicides and pesticides, and therefore testing for those contaminants was discontinued. The tailings extract did not contain metals, aside from Barium at concentrations that are consistent with its natural presence in rock and far below any regulatory standard (see appendix 3). Based on the initial tailings testing and the list of materials used in the plant, a sampling protocol was developed that focused on the substances associated with the tailings. Table 1 below shows the substances used at the plant and the test methods that have been used to identify those substances in the tailings. Material Safety Data Sheets (MSDS) for the substances used currently and previously by Omya are provided at the end of appendix 3. Table 2 below shows all test methods that have been used to analyze tailings, including the tests for those substances that are not a part of tailings, and that are not routinely performed (i.e. RCRA metals, pesticides, and herbicides).

Table 1: Substances Used at Omya Verpol Plant (1), In tailings, and Lab Methods

Substance Listed on NPDES Permit	Substance Identified in Tailings	Design Worst-Case Concentrations in Tailings	Laboratory Test Used to Identify Substance
Miramine TO-DT I	Tall Oil hydroxyethyl imidazoline (TOHI) Amine acetate Aminoethyl-ethanolamine	3484 ppm **	AG-24
P-1	Ortho-Phenylphenol (OPP)	1.36 ppm *	EPA 8270C
Stearic Acid	Stearic Acid	19.6 ppm *	EPA 8270C
Super A-130 Flocculant	Polyacrylamide (Flocculant)	0.59 ppm **	None
	Acrylamide monomer (impurity in flocculant)	< 0.050 ppm	EPA 8032
AB-73 CW-93 M566 M777 M882 M918 M922 M980 M981 M987 M988 M989 Polycryl M787/45A Phosphoric Acid	Acetone	0.597 ppm	EPA 8260B
	Isopropyl Alcohol	< 2 ppm	EPA 8260B
	Polyacrylates (dispersant)	68.8 ppm **	None
	Phosphorus (from dispersant/ phosphoric acid)	3.7 ppm **	None (phosphorus mineralizes on contact w/ carbonate in tailings)
N-521 N-922 (2)	Methyl Isothiocyanate	0.108 ppm *	EPA 8260B
	Methylamine	<5 ppm	EPA 8015
Sodium Hypochlorite and/or bleach	Free Chlorine	<0.2 ppm	SM 4500 CI-G
	Trihalomethanes	None Detected in Tailings	EPA 8260B
--	Barium	0.108 ppm	EPA 6010
--	Toluene	< 0.020 ppm	EPA 8260B
--	“Petroleum Products”	68.2 ppm *	EPA 8270C
--	Minerals	99.6% ±	--

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* Not typically found in tailings; these worst-case concentrations represent the maximum levels detected from testing. See complete data in section IV.
** Based on mass balance.

(1) Based on the list of chemicals used at site, as identified in the NPDES permit (9/27/2001). Note that no new chemicals are used at the site since the date of the permit. A new list contained in the 4/10/2006 draft of the renewed NPDES permit contains some different chemical names that indicate the same substances, but are provided under different brand names or different vendors, and also includes proposed new dispersants, which have not been used yet and that are not materially different from the present compounds.
(2) Now AMA415 is used (same composition as N-922)

Table 2: Tailings Sample Analysis Methods

Types of Analyses	Parameters	Test Methods
RCRA Metals	arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver	EPA 6010, SM 7470
Herbicides and Pesticides	Chlordane, Endrin, Heptachlor, Heptachlor Epoxide, Lindane, Methoxychlor, Toxaphene, 2,4,5-TP(Silvex), 2,4-D	SW 8081A, SW 8151, SW 8150
Volatile Organic Compounds	67 volatile organic compounds	EPA methods 8260 and 8260B
Semi-Volatile Organic Compounds	78 semi-volatile organic compounds	EPA method 8270C
Tailings Components and Associated Substances ("Omya List")	Tall Oil hydroxyethyl imidazoline (TOHI) Amine acetate Aminoethyl-ethanolamine	AG-24
	Ortho-phenyl phenol (OPP)	EPA method 8270C
	Stearic Acid	EPA method 8270C
	Acrylamide monomer (impurity in flocculant)	EPA method 8032
	Acetone	EPA method 8260B
	Isopropyl Alcohol	EPA method 8260B
	Methyl Isothiocyanate	EPA method 8260B
	Methylamine	EPA method 8015
	Free Chlorine	SM 4500 CI-G
	Trihalomethanes	EPA method 8260B
	Toluene	EPA method 8260B
	Percent Solids	EPA method 160.3

Since early 2003, the "Omya List" of analyses has been used to quantify the levels of various substances. The Omya List is as follows:

- 67 volatile organic compounds by EPA method 8260B
- 78 semi-volatile organic compounds by EPA method 8270C
- acrylamide monomer (SW 8032)
- free chlorine (SM 4500 CI-G)
- isopropanol (EPA method 8260 B screen)
- methyl isothiocyanate (EPA method 8260 B screen)
- monomethyl amine (SW 8015)
- Ortho phenylphenol (OPP) (EPA method 8270C Screen)

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- Petroleum products (EPA method 8270C Screen)
- Stearic Acid (EPA method 8270C Screen)
- Tall Oil Hydroxyethyl Imidazoline (TOHI) Based Reagent (Omya AG 24)
- PH (EPA method 150.1)
- Percent solids (for samples of tailings solids)

In order to characterize the potential leachate from the tailings, various tests have been performed. The pore water and supernatant water from the TMAs was collected and analyzed directly in the laboratory. Pore water refers to the water contained within the tailings themselves, and was collected from temporary monitoring wells installed into the TMAs, into which the pore water was allowed to seep. Supernatant water refers to the free water on top of the tailings solids where it occurs. Secondly, as an initial attempt to perform laboratory leachate testing, TCLP tests were performed on the tailings solids. However, these tests may be conservative, because they do not replicate the on-site conditions; the TCLP test method requires the use of a combination of agitation and low-pH liquid to extract simulated leachate from the solid sample in the laboratory. In contrast, the pH of the pore water within Omya's tailings is slightly alkaline at 7.8 (see pages 8 – 11 of appendix 3). Thirdly, a more representative test procedure was developed by conducting a TCLP-type test, but using pH 7.8 water to generate the simulated leachate. Samples obtained by this method were analyzed for the flotation reagent by method AG-24. This procedure is considered the most representative test for the flotation reagent.

To test the older tailings, which have been present on-site for many years, deep cores were advanced in three locations into the TMAs, using a macrocore direct-push sampler on a drill rig. One core was completed in the Kane and Drake Quarry to the depth of 63 feet on January 13, 2004. Two cores were completed within the Dolomite Quarry. A 24 foot deep core in the north end of that quarry was completed on January 13, 2004. A core in the south end was advanced to a depth of 62 feet on January 19, 2004. All cores were advanced to the greatest possible depth, terminating upon refusal on bedrock or boulders. The cores therefore represent the complete depth of the tailings at those locations.

Samples of the tailings solids were taken from the cores at discreet depths using the macrocore sampler. The samples were analyzed for physical, chemical, and bacterial parameters. Chemical tests included thermo-gravimetric analyses (TGA), which measured the total chemical load on the tailings without identifying specific substances, as well as the complete "Omya List".

The pore vapor from the tailings was tested on April 9, 2004 for the presence of biodegradation indicators. Oxygen (O_2), carbon dioxide (CO_2), and methane (CH_4) were analyzed at three locations within the tailings as well as background.

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III. SITE CHARACTERIZATION METHODS

The following geologic methods were used to characterize the Verpol plant site: review of surficial and bedrock geologic maps, fracture trace analysis, field mapping of bedrock outcrops, a field reconnaissance using very-low frequency (VLF) radio and geomagnetics, well drilling, borehole logging with a down-well video camera, water elevation contouring, streamflow gauging, and collection and laboratory analysis of surface water and groundwater samples.

A. Map Review

Bedrock geologic mapping from the Centennial Geologic Map of Vermont (1961) and surficial geologic mapping from the Vermont Surficial Geology mapping program (1956-1966) were reviewed. Maps were studied to identify bedrock type and the locations of formation contacts, faults, and surficial deposits. Geologic map information was used to site representative monitoring wells. Bedrock geologic cross-sections were generated based on geologic logs of onsite wells, to determine the locations of rock formation contacts in the vertical dimension, and to identify local water-bearing fracture patterns.

B. Fracture Trace Analysis

Two fracture trace analyses have been completed for the study area: one conducted by Geomapping Associates from unknown photographs, and one performed by Heindel and Noyes using three series of aerial photographs.[1] Fracture trace analysis was performed in order to identify bedrock fracture patterns that could direct groundwater flow, and in order to site monitoring wells in representative locations within the bedrock aquifer.

C. Bedrock Outcrop Field Mapping

A field reconnaissance of the site was performed to locate exposed, undisturbed rock outcrops in the vicinity of the Verpol plant. Strike and dip, when measurable, were recorded, and the locations of the outcrops were mapped, in order to evaluate structural features that would affect groundwater flow directions.

D. Field Geophysical Reconnaissance

A field geophysical reconnaissance was performed on the portions of the project site where use of Very-Low Frequency (VLF) radio and geomagnetic equipment was feasible. Electromagnetic interference from the plant itself, active railroads, and electric lines prevented use of this equipment in the northern portions of the site. However, in the wooded and undeveloped areas east of the Dolomite Quarry and south of the Kane

[1] US Army COE, 1977, Infrared 1:80,000 series. Flown at 40,000 ft. Photos 1-165, 1-164 VT Mapping Program, 1962, VT-62-H 1:18,000 series. Flown at 9,000 ft. Photos 21-92, 21-91 NASA, 1974, VT 7420

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& Drake Quarry, the geophysical instruments were not subject to electromagnetic interference, and therefore could be used in accordance with accepted procedures.

The purpose of the field geophysical reconnaissance was to identify likely water-bearing fracture zones in the bedrock beneath the Verpol plant site, in order to site monitoring wells. This approach was used, where feasible, to supplement the fracture-trace analysis and to further confirm the fracture locations for well drilling. Well drilling results, well video inspection, and pump testing confirmed the presence of water-bearing fractures in the locations selected for well drilling.

Field geophysical reconnaissance included use of a Geometrics G-856 proton-precession magnetometer to measure anomalies in the earth's magnetic field which may correspond to water-bearing fractures. Because the bedrock at the site consists of carbonates, the background magnetic reading was relatively low, and the higher-strength magnetic anomalies were identified as likely fractures, where the flowing water had deposited more conductive minerals.

Very-low frequency radio equipment was used in conjunction with the magnetometer to identify subterranean fractures in the rock. Two signal sources were used, because stations are reliable for detecting features that are 45° ± on-strike with the signal. The NAA 24 KHz military station in Cutler Maine (east of the site) was used to identify east/west features. Because no other detectable stations exist to the north or south of the site, it was necessary to set up a local transmitter to identify north/south features. A Geonics TX-27 18.6 KHz portable VLF transmitter was set up on the site with the 1-km long antenna oriented north to south in order to detect features with a parallel strike. A Geonics EM-16 receiver was used to measure inphase angle and quadrature of the radio signals.

Field data were collected from an approximately 100' x 100' grid pattern over the site, and measurement points were flagged in the field and mapped using a global positioning system (GPS) receiver with an accuracy of ±1 meter. Data were analyzed by standard methods to identify fracture zones. See data, pages 18-26 of appendix 1. From the field geophysical investigation, drilling sites were selected for wells C-2, G, H, and I.

E. Well Installation and Monitoring Network

A monitoring network consisting of 14 bedrock wells on the Verpol plant site was established. The monitoring network consisted of four pre-existing wells in addition to ten wells that were sited and drilled for the study of the site's geology and the potential effects of tailings. Beyond the on-site wells, fifteen surrounding private and public wells and springs also have been monitored. Page 1 of appendix 2 summarizes the details of the wells that have been used in the site characterization study. Well locations are

1:20,000 series. Flown at 10,000 ft. Photos 7-214, 7-215, 7-216.

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shown on the site maps on pages 3-4 of appendix 1, and on the geologic map on page 5 of appendix 1. Table 3 identifies the wells involved in the study.

