PROPOSAL TO REISSUE AN EXEMPTION TO INEOS USA LLC FOR THE CONTINUED INJECTION OF HAZARDOUS WASTE SUBJECT TO THE LAND DISPOSAL RESTRICTIONS OF THE HAZARDOUS AND SOLID WASTE AMENDMENTS OF 1984

Action: Notice of intent to reissue an exemption from the land disposal restrictions of the Hazardous and Solid Waste Amendments of 1984.

Summary: Today, the U. S. Environmental Protection Agency (EPA) is proposing to reissue to Ineos USA LLC (Ineos) in Lima, Ohio an exemption from the land disposal restrictions under the Hazardous and Solid Waste Amendments of 1984 (HSWA) to the Resource Conservation and Recovery Act (RCRA). If the exemption is reissued, Ineos may continue to inject only hazardous wastes designated by the RCRA waste codes found in Table 1 through its four Class I hazardous waste injection wells (#1, #2, #3, and #4).

In August 2005, Ineos submitted a petition to EPA seeking reissuance of its exemption from the prohibition on injection of restricted hazardous waste (petition) under Title 40 of the Code of Federal Regulations (40 CFR) Part 148, Subpart C. As part of its petition, Ineos was required to demonstrate, with a reasonable degree of certainty, that there will be no migration of hazardous constituents from the injection zone for as long as the waste remains hazardous. This demonstration requires compliance with 40 CFR § 148.20(a), (b), and (c) which includes, among other things, a showing that any injected fluids will not migrate within 10,000 years: (1) vertically upward out of the injection zone or (2) laterally within the injection zone to a point of discharge or interface with an underground source of drinking water (USDW).

EPA conducted a comprehensive review of Ineos's petition, revisions to the petition dated May 15, 2007, December 14, 2010, September 20, 2011 and May 29, 2013 and other materials submitted to EPA. Based on its review, EPA determined that Ineos has complied with 40 CFR § 148.20(a), (b), and (c). Accordingly, EPA is proposing to reissue Ineos's exemption to allow