Table 3: Wells and Springs Monitored in Site Characterization Study

Name (See Site Map)	Type	Notes
Well #2	Bedrock	Pre-existing well. Located between and downgradient from the three Tailings Management Areas (TMAs).
Well #5 ("CDP Well")	Bedrock	Pre-existing well. Formerly used to supply office-trailer. Located downgradient from the three TMAs.
Well 96-1	Bedrock	Pre-existing well. Located laterally downgradient from Loveland Quarry and settling cells.
Well 96-2	Bedrock	Pre-existing well. Located downgradient from all three TMAs and near downgradient edge of site property.
Well A	Bedrock	Geologically sited well. Located downgradient from all three TMAs, at upslope end of a fracture-trace lineation heading east-to-west.
Well B	Bedrock	Geologically sited well. Located at fracture trace lineation within the Kane and Drake TMA.
Well C	Bedrock	Geologically sited well. Located at fracture trace lineation southeast of Dolomite Quarry TMA.
Well C-2	Bedrock	Geologically sited well, southeast of Dolomite Quarry TMA. Location identified by field geophysical reconnaissance.
Well D	Bedrock	Geologically sited well. Located at fracture trace lineation downgradient from former tailings area used by White Pigment Corporation. Well is near downgradient edge of site property.
Well E	Bedrock	Geologically sited well. Located downgradient from former tailings area used by White Pigment Corporation. Well is near downgradient edge of site property.
Well F	Bedrock	Geologically sited well. Located within the former tailings area used by White Pigment Corporation. Well is near downgradient edge of site property.
Well G	Bedrock	Geologically sited well, east of Dolomite Quarry TMA. Location identified by field geophysical reconnaissance.
Well H	Bedrock	Geologically sited well, east of Dolomite Quarry TMA. Location identified by field geophysical reconnaissance.
Well I	Bedrock	Geologically sited well, south of Kane & Drake TMA. Location identified by field geophysical

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Table 3: Wells and Springs Monitored in Site Characterization Study

Name (See Site Map)	Type	Notes
		reconnaissance.
Pittsford-Florence Water District (PFWD) Wells	Gravel	Off-site public water supply wells.
O'Keefe Well	Bedrock	Off-site private water supply well.
LaFlamme Well	Bedrock	Off-site private water supply well.
Eugair Well	Bedrock	Off-site private water supply well.
Eugair Spring	Spring	Off-site private water supply spring
L&S Rosato Well	Bedrock	Off-site private water supply well.
Sandillo Well	Bedrock?	Off-site private water supply well.
Orvis Spring	Spring	Off-site private water supply spring.
Chrusciel Spring	Spring	Off-site primitive spring (not used as a water supply).
Doug Hard Well	Bedrock	Off-site private water supply well.
Devereaux Well	Bedrock	Off-site private water supply well.
Scarcello Well	Bedrock	Off-site private water supply well.
VELCO Well	Bedrock	Off-site private water supply well (not used for potable/drinking water).
P. Hard Well	Bedrock	Off-site private water supply well.
Ferraro Well	Bedrock	Off-site private water supply well.

The locations and drilling methods of the on-site wells, which were drilled for the site characterization study, were approved by the Vermont Department of Environmental Conservation (DEC). Locations and drilling specifications for wells A, B, and C were approved by staff at the Water Supply Division and Waste Management Division following review of a workplan and a site visit[2]. Locations of wells D, E, and F were approved by Waste Management Division staff following review of a workplan[3]. Locations of wells C-2, G, H, and I were approved by Waste Management Division staff[4] following review of field geophysical data and of Heindel and Noyes' Geophysical Study Report[5].

On-site wells have been monitored for water quality analysis and also have been monitored for water elevations, to map the groundwater potentiometric surface in order to determine flow directions. Off-site wells have been monitored for water quality analysis.

Well drilling logs are provided in appendix 2, pages 2-34.

The network of onsite monitoring wells characterizes the hydrogeology of the Verpol plant site in detail. Due to the interconnected nature of fractures in the bedrock and the locations of many wells downgradient from – and directly through – the Tailings Management Areas, water from the wells indicates the effect, or lack thereof, of the

[2] Letter from Michael B. Smith of Vermont DEC, 2/2/2001 to Ameddia Perry of H&N
[3] Letter from Michael B. Smith of Vermont DEC, 10/25/2001 to Ameddia Perry of H&N
[4] Meeting of 6/2/2005 and telephone conference 6/14/2005
[5] H&N, 9/9/2004. "Omya Inc. Verpol Plant Tailings Geophysical Study"

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tailings on groundwater. The monitoring network is spaced to allow for a large scale evaluation of the groundwater potentiometric surface and flow direction. The use of fracture trace analysis, geologic mapping, and VLF and geomagnetic geophysical methods, as discussed above, to site the wells has resulted in the wells encountering significant water-bearing fractures that are representative of the site.

F. Borehole Video Inspection

All bedrock wells at the site, with the exception of wells #2 and #5, were inspected with a borehole video camera in order to identify the depths and locations of the rock fractures. This inspection was done in order to confirm that the monitoring wells intercepted water-bearing rock fractures, to determine the depths in the wells from which to collect water quality samples, and to inspect the subterranean geology of the site. Well #2 could not be inspected with the camera due to significant accumulations of silt; well #5 could not be inspected because it was in-use and contains a submersible pump which blocked camera access. Well video logs are contained in appendix 2, pages 35-44.

G. Water Elevation Contouring

All bedrock wells at the site have been surveyed using a total station (laser transit) system so that water elevations may be compared to a common datum of mean sea level. Water levels in the wells and the onsite rock quarries have been measured at various times of year including spring high water levels, as well as drought low levels, to determine the gradient and flow direction of the bedrock aquifer water surface. The data have been analyzed by standard hydrogeologic methods; well potentiometric surface elevations have been contoured on accurately-scaled maps to indicate the groundwater flow directions. Measurements of the groundwater flow direction have been analyzed from the following dates:

- March 19, 2001 (winter conditions, ground snow-covered)
- May 15, 2001 (spring conditions, following significant snowmelt)
- July 26, 2001 (summer conditions, drought)
- October 31, 2002 (fall conditions, average water levels)
- November 6, 2003 (fall conditions, average water levels)
- June 27, 2005 (summer conditions, average water levels)
- October 25, 2005 (fall conditions, high water levels due to recent heavy rainfall)

In addition, piezometers were installed in overburden soils at two suspected groundwater discharge zones to determine the vertical flow component, for the purposes of confirming whether groundwater discharge occurred. Piezometers were installed along the “Post Office Swale”, and near the unnamed tributary to Smith Pond (see site map, page 3 of appendix 1).

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H. Pump Testing of Bedrock Wells

Pumping tests were conducted in wells 2, C-2, G, H, and 5 (CDP well). The tests were performed in order to measure the range of the aquifer properties transmissivity, permeability, and storativity, and to determine the orientation of water-bearing fractures through observation of the directions in which observation wells experienced drawdown in response to the pumping.

To obtain the best data for the purposes of measuring aquifer properties, observation wells were selected that were not in use themselves, so that use of a well did not obscure the changes in water level that may have resulted from the testing. Therefore, off-site water supply wells were not included in the testing. All such wells are located over 1,500 feet from the production wells, and would not be likely to have experienced any effect from the testing.

For the well #2 testing, a step-test was performed in 2001, using four hour-long steps of 2.2 gpm, 5.9 gpm, 12.6 gpm, and 13.8 gpm. Aquifer properties were measured from the highest-rate step because it caused the most stress (drawdown) to the aquifer. Well 5 and well B were monitored as observation wells during this test.

For the testing of wells C-2, G, H, and 5, 24-hour to 36-hour pumping tests were performed in July 2005. During these tests, observation wells included wells A, B, C, C-2, G, H, I, 2, and 5.

During all tests, water levels in the production well and observation wells were measured with automatic dataloggers and by the field staff supervising the tests. Drawdown and recovery data were analyzed to determine aquifer properties. Because the drawdown and recovery hydrographs indicated apparent radial flow under pumping conditions (see results in section V below), the Cooper-Jacob method of analysis was employed, as appropriate for the performance of the wells.

I. Streamflow Measurement

Streamflows have been measured at five locations along the length of the swale which originates on-site just east of bedrock monitoring well A. This swale, which flows east to the Otter Creek, is shown on the site map (page 3 of appendix 1) and is referred to as the “Swale Above the Post Office”, or “Post Office Swale”. Streamflow measurement stations along this swale are designated as PO-1 through PO-5. Flow measurements, in conjunction with geochemical analysis of the waters, were performed in order to understand the relation between the Post Office swale and the bedrock aquifer, including determining losing and gaining stream conditions.

Flow measurements were performed synoptically at the five stations along the Post Office Swale on 5/11/2004, 7/15/2004, and 7/18/2005 using the relative dilution and volumetric methods. The relative dilution method was chosen for this swale because the turbulent flow in this small, high-gradient channel prevented the proper use of the velocity-area method. The well-mixed conditions in this stream are appropriate for the relative dilution method. At station PO-2, the swale flow was measured volumetrically at the outfall from the culvert under West Creek Road, providing an exact flow measurement. To confirm the accuracy of the streamflow measurements, duplicate measurements were conducted at each station.

Additionally, streamflows were measured at three locations along the length of the tributary to Smith Pond, which is located north of the Omya plant, where most of the groundwater from the site is believed to discharge. Streamflow measurement stations along this tributary (referred to as “Smith Pond Tributary”) are designated as SP-1, SP-2, and SP-3 (see page 3 of appendix 1). Flow measurements were performed to identify groundwater discharge locations and to quantify groundwater discharge rates.

Flow measurements were performed synoptically at the three stations along the Smith Pond Tributary on 7/13/2005 using the current-meter method; depth and velocity in this stream were sufficient for use of a current meter. To confirm the accuracy of the streamflow measurements, duplicate measurements were conducted at each station.

J. Groundwater Sample Collection and Analysis

As of the October 2005 sampling event, a total of 197 groundwater samples collected from the network of 14 on-site wells and fifteen off-site wells and springs have been evaluated for the site characterization. Groundwater sample totals include 34 off-site samples and 163 on-site samples.

Groundwater samples have been collected following standard methods. Wells that are in-use and have permanently installed pumps (including all off-site wells) have been tested by purging the water at the tap and collecting a standard tap sample. Monitoring wells have been sampled using the low-flow purge technique[6]. As requested by the Waste Management Division of the DEC, bedrock monitoring wells were sampled using inflatable packers to collect a sample from the uppermost fracture zone, during the year 2001. For all other bedrock monitor well samples, a submersible sampling pump was positioned at the depth of the uppermost facture zone. For both packer-samples and packerless samples, wells were purged until monitored parameters (typically pH, temperature, conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO), stabilized, indicating that a representative sample of groundwater from the aquifer was being collected.

Groundwater samples have been analyzed for a wide range of parameters to test for the components of the tailings and their breakdown products. In addition, groundwater samples have been analyzed for the 13 priority pollutant metals, 78 semi-volatile organic compounds, and 67 volatile organic compounds, which are not necessarily

[6] Barcelona, M.J., Wehrman, H.A., and Varigen, M.D., 1994. Reproducible well purging procedures and VOC stabilization criteria for groundwater sampling. Groundwater, Vol. 32 No. 1, pp. 12-22

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associated with tailings, but which were tested in order to assess all of the substances which potentially could have been present. Finally, groundwater has also been tested for geochemical parameters and minerals in order to characterize the hydrology of the site. Table 4 below summarizes groundwater testing methods.

Table 4: Groundwater Sample Analysis Methods

Type of Analysis	Parameters	Test Methods
Metals	antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, zinc	SM 3113B, EPA 6010, SM 7470
Volatile Organic Compounds	67 volatile organic compounds	EPA methods 8260 and 8260B
Semi-Volatile Organic Compounds	78 semi-volatile organic compounds	EPA method 8270C
Geochemical Parameters/Minerals	pH	EPA method 150.1
	Temperature	EPA 170.1
	Electrical Conductivity	EPA 120.1
	Oxidation/Reduction Potential	
	Dissolved Oxygen	SM-4500-O-G
	Carbonate	SM 2400 CO2
	Alkalinity	EPA method 310.1
	Bicarbonate	SM 4500 CO2
	Chloride	EPA 300.0
	Fluoride	EPA 340.2
	Nitrate	EPA 300.0
	Total Dissolved Solids	EPA 160.1
	Sulfate	EPA 300.0
	Calcium	EPA 6010
	Magnesium	EPA 6010
	Silica	EPA 6010
	Sodium	EPA 6010
	Hardness	SM 2340B
Tailings Components and Associated Substances (“Omya List”)	Tall Oil hydroxyethyl imidazoline (TOHI) Amine acetate Aminoethyl-ethanolamine	AG-24
	Ortho-phenyl phenol (OPP)	EPA method 8270C
	Stearic Acid	EPA method 8270C
	Acrylamide monomer (impurity in flocculant)	EPA method 8032
	Acetone	EPA method 8260B
	Isopropyl Alcohol	EPA method 8260B
	Methyl Isothiocyanate	EPA method 8260B
	Methylamine	EPA method 8015
	Free Chlorine	SM 4500 CI-G
	Trihalomethanes	EPA method 8260B
	Toluene	EPA method 8260B

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Following initial testing to characterize the tailings and groundwater, a sampling protocol (the “Omya List”) was developed which focused on the substances associated with the tailings. Since early 2003 this set of analyses has been used to analyze groundwater for the substances which are associated with the tailings (see section II, Tailings Characterization Methods, above for an explanation of the development of the Omya List).

K. Surface Water Sample Collection and Analysis

A total of 21 surface water samples collected from a network of on-site and off-site surface water sampling stations have been evaluated for the site characterization. The sampling network consists of a seepage point at the base of the Kane and Drake TMA; the East Settling Pond, which is part of Omya’s permitted stormwater and discharge system; five stations along the length of the “Post Office swale”, and an on-site swale (“Truck Garage Swale”). Sampling stations are shown on the site map on page 3 of appendix 1. Table 5 below summarizes the surface water stations.

Table 5: Surface Water Sampling Stations

Name (See site map)	Notes
Seep 1	Seepage area at base of Kane and Drake Quarry (on-site)
East Settling Pond	Downstream from Tailings Management Areas; part of permitted discharge network (on-site)
PO-5	Head of Post Office Swale, at “Hendee Spring” (on-site)
PO-4	Along Post Office Swale downstream from PO-5 (off-site)
PO-3	Along Post Office Swale downstream from PO-4 (off-site)
PO-2	Along Post Office Swale at crossing under West Creek Road (off-site)
PO-1	Along Post Office Swale near mouth at Otter Creek (off-site)
Truck Garage Swale	Downslope of Tailings Management Areas (on-site)

Surface water samples have been collected from the path of flowing water using the standard grab sample method. Samples are collected by lowering the containers to the channel bottom, and then allowing them to fill with water while being slowly raised to the surface, so that the sample contains water from the entire water column and surface. Surface water samples have been analyzed for a wide range of parameters to test for the components of the tailings and their breakdown products. In addition, surface water samples have been analyzed for 78 semi-volatile organic compounds and 67 volatile organic compounds, which are not necessarily associated with tailings, but which were tested in order to assess all of the substances which potentially could have been present. Surface water has also been tested for geochemical parameters and minerals in order to characterize the hydrology of the site. Table 6 below summarizes surface water testing methods.

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Table 6:
Surface Water Sample Analysis Methods

Type of Analysis	Parameters	Test Methods
Volatile Organic Compounds	67 volatile organic compounds	EPA methods 8260 and 8260B
Semi-Volatile Organic Compounds	78 semi-volatile organic compounds	EPA method 8270C
Geochemical Parameters/Minerals	pH	EPA method 150.1
	Temperature	EPA 170.1
	Electrical Conductivity	EPA 120.1
	Alkalinity	SM18-2320-B
	Chloride	EPA 300.0
	Total Dissolved Solids	SM19 2540C
	Sulfate	EPA 300.0
	Barium	EPA 200.7
	Calcium	EPA 200.7
	Magnesium	EPA 200.7
	Sodium	EPA 200.7
	Gross Alpha Activity	EPA 900.0
	Tritium	E3H
Tailings Components and Associated Substances ("Omya List")	Tall Oil hydroxyethyl imidazoline (TOHI) Amine acetate Aminoethyl-ethanolamine	AG-24
	Ortho-phenyl phenol (OPP)	EPA method 8270C
	Stearic Acid	EPA method 8270C
	Acrylamide monomer (impurity in flocculant)	EPA method 8032
	Acetone	EPA method 8260B
	Isopropyl Alcohol	EPA method 8260B
	Methyl Isothiocyanate	EPA method 8260B
	Methylamine	EPA method 8015
	Free Chlorine	4500 CI-G
	Trihalomethanes	EPA method 8260B
	Toluene	EPA method 8260B

Following initial testing to characterize the tailings and groundwater, a sampling protocol (the "Omya List") was developed that focused on the substances associated with the tailings. Since early 2003, this set of analyses has been used to analyze surface waters for the substances that are associated with the tailings (see section II above for an explanation of the development of the Omya List).

IV. TAILINGS DESCRIPTION

Omya's Verpol plant tailings product consists primarily of naturally occurring minerals (mainly calcium carbonate, as well as other naturally occurring minerals that are considered impurities). Non-mineral components of the tailings comprise less than 0.5% of the tailings mass.

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A. Physical Description

Physically, the tailings resemble a sandy silt material. Testing by GeoDesign found a range in median grain size of 1 micrometer to 100 micrometers, depending on the location of the tailings sample. This testing was performed on material from the settling cells (see pages 1-2 of appendix 3).

Consistent with the small grain size, tailings have a low permeability. The following permeabilities have been identified through testing:

- H&N tested the sediment lining the Dogleg Quarry (where primarily floor tailings and railcar wash tailings are settled) and determined a permeability range of 0.01 to 0.08 ft/day (3.5×10^{-6} to 2.8×10^{-5} cm/sec), which is within the low end of the range reported for silt in hydrology texts[7]. (See pages 3 - 4 of appendix 3.)
- GeoDesign conducted testing on the compacted flotation tailings and found a permeability range of 0.31 to 0.42 ft/day (1.1×10^{-4} to 1.5×10^{-4} cm/sec). (See page 2A of appendix 3.)
- ASTM method D-5084 tests performed by GeoTesting Express and Golder Associates indicated that the hydraulic conductivity of the tailings product ranges to less than 1×10^{-5} cm/sec. (See Part D-4 (Closure/Post-Closure Plan) of the Application.)

B. Chemical Profile

Tailings consist primarily of minerals, which comprise over 99% of the mass. Minerals in the tailings include calcium carbonate and naturally occurring mineral impurities. The impurities consist of chlorite, plagioclase, feldspar, quartz, and mica, in general ascending order of composition. See X-ray diffraction results, page 5 of appendix 3. (Note the lab report indicates percent acid-insoluble material; the balance, or acid-soluble material, is the carbonate).

The non-mineral components of the tailings are found in varying concentrations. To provide the greatest factor of safely, we have selected the highest end of the ranges of concentration for each of these components as the “design concentration” of the tailings. Table 7 below presents the design concentrations of tailings for “old” and “new” tailings. “Old tailings” refers to the tailings material which has been stockpiled at the site dating back to circa 1980. “New tailings” refers to the tailings which have been produced beginning in 2002 when certain modifications to the process were implemented, and that will be produced in the future. Pages 6 - 16 of appendix 3 present data from the analyses of tailings solids, pore water, and simulated “leachate” extract.

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[7] Freeze and Cherry, 1979. Groundwater

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Table 7: Omya Verpol Tailings Design Composition (Worst-Case Concentrations)

Substance	Composition of Old Tailings	Design Composition of New Tailings	Explanation
Barium	0.108 ppm	0.108 ppm	Naturally present; no change
Toluene	0.399 ppm	< 0.020 ppm	May decrease due to attenuation of historic source
"Petroleum Products"	< 3.9 ppm	68.2 ppm*	Not typically present; this value is the maximum detected concentration in tailings solids.
Tall Oil Hydroxy-ethyl Imidazoline-based flotation reagent	1620 ppm	3484 ppm	Based on mass balance calculations, concentration of flotation reagent would move to the 3484 ppm-range with increased carbonate recovery efficiency. Currently near 1620 ppm based on laboratory testing.
Ortho-phenyl phenol (OPP)	5.27 ppm	1.36 ppm*	OPP source (spill, fall 2000) remediated, changes made to prevent recurrence.
Acetone	0.182 ppm	0.597 ppm	Maximum detected concentration in tailings solids.
Isopropyl Alcohol	0.329 ppm	< 2 ppm	Not detected in current tailings.
Stearic Acid	15.0 ppm	19.6 ppm	Maximum detected concentration in tailings solids.
Polyacrylamide (Flocculant)	0.59 ppm	0.59 ppm	Based on mass balance calculations.
Acrylamide monomer (impurity in flocculant)	< 0.050 ppm	< 0.050 ppm	Highest detection limit in tailings solids. Was detected at lower levels (0.006 ppm).
Polyacrylates (dispersant)	68.8 ppm	68.8 ppm	Based on mass balance calculations.
Phosphorus (from dispersant/ phosphoric acid)	3.7 ppm	3.7 ppm	Based on mass balance calculations. Phosphoric acid forms mineral phosphates on contact with carbonate.
Methyl Isothiocyanate	0.042 ppm	0.108 ppm*	Maximum detected concentration in tailings solids.
Methylamine	<5 ppm	<5 ppm	Not detected
Free Chlorine	<0.2 ppm	<0.2 ppm	Not detected
Minerals	99.6% ±	99.6% ±	Naturally present

* Not typically found in tailings; these worst-case concentrations represent the maximum levels detected from testing. See complete data in appendix 3.

Note that that tailings have been analyzed for metals and inorganic parameters, as has groundwater at the site (see appendix 3, page 14 for tailings metals data and appendix 5, pages 1-3 for groundwater metals data). Elevated levels of metals were not found in the tailings (by TCLP extract) or in groundwater. Testing of the tailings for metals found that only Barium, out of the eight RCRA-regulated metals, was present in the tailings. As discussed below, the barium levels in tailings and on-site groundwater were consistent with natural levels in Vermont. Therefore, metals analysis has not continued.

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The pore water/supernatant water analyses and pH-modified TCLP tests indicate that the majority of the non-mineral components of the tailings remain bound to the tailings solids, in particular the flotation reagent which is the primary non-mineral constituent of the tailings (see pages 8 – 16 of appendix 3). Consistent with its intended purpose, the bulk of the flotation reagent remains bound to the non-calcium carbonate minerals in the tailings. Table 8 below summarizes the chemical profile of the leachate based on analysis of pore water and extraction testing.

Table 8:
Omya Verpol Plant Tailings Leachate Design Composition

Substance	Typical Concentration in Leachate	Explanation
Barium	0.108 ppm	Naturally present, based on TCLP testing
Toluene	<0.001 - 0.0345 ppm	Range based on old and new tailings (pore water analysis). High end of range is from old tailings.
"Petroleum Products"	<0.320 – 0.847 ppm	Not typically detected in tailings. Upper end of range is highest single result from pore water tests.
Tall Oil Hydroxy-ethyl Imidazoline-based flotation reagent	0.053 – 0.467 ppm	Data from modified pH-TCLP test (n=49). Pore water data not considered representative due to suspended solids with adsorbed flotation reagent.
Ortho-phenyl phenol (OPP)	<0.017 – 0.907ppm	Not typically found in tailings/leachate. Upper end of range represents result of accidental release.
Acetone	0.065 – 2.950 ppm	Typically found in tailings pore water/leachate, range based on pore water analysis.
Isopropyl Alcohol	0.0898 – 1.530 ppm	Found in pore water.
Stearic Acid	< 0.330 ppm	Not detected in pore water.
Polyacrylamide (Flocculant)	0.59 ppm	Based on mass balance calculations.
Acrylamide monomer (impurity in flocculant)	< 0.00075 - 0.0037 ppm	Not typically detected in tailings. Upper end of range is highest single result from pore water tests.
Polyacrylates (dispersant)	68.8 ppm	Based on mass balance calculations.
Phosphorus (from dispersant/ phosphoric acid)	NA	Phosphoric acid in tailings forms insoluble mineral phosphates on contact with carbonate.
Methyl Isothiocyanate	< 0.002 – 0.684 ppm	Not typically found in tailings/leachate. Upper end of range represents result of accidental release.
Methylamine	<3 ppm	Not detected
Free Chlorine	<0.1 ppm	Not detected
Trihalomethanes	<0.001 – 0.0146 ppm	Not typically detected in tailings. Upper end of range is highest single result from pore water tests.
PH	7.8	Minimum pH (for most conservative analysis of leachability) based on tests of pore water.

C. Tailings Evaluation

This section of the report evaluates the tailings components identified above, in the context of their potential effects to the environment when placed in a Solid Waste Management Facility.

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Barium

Barium is a naturally occurring metal, and is present in the tailings in levels that are normal for carbonate bedrock in Vermont. Because it is not used in the production process, barium most likely is present in the tailings material due to its natural presence in the raw rock processed by Omya. Therefore, the barium level found in the old tailings is representative of the new tailings product. The barium levels in the tailings TCLP extract are about 1/1000th of the threshold for being considered a hazardous material.[8] The barium levels in groundwater at the Omya site are consistent with naturally occurring levels throughout the state, indicating that the tailings do not cause elevated levels of barium to leach into the environment.

Toluene

Toluene has been detected sporadically in low levels in the tailings product. It may have originated from previous land uses at the plant site, such as a former asphalt plant, or from incidental sources such as motor fuel or lubricant use on the site. There is no known source of toluene in Omya's production process.

The Safe Drinking Water Act and the Vermont Water Supply Rules have set a Maximum Contaminant Level (MCL) of 1.0 ppm for toluene in drinking water. In contrast, the highest toluene level found in groundwater at the Omya site is only 0.0126 ppm, far below levels that threaten health or the environment, and no toluene has been found in surface water at the site (see appendix 5 for groundwater data and appendix 6 for surface water data). Likewise, the highest toluene level found in the old tailings pore water is 0.0345 ppm, well below the MCL, levels in the new tailings are lower still (see appendix 3 for tailings data).

Tall Oil Hydroxyethyl Imidazoline (TOHI) – Based Flotation Reagent

Omya purchases flotation reagent currently under the trade name of Custamine 51D Flotation Reagent, and formerly purchased under the name Miramine TO-DT. The flotation reagent contains three ingredients, as shown in the following table.

Component	CAS#	Percentage of Custamine 51D Reagent	Percentage of Miramine TO-DT Reagent
Tall Oil Hydroxyethyl Imidazoline	61791-39-7	91.0%	>90%
Amine Acetate	61791-54-6	7.5%	8%
Aminoethyl-ethanolamine	111-41-1	1.5%	<2%

[8] State of Vermont, Hazardous Waste Management Regulations, 9/30/1998.

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Because the purpose of the flotation reagent is to separate the non-carbonate minerals from the product, and float them out of water, it must bind to those impurities and it must be insoluble in water. In the tailings product, it essentially will remain bound to the mineral solids and will not enter groundwater. TOHI flotation reagent levels in simulated leachate from tailings are 228 parts per billion (ppb), based on the modified TCLP testing, in contrast to 3484 *ppm* in tailings solids. The mobility and transport of flotation reagent is discussed in section VII below. The indicated Vermont Health Advisory level for TOHI is 126 ppb; all groundwater and surface water samples from the site are in compliance with this standard.

<u>Ortho-phenylphenol (OPP)</u>

OPP, a preservative which Omya adds to its final calcium carbonate product, was present in some tailings as a result of an accidental spill in November of 2000. The OPP was remediated in 2001 as part of a state approved monitoring and remediation program. The State has concluded that the remediation program has been successful and that the OPP does not pose any risk.[9] [10] [11] To reduce the chances that such an accident could occur again, changes to the Verpol plant, including the installation of leak detection software as well as secondary containment, have been implemented.

Following the OPP spill, some compounds that are believed to be breakdown products of the OPP biodegradation were found in groundwater. For example, Isopropyl Benzene was found in well #2 during March and July of 2001 at 1.3 and 1.8 ppb; during this time OPP was also being detected in the well and was the likely source of the isopropyl benzene. Similarly, bis (2 ethyl hexyl) phthalate found in well 96-1 on 7/26/2001 may also be related to the OPP degradation. These compounds have not been detected in groundwater at the site since the remediation of the OPP spill was completed.

Groundwater and surface water data (see appendices 5 and 6) shows that OPP is not being released to the environment. No OPP has been detected in groundwater following the complete remediation of the spill in 2001.

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[9] 12/27/2001 Letter from Mr. Ameddia Perry of Heindel & Noyes to Mr. Michael Smith of Vermont WMD and Mr. Timothy Raymond of Vermont Water Supply Division.

[10] 1/3/2002 Letter from Mr. Michael Smith of Vermont WMD to Mr. Ameddia Perry of Heindel & Noyes.

[11] 12/31/2001 Letter from Mr. Timothy Raymond of Vermont Water Supply Division to James O'Gorman, Pittsford Town Manager.

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Acetone and Isopropanol

Acetone and isopropanol (isopropyl alcohol) were detected in some tailings product samples. It has been determined that isopropanol originated as an impurity in the dispersant chemical that Omya uses to keep the calcium carbonate in aqueous suspension during its fine milling process. Acetone is also an impurity in the dispersant, and may also originate naturally.

Acetone has been detected in the tailings pore water samples, indicating its presence in the tailings stream. Acetone has been detected three times in groundwater at the site, out of 89 on-site groundwater samples. The three detections of acetone are all from well B during the year 2001. The first time the well was sampled on March 30, 2001, acetone was tentatively detected at 780 ppb as an unidentified peak. Subsequently, EPA method 8260B was used for laboratory analysis in order to accurately measure acetone. Two following tests, on May 15 and July 26, 2001, detected acetone at 489 and 85.3 ppb respectively, within the 700 ppb Vermont Groundwater Enforcement Standard. Acetone has not been detected in that well, or at any other location at the site, since July 2001.

Following the detections of acetone in well B, Omya conducted an investigation to determine the source of the acetone. It has been determined that acetone originated in a dispersant chemical that Omya uses to keep the calcium carbonate in aqueous suspension during its fine milling process. The acetone, which exists as an impurity in the dispersant, entered the Dogleg Quarry in the washwater stream from the mill (the Dogleg Quarry – part of the Loveland Quarry – no longer is used for the purpose of recirculating mill washwater). From there, it would enter the flotation system, as Dogleg Quarry water was reused for flotation. The acetone then would flow either to the Dolomite Quarry, or to the settling cells via the flotation tailings discharge. From the settling cells, it would enter the tailings management area along with the dredged tailings solids.

To reduce the chances of releasing acetone, OMYA has implemented changes to the process water circulation system. Most of the washwater from the mill has been redirected so it is used in the plant to make the final slurry product. This step significantly reduced the acetone entering the water circulation system, which ultimately has resulted in the lack of any detectable acetone in groundwater at the site since July 2001. Seventeen tests from well B between May of 2002 and April of 2006 have shown no detectable acetone. No acetone has been detected in any of the other on-site or off-site wells out of a combined total of 117 samples. Likewise, no acetone has been detected in any of the 21 surface water samples from the area.

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As specified in section 12-706 of the Vermont Groundwater Protection Rule and Strategy (1/27/2005), the 95% confidence level statistic should be calculated to determine whether a groundwater standard has been exceeded. As indicated by the 95% confidence level from well B of 161 ppb (as of October 2005), acetone levels in groundwater are within the 0.700 ppm Vermont Groundwater Enforcement Standard. Acetone has not been detected in any other well or in surface water; isopropanol has not been detected in groundwater or in surface water at the site or in the off-site locations.

Stearic Acid

Stearic acid is not used in the flotation process; however, it is added at low levels (typically <1%) to dry calcium carbonate products in the production process after the flotation process and other steps. Infrequently in the past, product batches that failed Omya's quality control tests were deposited in the tailings management area. This practice of disposal has been discontinued. Stearic acid has been found only sporadically in samples of the tailings solids, and has not been detected in tests of the leachate. Therefore, stearic acid is not expected to be involved in the tailings product in the future. Because stearic acid is a Generally Recognized as Safe ("GRAS") food ingredient by the US FDA, it poses no risk to public health. Stearic acid does not enter groundwater or surface water due to its tendency to bind to the tailings solids.

Methyl Isothiocyanate

Methyl Isothiocyanate (MITC) is one of two breakdown products formed from the thione preservative used by Omya. MITC is formed rapidly when the thione (Dazomet) preservative contacts water. Health and environmental effects of MITC include eye and skin irritation, and toxic effects related to the nervous system, liver, and testes. MITC is not considered carcinogenic, teratogenic, or mutagenic.[12] MITC is not regulated in Vermont or by the Safe Drinking Water Act; it is on the EPA's list of extremely hazardous substances requiring reporting when stored in excess of 500 pounds. MITC biodegrades rapidly and is water soluble.

Groundwater and surface water test results from the site show no detectable levels of MITC (see appendices 5 and 6). The substance is not typically associated with tailings and has only been detected in tailings following an accidental release of thione in 2003. The washwater system has since been modified to prevent the recurrence of a similar release.

[12] Australian Government Publishing Service, 1997. "NRA Special Review of Metham Sodium, Dazomet and Methylisothiocyanate (MITC) Volume II" http://www.apvma.gov.au/chemrev/chemrev.shtml.

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Methylamine

Methylamine (also called monomethylamine) is the other breakdown product formed from the thione preservative used by Omya. Methylamine also is formed from the breakdown of the isothiazolin preservative used by Omya. Methylamine is formed rapidly when the thione (Dazomet brand) or isothiazolin (Kathon brand) preservatives contact water. Groundwater and surface water test results from the site show no detectable levels of methylamine (see appendices 5 and 6). The substance is not typically associated with tailings, and has not been detected in the tailings or pore water.

Free Chlorine

Free chlorine was not detected in the tailings or in the tailings pore water. Free chlorine was investigated because of Omya's use of bleach at the Verpol plant. The presence of low levels of chloroform (1.6 - 14.6 ppb) in the tailings pore water indicates the product of reactions between the free chlorine and organic matter. Low levels of chloroform and other trihalomethanes occasionally have been found in on-site groundwater. The concentrations of chloroform observed in the tailings pore water and groundwater at the site are well below the drinking water standard of 80 ppb total trihalomethanes. No trihalomethanes have been detected in surface water at the site (see appendices 5 and 6).

Dispersant

Certain chemicals used as dispersants in Omya's production process may be able to enter the tailings, although their presence has not been confirmed. Testing methods are not available to detect those substances in their expected concentrations in the tailings and environment. To assume a worst-case scenario, we have evaluated the maximum potential concentrations of those substances in tailings, based on mass balance calculations performed by Omya (confidential information to be provided separately).

The substances of concern from the dispersant are the acetone and isopropanol, which can have adverse health and environmental effects in sufficient concentrations. Those two compounds have been discussed above, and have not been found in concentrations sufficient to cause environmental harm or adverse health effects. However, the dispersant also contains other chemicals, which might become part of the tailings, but that have not been identified by testing. Those other chemicals are phosphoric acid and polyacrylates, neither of which is believed to have adverse health or environmental effects from its presence in tailings. The toxicology memorandum (see appendix 7) describes the nontoxic nature of these chemicals.

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The phosphoric acid is reported to form calcium phosphates, upon contact with the calcium carbonate, which are poorly water-soluble. The phosphoric acid itself cannot positively be identified by a laboratory test. However, phosphorus can be detected positively, and would serve as a tracer. Use of phosphorus testing as a tracer for the tailings would be confounded by the fact that other phosphorus sources exist, including natural minerals, septic systems, and agriculture. Natural levels of phosphorus in the eastern United States range from <20 to 6,800 ppm, averaging 200 ppm.[13] In the tailings, phosphorus may be present at a concentration of no more than 3.7 ppm, according to Omya's mass balance calculations (confidential information to be provided separately).. Compared to the background range, the addition of 3.7 ppm of phosphorus in tailings is not a significant change.

Phosphoric acid is a Generally Recognized as Safe (GRAS) food ingredient, and the calcium phosphate poses no environmental or health risk. Phosphorus is not considered a health hazard. Ecologically, phosphorus is considered a pollutant to surface waters because it is a plant nutrient; excessive levels of phosphorus can contribute to eutrophication and algae blooms. However, the calcium phosphate in the tailings would not threaten to cause eutrophication because it is not water-soluble, and will remain with the tailings.

The other components of the dispersants are the polyacrylates. These molecules are large polymers that cannot be detected by any available methods, in the expected environmental concentrations. Mass balance calculations provided by Omya show that based on dispersant usage, there should be no more than 68.8 ppm of polyacrylates in the tailings (confidential information to be provided separately). That concentration is expected to decrease, as the carbonate slurry recovery efficiency improves. The polyacrylates are nontoxic[14] and thus do not pose a health or environmental risk.

Flocculant

The flocculant is an anionic polyacrylamide, and contains less than 500 ppm of residual monoacrylamides. The anionic (negatively charged) flocculant is used because it binds to the cationic (positively charged) carbonate particles. Flocculant is not likely to enter tailings, because it is used "downstream" from the flotation process; once added to the process, the flocculant should leave the plant as part of the final product. However, because Omya recycles its process water, some flocculant may remain in the process water, and thus could come into contact with the tailings. To assume the worst-case, Omya's mass balance calculations indicated that typically 0.59 ppm of polyacrylamides, and 0.003 ppm of monoacrylamides, could be present in the tailings pore water. Testing for the monoacrylamides has confirmed the mass balance prediction, as the

[13] Shacklette, H.T., and Boerngen, J.G., 1984. "Element Concentrations in Soils and Other Surficial Materials of the Coterminous United States" U.S. Geological Survey Professional Paper 1270.

[14] Refer to 9/22/2004 memorandum from toxicologist Robert Matthews (see appendix 7)

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maximum level of monoacrylamides detected in the tailings pore water of 0.0037 ppm is in-line with the mass balance figure.

The polyacrylamide, which is the primary ingredient of the flocculant, is not known to have any significant health or environmental risks, and is commonly added to drinking water systems for use as a flocculant. However, the acrylamide monomer, which the manufacturer has reported may be present in the flocculant at less than 500 ppm, is of concern. Acrylamide is listed by the EPA as a probable human carcinogen. Acrylamide also has acute and chronic (noncancer) toxic effects. Based on the EPA's study of the health risks associated with acrylamide, it has set 0.5 ppb (0.0005 ppm) as the maximum acceptable level in drinking water. The EPA regulates the acrylamide monomer under the Safe Drinking Water Act because flocculants commonly are used in public drinking water systems to remove solids and reduce turbidity. Acrylamide monomer concentrations are enforced by regulating the use of flocculants in water systems.[15]

The acrylamide monomer is water-soluble and thus is not expected to partition onto the tailings. However, it is reported to biodegrade rapidly in the environment both aerobically and anaerobically. Aerobically, half-lives of 18 to 45 hours have been reported for moist soils (not unlike the tailings), and similar breakdown rates have been reported for river water; anaerobic degradation rates of up to 55% have been measured in experiments over a two-week test period[16]. Therefore, any acrylamide that might exist in the tailings would not be expected to persist in the environment. While actual rates of degradation may be slower in the tailings management areas than under laboratory conditions, nonetheless acrylamide has not been detectable in groundwater or surface water at or near the site; all 53 groundwater samples and 15 surface water samples to date have shown it to be non-detectable (detection limit of 0.0005 mg/L).

The polyacrylamides in the flocculant, in contrast, bind to the carbonate product. This flocculant is used because it is anionic (negatively charged), and thus binds to the cationic (positively charged) carbonate particles. Most of the polyacrylamides used in Omya's process are thus expected to leave the plant in the final product, bound to the carbonate. Mass balance calculations indicate that a flocculant concentration of 0.59 ppm or less exists in the process water, which could contact the tailings.

[15] US EPA, 11/26/2002. EPA Website, Office of Water, Groundwater and Drinking Water. www.epa.gov/safewater/dwh/c-voc/acrylami.html

[16] National Library of Medicine, National Institute of Health, 2006, TOXNET Hazardous Substances Databank of Toxicology and Environmental Information. http://toxnet.nlm.nih.gov

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Concerning the potential hazards of the flocculant used at Omya, the flocculant levels in the tailings will pose no toxicological risk. The MSDS sheet[17] states that it is not expected to be harmful by ingestion or inhalation. No test method is available to detect the polyacrylamide flocculent in the tailings. However, because it is not toxic and is added to drinking water systems, the expected 0.59 ppm concentrations are not considered harmful. Refer to the toxicology memorandum in appendix 7 for further explanation of the polyacrylamides.

Testing has been performed for the acrylamide monomer in the tailings, leachate, groundwater, and surface water at the site. Acrylamide levels are 0.0058 ppm or less in the tailings solids, 0.0037 ppm in tailings pore water, and no acrylamide has been detected in groundwater or surface water (see appendices 4, 5, and 6).

Tailings Evaluation Summary

Tailings consist primarily of minerals, which comprise approximately 99.6% of the mass. Minerals in the tailings include calcium carbonate and naturally occurring mineral impurities. The non-mineral components of the tailings are found in varying concentrations. To provide the greatest factor of safely, we have selected the highest end of the ranges of concentration for each of these components as the "design concentration" of the tailings. As discussed above, the design concentrations of the non-mineral components of the tailings do not pose a risk to public health or the environment.

D. Results of Testing Old Tailings Product

Tailings Physical Parameters: The percent solids of the tailings was consistent over the depth profiles within each core boring. However, the south end of the Dolomite quarry had a lower solids content than the other two sites, most likely because tailings enter the quarry at that end to be settled. Solids contents in the Kane & Drake TMA ranged from 81.6% to 85%. In the Dolomite Quarry, solids contents ranged from 76.8% to 79.8% at the south end and from 84.7% to 88.8% at the north end (see page 17 of appendix 3 for results).

Tailings Chemical Parameters: Generally, the concentrations of chemicals within the tailings decreased with greater depth below the surface. Of all the tested chemicals, only flotation reagent, OPP, and toluene were found in any of the core samples.

The TGA results indicate that generally chemical concentrations were highest near the surface, and decreased with depth. Total chemical loads dropped roughly in half from about 0.4% near the surface to about 0.2% at the bottom of the coreholes. The graph on page 18 of appendix 3 shows the results.

[17] Cytec, 10/29/1998. "MSDS No. 6913: Superfloc A-130 Flocculant"

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The flotation reagent testing showed a similar pattern as for total chemical load: decreasing concentration with depth. See graph, page 19 of appendix 3. The exception was the Dolomite Quarry south corehole, where the flotation reagent concentration was highest at 36 to 40 feet deep. In concert with the TGA and bacterial test data from that core sample, the flotation reagent data suggest decreased biodegradation at that depth.

Bacteria test data are summarized in the graph on page 20 of appendix 3 (pages 21 – 44 tabulate the bacterial data). Aerobic bacteria were found in high concentrations, while anaerobic bacteria were present in relatively much lower amounts. The bacterial abundance results indicate a close correlation of the microbe population with the flotation reagent and total chemical load data. The highest levels of aerobic bacteria were in the surface samples, and the lowest levels were found at depth. Comparing the bacteria data to the chemical data, it appears that bacterial levels decrease with depth, due to lower amounts of organic chemicals and oxygen from which the bacteria can obtain energy.

Note that flotation reagent was the only tailings component that was found in all corehole samples. Toluene was found in one location only (46.2 ppb at 28-32 feet in the Kane and Drake TMA), and ortho-phenylphenol (OPP) was found in one other location only (1360 ppb at 4-8 feet in the north end of the Dolomite Quarry). These results affirm that most of the tailings components identified in Table 7 are normally non-detectable in the tailings; the design concentrations presented in the table are worst-case levels that are not typical of the old or new tailings.

<u>Pore Vapor Results:</u> The data (page 45 of appendix 3) from each of the three test locations show a decrease in oxygen and an increase in carbon dioxide and methane, compared to background (atmospheric) levels, indicating aerobic activity. In concert with the chemical data and the measured bacterial populations, the pore vapor data show that biologic activity in the tailings stockpile is likely causing biodegradation of the chemical compounds associated with the tailings.

<u>Discussion:</u> Noting that the deeper samples generally contain lower amounts of chemicals than the shallow samples, it appears that biodegradation has been occurring in the tailings. Testing of tailings from different depths indicates that chemical concentrations generally decrease with depth. Total chemical concentrations at the bottoms of the tailings stockpiles were about one-half the amounts at the top of the sites. Corresponding trends in aerobic bacteria suggest that aerobic biodegradation occurs in the tailings. Anaerobic bacteria were not found in high levels, suggesting that aerobic biodegradation is the primary form of biologic activity.

Flotation reagent levels appear to be decreased by the biologic activity in the tailings stockpiles. Although acetone and stearic acid have been found in tailings from the settling cells and surface tailings samples, these compounds were not found in any of the deeper (older) tailings core samples, suggesting that they are rapidly biodegraded.

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V. SITE DESCRIPTION

A. Topography

The Omya Verpol plant is located in a shallow, north-facing valley on the western edge of the larger Otter Creek valley which runs from south-to-north. A north-to south running ridge is located west of the plant and the TMAs, with a summit near 600 feet in elevation. The west side of this ridge drops steeply to a narrow valley, beyond this valley much larger hills rise to the west, reaching 1200 feet. A low ridge east of the plant and TMAs crests at about 560 feet above sea level. East of this low ridge, topography drops to the lowlands and floodplain along the Otter Creek, which flows north. At the plant, which is at an elevation of 500 to 520 feet, the land surface slopes gently north. Northwest of the plant are wetlands in the mouth of the narrow valley. South of the plant and TMAs, topography is uneven and rolling. USGS topographic maps are provided on pages 1 and 3 of appendix 1.

B. Surficial Geology

Surficial materials vary between the upper locations at the plant site, and the valleys on the northwest and east. Surficial mapping is shown on pages 7-8 of appendix 1. At the sites of the TMAs, thin layers of glacial till cover bedrock, and, at many locations, the bedrock surface is exposed. Drilling logs from the bedrock monitor wells at the site indicate till thicknesses from 1 to 3 feet in the area surrounding the TMAs. In the valley to the northwest of the plant site, gravel wells have been drilled into a confined aquifer that is covered by 60 to 70 feet of clay, peat, and silty clay. The confined gravel aquifers are underlain by glacial till. To the east of the plant, in the lowlands across West Creek road, surficial materials consist of silt and clay covering deep deposits of gravel. The Pittsford-Florence Water District wells are drilled 110 feet deep into the gravel beneath layer of clay. The gravel aquifer at these wells is primarily recharged by the Otter Creek, which cuts through the clay layer.

The glacial till at the plant site and beneath the gravel aquifers was deposited during glaciation. Later, as glaciers began to melt, the gravel was deposited in the low areas by the glacial meltwater that flowed through the valleys. Next, as the meltwater rivers were dammed by ice to the north, glacial lakes developed, the valleys around the Verpol plant were submerged, and the clays and silty clays settled out of the lakewater, accumulating on top of the gravel. The higher terrain at the plant site was above the level of the lakes and therefore did not receive any gravel, clay, and silt from the meltwater and glacial lakes. East of the plant property, the modern Otter Creek has deposited recent alluvial materials, consisting of silt, in its floodplain over the older clay and gravel deposits.

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C. Bedrock Geology

The bedrock formations at the Verpol plant site have been characterized in detail because of the use of the site for bedrock mining and through extensive hydrogeologic study. Bedrock mapping is shown on pages 5-6 of appendix 1.

Carbonate bedrock with karst features underlies the site, and fractures run in a north-northwest to south-southeast orientation, nearly parallel with the valley. Bedrock consists of closely related carbonates: dolomite, limestone, and marble. Directly beneath the plant and the TMAs, the Ordovician-age Shelburne Limestone formation has been identified. To the east, the Cambrian-age Clarendon Springs Dolomite and Danby Dolomites are identified.

The bedrock geologic mapping shows the north-northwest to south-southeast orientation of the contacts between the rock formations. These contacts have been shown to be zones for primary fracturing and movement of bedrock groundwater. For example, well#2 was reported to be hydrogeologically connected with two now-abandoned wells located 600' and 1500' to the north-northwest.[18] Pump-testing showed a connection between the wells. All three of these wells had apparently tapped into solution voids (karst features) that contained clay minerals, as evidenced by heavy sediment loads in the well water. The presence of the karst formations indicates that significant erosion and dissolution of the rock material by groundwater had occurred along the primary fracture zone.

The site appears to be located along a northward-plunging syncline. Secondary folds within the syncline appear to form the south-to-north bedrock ridges bounding the site on the east and west sides. Rock outcrops indicate a consistent north-to-south alignment of the strike of the formations. The bedrock at the outcrops was observed to dip eastward at about 70 degrees from horizontal. Bedding plane fractures are observable running in the same plane as the formation.

A fracture trace analysis was performed, which supported the determination of a north-northwest to south-southeast orientation of the rock structure. Fracture trace lineations indicate a primary orientation of bedrock structural features in this direction, parallel with the mapped rock formation contacts. Fewer bedrock fractures exist in the transverse direction, running from east to west. (See bedrock geologic map, page 5 of appendix 1).

Bedrock cross-sections have been developed based on the results of the bedrock well drilling on site. See pages 14-17 of appendix 1.

[18] 1/7/1997 Geomapping Associates Report "Verpol Plant Process Water Supply Groundwater Source Development Phase I Evaluation"

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D. Groundwater Location and Flow Direction

<u>Groundwater Conditions and Location</u>
The groundwater at the TMAs and Omya's Verpol plant property is designated as Class III.

At the Omya Verpol plant, groundwater is primarily located in the bedrock aquifer. Overburden soils are very thin (typically less than 3 – 5 feet deep) in and around the TMAs, and thus do not contain significant groundwater. The fractured marble, limestone, and dolomite bedrock contain an interconnected network of water-bearing fractures.

The groundwater flow system at the Omya Verpol facility measures 252± acres (see map, page 1 of appendix 8 showing the groundwater "Flow System Boundary"). The flow system is bounded by groundwater divides to the east, south, and west, which are formed by topographic divides. To the north, the flow system most likely ends at its main discharge zone along the Smith Pond Tributary.

Groundwater originates as recharge in the terrain throughout most of the flow system. Soils covering bedrock are thin glacial till, allowing precipitation to recharge the bedrock groundwater readily (approximately 12 inches of recharge per year). Of the 14 bedrock wells at the site, only well E, near the northern end of the flow system, displays an artesian overflow indicating that it is located in a discharge area, rather than a recharge zone.

Yields of bedrock wells at the site range from 0.25 gallons per minute (gpm) in well I, to 70 gpm in abandoned supply well #1. However, well I is not typical of the site, as it was drilled in an upgradient location where the marble is so competent (unfractured) that Omya had even considered quarrying. The higher-yielding bedrock wells have been abandoned due to sediment problems. The highest-yielding bedrock well that was not abandoned is well #5, which has a yield of 25 gpm as reported by the driller. Even this well produced silty water when pumped at rates above 20 gpm, although at lower production rates it produces silt-free water. The sediment and silt that has been found in well #2 (50 gpm driller's reported yield), for example, indicates the presence of weathered bedrock and karst formations; the sediment is the result of the dissolution and erosion of the bedrock matrix.

Well completion reports for the 14 on-site bedrock wells, two on-site gravel wells, four abandoned on-site wells, and surrounding off-site wells are included in appendix 2, pages 2 – 34. A summary of well statistics is on page 1 of appendix 2.

Well records indicate that, aside from the karst solution cavities along the rock contact running through the center of the site, yields are modest and rock fractures are not very extensive or well developed.

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Well-bore video records indicate the specific depths and locations of rock fractures and other features (see appendix 2, pages 35-44). Water-bearing fractures have been found between depths of 22 and 420 feet below grade. With the deepest well on site (96-2) having been drilled to 590 feet below grade, there do not appear to be significant numbers of water-bearing fractures below the 420-foot depth, which corresponds to an elevation of 115 feet above sea level. See page 45 of appendix 2 for a tabulation of the depths and elevations of the water-bearing fractures identified in on-site wells. In the on-site wells, most of the water-bearing fractures were encountered between 50 and 250 feet below grade.

Water levels in the bedrock wells range from 40 – 50 feet below grade in the upgradient end of the flow system at wells B and 96-1, to overflowing by artesian pressure at the northern (downgradient) end, at well E. Refer to the table on pages 46 - 47 of appendix 2 for water level and elevation data.

Water elevations in the rock aquifer fluctuate by varying degrees, depending on the location. In the upgradient end of the flow system, water levels fluctuate by 15 to twenty feet from dry to wet times of year. In contrast, downgradient wells demonstrate only a few feet of water level change. The difference is because the water levels at the upgradient zones are directly influenced by the volume recharge water; no other source of water besides recharge from rainfall and snowmelt exists; whereas at the downgradient zones, there is a steady supply of groundwater flowing from the upgradient regions to moderate any seasonal fluctuations in recharge throughout the watershed.

Well Pump Testing Results

From the pumping tests conducted on wells C-2, G, H, 2, and 5, aquifer properties were measured and the primary axis of flow in the rock aquifer was observed. Appendix 4 contains the results of the pumping tests.

As summarized on page 1 of appendix 4, a total of 17 measurements of aquifer transmissivity were made from the well tests, based on drawdown and recovery data, including pumping and responding observation wells. Transmissivity values ranged from 3.2 ft^2/day to 249.6 ft^2/day, averaging 55.2 ft^2/day. This range of values is typical for fractured carbonate bedrock, with the low values reflecting areas where small or few fractures were encountered, and the rock matrix has a greater influence on hydrology; and the high end of the range reflecting the larger fracture networks.

Storativity values cannot be calculated from a production well and must be measured from a responding observation well. As shown in appendix 4, there were 5 instances in which an observation well responded to the pumping of a production well. Hence 5 measurements of storativity were made, ranging from 6.5×10^{-6} to 5.54×10^{-4}, which is typical of this rock type.

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Permeability values ranged from 0.01 ft/day to 1.42 ft/day, averaging 0.35 ft/day. Like the transmissivity figures, these values were calculated over the entire aquifer thickness, thus reflecting the combined influence of the low-permeability rock mass and the density of the high-permeability fractures at this site.

Drawdown plots from the pump testing were typical of a radial flow pattern developing under pumping conditions (straight-line slope on semi-log plot), and did not show the characteristic curve that would indicate linear flow, which occurs when a single discreet fracture is controlling. This pattern indicates that the fracture network is well-interconnected; hence when a well is actively pumped it draws groundwater from a three-dimensional web of connected rock fractures. This condition is not to be confused with the natural groundwater flow pattern which exists when a well is not pumped at a high rate for an extended period of time. During non-pumping conditions, water flows through the network of fractures in the path of least resistance, which at this site is to the north-northwest, because of the orientation of the dominant fracture fabric.

Observations of responding wells showed that flow in the fracture networks occurred primarily along a north-to-south and a northwest-to-southeast axis.

- Pumping of well C-2 appears to have affected well C, located to the northwest. Well C water levels declined during the pumping test, indicating a likely drawdown impact. Well C did not recover following the test, which would have affirmed that the drawdown was due to the pump test and not due to natural summertime lowering of water levels. However, the absence of a recovery is most likely because the subsequent well H test also affected well C. Therefore the behavior of well C is most likely a response to the pump test.
- Pumping of well H possibly affected well C, located to the south. Water levels in well C declined more steeply during the well H pump test than prior to the test, and recovered following the test.
- Pumping of well H affected well G, located to the northwest. Water levels in well G clearly experienced drawdown and recovery in sync with the pumping of well H.
- Pumping of well G affected well H, located to the southeast. After having recovered from its own pump test, well H water levels clearly experienced drawdown and recovery in sync with the pumping of well G.
- Pumping of well G appears to have affected well C, located to the south. Water levels in well C had been recovering from the well H pump test, but once the well G test began, they stopped recovering without attaining the previously established static level, and then resumed recovery after the well G test had ended, suggesting an effect. Because the well C water levels did not actually draw down during the test, it was not possible to measure aquifer coefficients. However, the data suggest qualitatively that an effect occurred along the north-to-south axis.

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- Pumping of well 5 affected well H, located to the southeast. Although well H did not affect well 5, normally a well's zone of influence extends farther upgradient (i.e. from well 5 to well H) than downgradient (i.e. from well H to well 5).

Well I, located upgradient (south) of the TMAs is drilled into bedrock that is typical of the site, as indicated by the other 13 wells. The well has an extremely low yield and does not appear to be connected to an extensive fracture system. Bedrock at this location was very solid, competent marble without significant fracturing. For this reason and because the well is near a groundwater divide, very little groundwater flows through this area. After the well was drilled on July 20 2005, water levels began to gradually rebound from the drilling. A full month later, water levels in well I were still rebounding, having only risen by 186 feet in a month. While pumping tests were being conducted on wells C-2, G, H, and 5, well I was still in rebound and therefore it did not indicate any interference from the test pumping. Due to the slow, steady seepage of water into well I, it is clear that the groundwater at this well is controlled by the rock matrix.

From the rate of water level rise into well I, an inflow rate of 0.006 gpm was measured. Analyzing the recovery from drilling based on the 0.006 gpm flow rate, a transmissivity of 3.9 x 10^{-6} ft/day was estimated, which pertains to the unfractured rock at the site. See pages 107-108 of appendix 4.

Flow Direction

Water level measurements were obtained in the network of bedrock wells and quarries at the site and were used to develop groundwater contour maps to indicate the direction of flow in the aquifer. Wells #2, #5, 96-1, 96-2, A, B, C, D, E, F, C-2, G, H, and I, have been measured to determine the aquifer potentiometric surface. Additionally, the water surfaces in the Dolomite, Dogleg, and Pittsford-Italian Quarries were measured when a free water surface was present (due to tailings placement in the Dolomite Quarry, this no longer can be done).

A typical groundwater contour pattern is shown on the bedrock geologic map, page 5 of appendix 1. The map shows that the groundwater contours form a trough, funneling groundwater from the vicinity of the TMAs into the central portion of the Omya property, from where groundwater flows in a north-to-northwest direction. This map is based on data collected during November 2003 following a period of average rainfall; similar patterns have been measured in a wet spring (May 2001) and summer drought (July 2001), indicating the consistency of the flow pattern through different hydrologic conditions. Pages 9-13A of appendix 1 show groundwater contour maps from March 2001, May 2001, July 2001, October 2002, June 2005, and October 2005 and all show the same general pattern of groundwater flow. Between the upgradient wells in the south and downgradient wells in the north, the change in the water surface elevation is considerable, equal to approximately 90 feet.

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On all occasions when groundwater flow has been measured, the flow direction in the bedrock groundwater from the vicinity of the TMAs has been to the north-northwest, consistent with the strike of the rock formations, with the primary fracture trace orientation, and with the shape of the localized valley in which the plant is located (following the apparent plunge of the syncline). These alignments are consistent with the belief that the shallow valley at the plant is a northern-plunging syncline. As a principal bedrock structural feature, it is significant in local hydrology.

<u>Aquifer Discharge Locations</u>

The north-northwest flowing bedrock groundwater likely discharges to the unnamed tributary to Smith Pond, north of the Verpol plant, and into the wetlands feeding that tributary, northwest of the plant (see USGS map, page 3 of appendix 1). Because the Smith Pond tributary is located in the regional low point, it is the expected groundwater discharge area for the aquifer. Beyond the tributary, the ground slopes uphill considerably, and therefore it is unlikely that groundwater flows beyond the tributary to the north.

The Hendee spring, to the east of the processing plant, is a local groundwater discharge zone which intercepts a small portion of the groundwater from the Omya property. Some groundwater discharge may also collect in the swale near well E. A complete reconnaissance of the site did not indicate any other likely groundwater discharge areas (as would be indicated by seeps, springs, or surface waters).

<u>Hendee Spring Groundwater Discharge Location</u>

The Hendee spring is a swampy area located to the east of bedrock well A, at the head of an eastward trending valley which contains the "Post Office Swale". Although no classic "spring" exists with groundwater bubbling to the ground, the area is reported to remain wet regardless of weather conditions. Geochemical testing conducted at the spring indicates that the water is typical of groundwater. See pages 1-3 of appendix 6 for data. The tributary to Smith Pond (station SP-2) was also sampled for comparison to surface water/runoff; this tributary has a larger watershed and thus comprises mostly runoff and surface water. Relatively elevated levels of minerals and gross alpha radioactivity in the Hendee Spring water, compared to the Smith Pond tributary sample, are indicative of deep bedrock water sources. The elevated calcium, magnesium, and sulfate levels in particular show that the Hendee spring water has been in contact with the dolomite rock.

The Hendee spring water is at least one year old, and may be as many as twelve years old. Analysis of tritium, an unstable isotope of hydrogen that forms in the atmosphere, was performed to determine the age of the water. Tritium is naturally formed in the atmosphere at a level of about 5 tritium units (TU). Additional tritium was formed from above-ground nuclear weapons testing during the 1950s and 1960s; tritium levels peaked in 1964 at 6000± TU, and have been decreasing since then. Knowing the half-life of tritium, the initial concentration in the atmosphere, and the tritium content of the Hendee spring, the age of the water can be estimated. Due to the changing atmospheric levels of tritium, the age cannot be determined precisely; the Hendee spring sample from 2003 could have resulted from precipitation from 2002, which had been underground for one year; precipitation from 1999, which had been underground for four years; precipitation from 1997, which had been underground for six years; or, precipitation from 1991, which had been underground for twelve years. See pages 4-5 of appendix 6 for data and calculations. At a minimum level of certainty, it can be stated that the Hendee spring water is at least one year old.

The north-northwest trending ridge bordering the site to the east appears to function as a groundwater flow divide because it is a bedrock structural feature aligned with the formation and fracture strike. The Hendee spring appears as a wet area on the USGS map in a notch that cuts eastward through the ridge; a fracture trace lineation cuts through this notch in an east-to-west direction. Based on the fact that the water surface at the Verpol plant does not slope east towards the Hendee spring but slopes perpendicular to it (north-northwest), there does not appear to be a significant flow from the aquifer towards the spring. North of the spring, the water elevations continue to slope to the north.

While groundwater flows predominantly to the north-northwest as controlled by the fracture network, a small portion (3% to 6%, discussed below) of the flow discharges to the surface at the Hendee Spring because of the topographic low point at that location. The groundwater may be surfacing there because it cannot flow eastward, due to the north-to-south orientation of the rock fractures.

Streamflow gauging conducted at the Hendee Spring (station PO-5) and the four downstream stations along the Post Office Swale indicated a groundwater discharge rate of 5 to 7 gpm at the spring during the summer of 2005. See pages 6 - 27 of appendix 6 for flow gauging data.

Smith Pond Tributary Groundwater Discharge Locations

Two clusters of piezometers installed near the Smith Pond tributary indicated an upwards gradient from the shallow to deep piezometer, confirming groundwater discharge in this location. See page 48 - 49 of appendix 2 for piezometer data.

Streamflow gauging along the Smith Pond Tributary indicated an absence of groundwater discharge in the reach of the stream upstream from station SP-2, but confirmed groundwater discharge between SP-2 (north of the downgradient wells) and Smith Pond. Additional groundwater discharge may occur beneath the pond; however this was not field-quantifiable. Also, groundwater discharge likely occurs in the swampy areas west of well 96-2, leading into the Smith Pond tributary upstream of station SP-1; this flow rate could not be measured because flow gauging is not feasible in the swampy location where there is no measurable current or defined channel.

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Between stations SP-2 and SP-3, a 52-gpm increase in streamflow was measured on July 13, 2005, corresponding to the groundwater discharge rate to that portion of the stream (see pages 28-34 of appendix 6). As the stream is in a valley, it is likely that groundwater discharge originates from both sides of the stream, hence approximately ½ of the measured discharge (26 gpm) is attributed to the groundwater flow system from the Omya site and the other portion likely originates from the north of the stream.

A minor seepage point was observed at the base of the Kane and Drake TMA (see "seep 1", shown on the site map). The seep likely represents localized groundwater discharge at the base of the hill.

Other Discharge Locations

Other springs exist in the general vicinity of the site, including the Fox Rock spring, a bedrock spring on the opposite (west) side of the hill from the Kane and Drake TMA, and springs on the Orvis and Chrusciel properties to the north and east of the plant site. These springs are all located at the base of steep hills, where the water table is forced to the ground surface by the change in slope.

The swale near well E is part of Omya's permitted discharge system, and may collect some groundwater discharge. Well E has an artesian flow rate, indicating a groundwater discharge condition exists in that area, provided that fractures connect to the shallow environment.

Groundwater Flow Rates

A water balance performed for the entire 252± – acre flow system indicates an annual average groundwater discharge rate of 156 gpm based on recharge rates. A second calculation suggests a comparable rate of 122 gpm based on the permeability measured from pump testing, the gradient measured from the June 27, 2005 water level contours, and depth and width of the flow system. See calculations, pages 50 – 51 of appendix 2. Note that the calculated rate for the entire flow system is not only approximate because it is based on assumed recharge rates, it also is an annual average. In contrast, the measured flow rates were made specifically in the month of July, when flows are at their yearly lowest point. Therefore it is expected that rates of groundwater discharging to the tributary in July of 2005 would be less than the annual average groundwater discharge rate. The fact that the measured flow rates are lower than the estimated annual rates, within an order of magnitude, indicates that the calculations of annual average groundwater discharge are reasonable.

The fact that the measured discharge rates are lower than the estimated groundwater discharge rate also suggests that additional groundwater discharge may occur at the Pittsford-Italian Quarry (water pumped into the Verpol plant), and at the identified discharge locations on the northwest portion of the flow system and the swale near well

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E (flow was not measured in these areas because the diffuse flow of the swampy areas is not amenable to standard gauging procedures).

Flow gauging along the discharge points reveals a groundwater discharge rate of 5 to 7 gallons per minute (gpm) at the Hendee Spring, and approximately 26 gpm to the Smith Pond tributary north of the Verpol plant, as discussed above These flow rates, measured during July of 2005, represent seasonally low groundwater flow conditions. These summertime discharges at the Hendee spring represent 3% to 6% of the regional groundwater flow rate through the site.

Bedrock-Gravel Aquifer Separation

The bedrock aquifer at the plant is not hydraulically connected with the gravel aquifer where Omya's two gravel wells are located, or with the gravel aquifer along Otter Creek where the Pittsford-Florence Water District wells are located[19].

A pumping test was performed to assess the connection between the confined gravel aquifer, where Omya's two gravel wells are located, and the bedrock aquifer at the plant site. This test was conducted between May 8 and May 10, 2001, with the gravel wells operating at the constant rate of 66 gallons per minute, which is the normal production rate of the wells. Monitoring was conducted using automatic dataloggers in bedrock wells A, B, and C, which surround the tailings stockpiles and quarries.

Monitoring results from the pumping test show that the bedrock aquifer at the plant site is not connected to the gravel aquifer. The three bedrock wells did not respond to the pumping of the gravel wells. Well B, located within the current tailings stockpile area, displayed receding water levels in response to dry weather experienced during the test period. Well C, located adjacent to the Dolomite Quarry, also displayed a receding water level in response to the dry weather following the snowmelt. The recession rate was constant prior to, during, and after the pumping period, indicating no connection to the gravel wells. Well A, located in the center of the Omya plant site, displayed a gradually rising water level before, during, and after the test. Water levels rose in well A because it is located downgradient from the other two wells, where the lag time in response to weather events is longer. Wells B and C already had begun receding following snowmelt while well A still was experiencing recharge. (See data, pages 109 - 110 of appendix 4).

The gravel aquifer which supplies the Pittsford-Florence wells is primarily recharged by the Otter Creek. Pump testing of the public well[20] indicated that drawdown from the operation of the well extended in the opposite direction from the Verpol plant, based on piezometer monitoring. As the public water supply is not located in the direction of

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[19] The Vermont Water Supply Division has stated (letter of 2/21/2003 from Tim Raymond) that the Omya facility and quarries are not located within the zone of groundwater contribution for this public water supply.

[20] Scott Associates, Inc. 12/1/1982 Report Relative to Evaluation of 16-Inch Gravel Well, Pittsford, Vermont

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groundwater flow from the TMAs, there can be no passive groundwater flow from the site to the well, either.

E. Groundwater Geochemistry

The geochemistry of the bedrock groundwater is typical for carbonate bedrock aquifers. The pH is neutral to alkaline, and the water contains significant concentrations of carbonate, alkalinity, and hardness. The anion distribution is typical of bicarbonate-type water, and the cation distribution is typical of calcium-type water (see appendix 5, pages 1-2). Conductivity levels of over 500 umhos/cm^2 indicate a high level of dissolved ions. Molecular sulfur, as detected in wells B and C by laboratory testing, indicates that some portions of the rock contain mineral sulfur from the original sedimentary deposits which metamorphosed into the dolomite and marble rock.

As discussed above, the geochemistry of the Hendee spring is indicative of groundwater from a carbonate bedrock aquifer. Depending on weather conditions, the spring may contain a high proportion of groundwater when runoff and rainfall are low, or the groundwater discharge may be diluted with precipitation and runoff during wetter conditions (see pages 1-3 of appendix 6).

F. Surface Water

The principal surface water body in the vicinity is the Otter Creek, which flows north, located about ½ mile east of the site. Two tributaries to the Creek, the unnamed tributary to Smith Pond, and the “Post Office Swale”, collect groundwater discharge from the plant site. Additionally, Omya’s permitted discharge system includes a swale leading to the Creek from the East Settling Pond.

Surface water in the Post Office Swale originates on the Verpol plant property as groundwater discharge in the Hendee Spring, as well as localized runoff from the notch in which this swale is located. Streamflow gauging conducted at five locations along the swale indicate that it is a gaining stream (collecting groundwater and runoff) from its origin at the Hendee Spring as far as the culvert under West Creek Road, because flow rates in the swale increase heading downstream. From the road crossing to the Otter Creek, the surficial geology and topography change significantly, transitioning from a steep hillside with glacial till soils to a gently sloping alluvial plain. Water from the upper reaches of the swale discharges into the silty and sandy soils along its lower reaches, causing flow rates in the swale to decrease downstream. This pattern was identified during both wet runoff conditions during May of 2004, and during drier conditions in July 2004 and July 2005. Pages 1 – 27 of appendix 6 contain flow gauging data for this location.

Piezometer clusters installed along the tributary to Smith Pond and the Post Office Swale indicated groundwater vertical gradients. Upwards gradients at the Smith Pond tributary indicated discharge of groundwater to the stream; this location is the

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topographic low point in the direction toward which groundwater from the site flows, and thus is most likely the primary groundwater discharge zone. Upwards gradients along the upper reaches of the Post Office Swale also indicate groundwater discharge in this location. Likewise, downward gradients along the swale near West Creek Road indicate the discharge to groundwater, as corroborated by the flow gauging measurements. Piezometer data are shown on pages 48 - 49 of appendix 2. As explained above, about 3% to 6% of the groundwater flow from the site discharges to the Post Office Swale.

VI. CONCEPTUAL MODEL

The Tailings Management Areas consist of low permeability material placed in excavations into the native bedrock. The tailings are primarily (>99%) composed of minerals, consisting of chlorite, plagioclase, feldspar, quartz, mica, and calcium carbonate in general ascending order of composition. The ground minerals have a median grain size comparable to the grain size of silt (see above for detailed description of the tailings). The chemicals used in Omya's process comprise the remaining less than 1% of the tailings, and tend to bind to the minerals in the tailings. The retardation factor of 1,843.2 for TOHI indicates that this substance travels 1,843.2 times slower through the tailings than does water (see appendix 8, page 2 for retardation factor calculations).

Water may seep from the tailings to the bedrock, due to the initial pore water present in the tailings and due to precipitation onto the TMAs. Based on the measured tailings permeability and a worst-case vertical gradient of 100%, the seepage rate from the tailings is calculated by Darcy's law to be no more than 1.02×10^{-2} ft^3 per day, per square foot of TMA. Due to the tendency of the TOHI and other processing compounds to adsorb to the tailings solids, the emission of these substances to groundwater is restricted.

Within the TMAs, biodegradation of the chemical components occurs. Test results from core drilling into the tailings indicates a 50% reduction in chemical concentrations from the recent tailings near the surface, to the 20-25 year old tailings near the base. The observed TOHI biodegradation rate is considerably slower than theoretical biodegradation rates derived from laboratory studies, suggesting that restricted availability of oxygen through the low-permeability tailings has slowed the biodegradation rates.

Water that may be emitted from the TMAs would enter the bedrock, because the bases of the TMAs are on top of bedrock. The bedrock groundwater system at the site consists of an interconnected network of fractures within the limestone, marble, and dolomite bedrock. The groundwater flow system at the TMAs measures 252± acres (see map, page 1 of appendix 8 showing the groundwater "Flow System Boundary"). The flow system is bounded by groundwater divides to the east, south, and west, which are formed by topographic divides. The localized valley at the plant site appears to be a northern-plunging syncline. As a principal bedrock structural feature, the syncline is significant in local hydrology and affects the direction of groundwater flow. Other aquifers in the region, such as the gravel aquifer supplying the Pittsford-Florence water district or the confined gravel aquifer supplying Omya's on-site gravel wells, are not hydraulically connected to the bedrock aquifer at the Verpol plant site.

Pumping tests conducted on wells C-2, G, H, 2, and 5 indicate that the fracture network is well-interconnected. Drawdown patterns in the production wells indicate radial flow patterns which correspond to interconnected fracture systems. Wells affected by the pumping were oriented to the north-northwest, south, and southeast of the production wells. The orientations of the responding wells indicate the axes of the dominant fractures are north-northwest to south-southeast, north to south, and northwest to southeast.

Individual rock fractures, as identified by down-well camera exploration, range from small-aperture cracks (under 1-2 inches in aperture) found in most wells on site, to large karst cavities 5 to 10 feet in aperture (found in wells A and H). In a carbonaceous rock aquifer, the large bedding plane fractures and karst features which may develop along them are typically interconnected by the smaller sheet fractures which cross the bedding planes.

Groundwater originates as recharge in the terrain throughout most of the flow system. Soils covering bedrock are thin glacial till, allowing precipitation to recharge the bedrock groundwater readily (approximately 12 inches of recharge per year). Of the 14 bedrock wells at the site, only well E, near the northern end of the flow system, displays an artesian overflow indicating that it is located in a discharge area, rather than a recharge zone.

Groundwater discharges primarily at the north end of the system into the tributary to Smith Pond and along the northwest side of the flow system, into the wetlands feeding this tributary. A minor groundwater discharge point also exists at the east side of the system where the Hendee spring feeds the "Post Office swale". Some groundwater discharge may also collect in the swale near well E. A thorough reconnaissance of the site did not indicate any other likely groundwater discharge areas.

Groundwater within the flow system at the Verpol plant study area flows to the north-northwest. In response to recharge events, water elevations in the wells fluctuate as much as 15-20 feet (as in upgradient wells B and C); nonetheless the flow direction is steadily maintained in the same north-northwest direction throughout drought, normal, and wet periods. The groundwater flow direction is governed by the local topography, the discharge points, and by the rock structure. The formation contacts, bedding planes, and the dominant fractures (which are bedding plane fractures at this site, as is typical of carbonaceous sedimentary and metasedimentary rock such as dolomite, marble, and limestone) are aligned in the north-northwest direction, as confirmed by fracture trace analysis, geologic mapping, rock outcrops, and pump testing.

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Contaminants such as TOHI may seep from the TMAs at a continuous, gradual rate. Contaminant fate and transport through the bedrock groundwater is determined by the dilution with the existing groundwater flowing through the site, dispersion, and retardation. The low seepage rate from the TMAs is mixed with the groundwater flowing through the bedrock. Contaminants and groundwater are then dispersed laterally and vertically due to the tortuous flowpath which groundwater takes through the fracture network. Retardation of the contaminants occurs within the bedrock due to adsorption to the fracture walls and into the rock matrix, according to the physical properties of the individual contaminants.

Groundwater downgradient from the TMAs and water discharging from the groundwater system at the Hendee spring does not contain detectable levels of contaminants. Monitoring results indicate that the combination of dilution, adsorption and retardation, dispersion, and biodegradation has reduced the levels of any contaminants potentially seeping from the TMAs to below detectable levels.

VII. COMPLIANCE WITH SITING STANDARDS FROM THE VERMONT SOLID WASTE MANAGEMENT REGULATIONS

A. Prohibited Areas

The site is not located within any of the Prohibited Areas (Section 6-502) listed in the Solid Waste Management Rules. Refer to the setback map on page 4 of appendix 1.

1. The Plant site, including the TMAs, is not within the Green Mountain National Forest
2. The Plant site, including the TMAs, is not within a class I or II Groundwater Area.
3. The Plant site, including the TMAs, is not within a class I or II wetland or their buffer zones.
4. The Plant site, including the TMAs, is not within a class III wetland.
5. The Plant site, including the TMAs are not within a National Wildlife Refuge.
6. The Plant site, including the TMAs, is not within a wildlife management area designated by the Vermont Agency of Natural Resources.
7. The Plant site, including the TMAs, is not within a habitat for a threatened or endangered species as designated by the Vermont Agency of Natural Resources.
8. The Plant site, including the TMAs, is not within a watershed for a Class A water.
9. The Plant site, including the TMAs, is not within a floodway of 100-year floodplain.
10. N/A (for diffuse facilities)
11. The Plant site, including the TMAs, is not within 500 feet of any Outstanding Resource Waters.
12. The Plant site, including the TMAs, is not within an approved Public Water Supply Source Protection Area.

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B. General Performance Standard

The TMAs comply with the General Performance Standard from section 6-503(a) of the Rules, which requires that "an emission or discharge from the facility will not unduly harm public health, and will have the least possible reasonable impact on the environment." Compliance with this standard is demonstrated below in two ways: groundwater monitoring results, and a fate and transport model to predict worst-case concentrations of contaminants in groundwater. First, groundwater and surface water monitoring from the site, and off-site, shows that with the TMAs having been in use for roughly 25 years, all groundwater and surface water meets all applicable standards. All tested groundwater at the site is in compliance with Vermont Groundwater Enforcement Standards; contaminants that have no established standard are either non-detectable, or present in levels that have been established as safe for drinking water. No tailings-associated contaminants have been detected off-site. Secondly, the groundwater fate and transport model demonstrates that, even assuming an emission from the TMAs to groundwater, such an event would not result in detectable quantities of contaminants off-site or at compliance points. The modeling results are consistent with the monitoring data from the site.

1. <u>Groundwater and Surface Water Monitoring Results</u>

Groundwater test data have been analyzed in accordance with Vermont's Groundwater Protection Rule and Strategy (2000), which required the statistical calculation of the 95% confidence level ("95% CL") for groundwater results. The 95% CL's for each contaminant were compared to the applicable standard, if one exists. For compounds which are unregulated, the 95% CL's were compared to safe concentrations for drinking water which were determined by an independent toxicologist[21]. For all tailings constituents, the tested concentrations in groundwater were below the safe levels, indicating that the tailings do not pose a risk to health or the environment.

On-site, in the 14 bedrock wells and four surface water locations described above, 163 well sampling events and 15 surface sampling events have been conducted to date. All groundwater and surface water on Omya's site is in compliance with Vermont's Drinking Water Standards, Groundwater Enforcement Standards, and Water Quality Standards, respectively. See Table 9 and Table 10 below for a summary of the test results. Refer to appendix 5 for all groundwater data and appendix 6 for all surface water data. These appendices begin with tabulated data, grouped by location, showing the results from all sampling events at each well, spring, or surface water site. These tables include statistical calculations for all monitored parameters. These tables are followed by additional tables which group all data by contaminant, showing all results for each particular contaminant across all sampling locations.

[21] Refer to the 9/22/2004 Memo from toxicologist Robert A. Matthews, attached as appendix 7.

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Off-site, in the fifteen wells and springs and four surface water locations described above, 34 well sampling events and seven surface sampling events have been performed to date. No contaminants have been found in any off-site drinking water source.

Table 9: Omya Groundwater Testing Summary Through Fall 2005 Sampling Event

Tailings Component	Standard (ppm)	# samples on-site	Highest 95% CL from any well on-site (ppm)	# samples off-site	# detections from all off-site wells/springs	Conclusion
Acetone	0.700 (a)	89	0.161 (well B)	28	0	Within standards
Acrylamide	0.0005 (b)	30	all non-detect	23	0	None detected
Free Cl	4.0 (c)	26	all non-detect	23	0	None detected
THMs**	0.080 (c)	79	0.018 (96-1)	32	0	Within standards
IPA	33 (e)	89	all non-detect	28	0	None detected
Methyl-amine	280 (e)	30	all non-detect	23	0	None detected
MITC	0.018 (e)	30	all non-detect	23	0	None detected
OPP	0.018 (d)	100	0.044 (well 2*)	33	0	None detected following remediation
Stearic Acid	GRAS (f)	100	all non-detect	32	0	None detected
TOHI-based flotation reagent	0.126(d)	148	0.049 (well B)	32	0	Within standards
Toluene	1.000 (a,c)	89	0.007 (well 96-1)	32	1 (0.0016 ppm)	Within standards; only offsite detection is from Chrusciel spring (not a drinking water source)

(a) GES
(b) EPA drinking water standard
(c) VT Drinking Water Standard
(d) VHA level
(e) = No Standard Established; this is the recommended MCL determined by toxicologist Robert Matthews (see appendix 7)
(f) Generally Recognized as Safe by FDA
* OPP was remediated, no OPP has been found in groundwater since July 2001 (ND <0.002 ppm).
**THMs = Trihalomethanes by-products of chlorination, tested by the 8260 and 8260B methods.

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Table 10: Omya Surface Water Testing Summary Through Fall 2005 Sampling Event

Tailings Component	Standard (ppm)	# of surface water samples on- and off-site	Highest Detected Level from any surface water (ppm)	# detections from all surface waters on- and off-site	Conclusion
Acetone	NS	21	all non-detect	0	Not detected in surface waters
Acrylamide	0.0005 (a)	15	all non-detect	0	Not detected in surface waters
Free Cl	0.011 (b)	14	all non-detect	0	Not detected in surface waters
THMs**	0.080 (c)	21	all non-detect	0	Not detected in surface waters
IPA	33 (f)	21	all non-detect	0	Not detected in surface waters
Methyl-amine	280 (f)	14	all non-detect	0	Not detected in surface waters
MITC	0.018 (f)	14	all non-detect	0	Not detected in surface waters
OPP	0.018 (d)	21	all non-detect	0	Not detected in surface waters
Stearic Acid	GRAS (g)	21	all non-detect	0	Not detected in surface waters
TOHI-based flotation reagent	0.126(d)	21	0.0601	1	Within Standards; not detected off-site
Toluene	6.8(e)	21	all non-detect	0	Not detected in surface waters

(a) EPA drinking water standard
(b) Vermont Water Quality Standard – Aquatic Biota Protection, Chronic Exposure
(c) VT Drinking Water Standard
(d) VHA level
(e) Vermont Water Quality Standard – Human Health Protection, Consumption of Water & Organisms
(f) = No Standard Established; this is the recommended MCL determined by toxicologist Robert Matthews (see appendix 7)
(g) Generally Recognized as Safe by FDA
**THMs = Trihalomethanes, which are by-products of chlorination that are tested by the 8260 and 8260B methods.

2. Fate and Transport Modeling

The environmental fate and transport of the TOHI flotation reagent in the bedrock aquifer was modeled. Results and a complete narrative report of a preliminary model are included in appendix 8. In this preliminary model, computer modeling runs were performed individually for the three components of the flotation reagent, based on published physical and chemical properties, and environmental half-lives of the components, and based on the measured groundwater characteristics of the site. Starting concentrations of the reagent, simulating an emission or discharge from the TMAs, were determined from the laboratory leaching tests performed on the tailings (modified TCLP tests performed with a pH 7.8 extractant; see page 12 of appendix 3); the 95% confidence level of the 49 test samples was used as a representative concentration for the preliminary model.

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The preliminary model results indicate that the rates of biodegradation and adsorption are sufficiently rapid, compared to the groundwater transport rate, that the concentrations of flotation reagent components will have decayed to within the Vermont Health Advisory level of 0.126 ppm within 5 feet of the TMAs, and to a zero concentration within 300 feet from the TMAs. At the design management zone boundary (one-third the distance from a TMA to a property line), groundwater will be in compliance with the standards. Therefore an emission or discharge from the facility will not unduly harm public health, and will have the least possible reasonable impact on the environment. Hence, the model results also conform to the liner waiver requirements that the tailings are not the source of leachate harmful to public health and safety or the environment, or that creates nuisance conditions. This modeling prediction is affirmed by the groundwater monitoring data discussed in section 1 above.

Further groundwater modeling has been completed as part of the Interim Certification process. A workplan describing the detailed modeling is presented in appendix 8 following the Fate and Transport Model. The detailed modeling report is included as a separate part of the Interim Certification Application ("Numerical Groundwater Fate and Transport Modeling Report", by Sanborn, Head & Associates, 12/22/2005). This more detailed modeling procedure evaluated not only the typical "base case" scenario using the 95% confidence levels, but also a sensitivity analysis including "worst case" scenarios using the single highest concentrations from the tests of the tailings pore water and leachate. The sensitivity analysis also assumed worst-case hydrologic parameters for the site. As described in the modeling report, the sensitivity analysis as well as the base case showed that groundwater will be in compliance with all applicable standards at the design management zone boundary.

C. Specific Standards

To demonstrate that the TMA facilities meet the General Performance Standard, the following criteria listed in section 6-503(b) are addressed below.

(1) <u>Isolation distances from high seasonal water table, bedrock, and waters;</u>

The distances from the TMAs to seasonal high groundwater, bedrock, and waters have been shown to be sufficient such that any emission or discharge from the facilities has met all applicable environmental quality and public health standards and rules. As documented in section B above, monitoring has shown that, despite the absence of a liner, and thus conceivably emitting or discharging, the TMAs and the quarries into which the tailings product has been deposited have not resulted in any violation of environmental or health standards for groundwater or surface water.

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(2) Isolation distances to public and private drinking water sources;

The nearest public drinking water source is 3100 feet and the nearest private wells (Sandillo and LaFlamme) are 1600 feet from the closest edge of the TMAs; these distances exceed the 1000-foot minimum distance requirement. Although no water supplies exist in the direct groundwater flowpath from the TMAs as far as the identified groundwater discharge location along Smith Pond Tributary (see groundwater contour maps, appendix 1), the closest drinking water supply in the general northwest direction from the TMAs is the O'Keefe private well, which is 2500± feet from the closest TMA, the Loveland Quarry. The VELCO well (1,250± feet) and Omya's gravel wells #1 (1800± feet) and #2 (1500± feet) are closer than the O'Keefe well in the general northwest direction, but are not drinking water supplies. These three wells are all greater than the 1,000-foot distance from the TMAs that would be required if they were drinking water sources.

Monitoring of the public and private drinking water sources nearest to the TMAs has demonstrated no impact from the 25-plus year presence of the TMAs, indicating that an emission or discharge from the facilities does not, and will not, affect drinking water. The monitoring data are confirmed by the fate and transport model; all drinking water sources are greater than 300 feet from the TMAs and thus beyond the point at which flotation reagents are non-detectable.

(3) Isolation distances to property lines, residences, schools, day care facilities, hospitals, and nursing homes

Isolation distances to these features are sufficient to assure that the facility will not (A) result in objectionable odors off the site of the facility; (B) result in unreasonable visual impact off the site of the facility; (C) unreasonably increase the level of noise detectable off the site of the facility; or (D) otherwise adversely affect public health. Unlike municipal solid waste, the tailings product does not emit odors or create unpleasant visual impacts and is not attractive to rodents or other vectors of disease. The TMAs are well screened from public view by topography and trees.

(4) Table A criteria

As summarized below in Table 11, the TMAs comply with some of the table A criteria, but not all. However, in the cases where the TMAs do not meet the numerical requirements of Table A, the facilities do meet the intent of the Rules: as documented above, groundwater and surface water are in compliance with all standards and the facilities do not cause, and will not cause, any adverse environmental impact.

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Table 11: Table A Criteria

Category	Requirement for a Discrete Disposal Facility	Actual Distance at Omya TMAs	Comment
Minimum vertical separation from high seasonal groundwater table	6’	0’	Portions of the filled quarries are below the native water table. Monitoring has confirmed no adverse environmental impact.
Minimum vertical separation to bedrock	10’	0’	Filled quarries are on bedrock. Monitoring has confirmed no adverse environmental impact.
Minimum distance to waters from the waste management boundary	300’	600’ ±	Refer to setback map, page 4 of appendix 1.
Minimum distance from waste management boundary to drinking water source not owned by applicant	1000’	1600’ ±	Distance from Dolomite Quarry to Sandillo and LaFlamme wells is 1600’ ±
Minimum distance to property line from waste management boundary	300’	120’	Distance from S.E. corner of existing Kane & Drake TMA to property line is 120’; no odors, noise, visual impacts, or adverse health effects exist. New tailings would not be placed within 300 feet of the property line. Also see page 2 of Part A-10 of the Application.
Minimum distance from waste management boundary to residences, schools, daycare facilities, hospitals, nursing homes	1000’	1575’ ±	Distance from Dolomite Quarry to nearest residence is 1575’ ±.

(5) <u>Serious development limitations</u>

The former quarries have been shown to be suitable sites for disposal of calcium carbonate tailings. Steep slopes and erodible soils are not problems at the locations of the TMAs. The bedrock surfaces are not erodible and, despite their steep slope, are stable because the rock is solid and competent.

The karst-type of features that have been identified in some of the bedrock wells at Omya’s property do not pose any development limitations for the TMAs. There are no surface manifestations of karst features such as subsidence or sinkholes anywhere in the vicinity; such hazards are not typical of Vermont karst terrain.

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(6) Accessibility from highways

Not applicable; the TMAs are accessible from and are on the same site as Omya's processing facility, which is the only generator of material to be placed in the TMAs. As noted, the continued use of the TMAs will not increase traffic on the highways, in direct contrast to the impact that would be caused by shipping the tailings product off-site.

Because Omya desires to retain the tailings product on-site in anticipation of being able to utilize some of the calcium carbonate content, shipping the material to off-site locations would reduce Omya's immediate access to and control of the tailings product, increase traffic on the highways, and, if the tailings product were disposed of in other operating landfills, limited landfill capacity would be consumed. In addition, co-mingling the tailings product with municipal solid waste would impede the opportunity to reclaim or reuse the calcium carbonate content of the tailings product.

(7) Distance to airports

Although the TMAs do not attract birds, because of their lack of organic matter, the nearest airport is nonetheless greater than 10,000 feet away. Refer to map, page 27 of appendix 1.

VIII. CONCLUSIONS

The tailings management operation at the Omya Verpol plant in Florence, Vermont has been investigated via characterization of the tailings product, study of the site geology and hydrology, and water quality monitoring. Extensive testing of groundwater and surface water on and off the Omya property, including public and private wells and springs, has been conducted.

First, the tailings product itself was studied in order to understand its properties and chemical constituents to understand whether it posed any risk. Omya's process was reviewed and all chemicals used in the plant were inventoried. Testing was then performed for the chemicals on the inventory, including those that are not involved in the tailings process, but rather are used in other parts of Omya's operation. Additionally, testing also analyzed dozens of substances that were not on the inventory, simply because many of the test methods identify numerous compounds in addition to Omya's process chemicals. Testing of the tailings began with laboratory analyses to determine whether the tailings contained substances that are classified as hazardous, and they were found not to do so. Tailings have a very low permeability and thus are not the source of significant amounts of seepage or leachate.

A thorough investigation of the site was undertaken. The following geologic methods were used to evaluate the hydrogeology of the Verpol plant site and to select well drilling locations: fracture trace analysis, geologic map review, field mapping of bedrock outcrops, borehole logging with a borehole video camera, water elevation contouring,

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and a field reconnaissance using very-low frequency (VLF) radio and geomagnetics. The fracture trace analysis, measurements of outcrop strike, and mapped geologic contacts all indicated a predominant south-southeast to north-northwest structural alignment at the site, which dictates the local flow of groundwater.

Groundwater at the Omya plant site has been studied in detail via a network of 14 onsite bedrock wells, as well as four surface water sampling stations. The on-site monitoring network includes four pre-existing wells, ten geologically sited wells, and natural groundwater discharge locations (seeps and springs). The wells were appropriately sited to be representative of the tailings; some wells were drilled directly through tailings stockpiles as well as downgradient of the stockpiles (based on the measured groundwater flow direction). The fracture trace analysis and geophysical testing was used to ensure that onsite monitoring wells were sited along significant bedrock fractures where groundwater flow occurs. Additionally, off-site monitoring locations include fifteen wells and springs including private and public water sources, gravel and rock wells; and four surface water locations along “Post Office Swale”.

Groundwater contour mapping shows a predominant north-northwest flow direction in the bedrock groundwater at the site, which is consistent with the fracture trace analysis, geologic mapping, and outcrop measurements. This flow pattern has been found to be consistent at various hydrologic conditions such as spring recharge or summer drought. A small portion of the flow in the bedrock discharges at the “Hendee spring” near monitor well A, and flows eastward through a swale that crosses Creek Road near the Post Office (the “Post Office Swale”).

Extensive groundwater testing at the site where Omya’s tailings have been placed for over 25 years shows that the tailings product does not adversely affect groundwater or surface water.

All on-site and off-site groundwater and surface water is in compliance with Vermont Groundwater Enforcement Standards, Water Quality Standards, and Drinking Water Standards. For compounds associated with Omya’s process that do not have any such standard, concentrations in all on-site and off-site groundwater and surface water are below levels that have been determined to be safe. No substances have been detected in off-site groundwater or surface water that are the result of Omya’s operation.

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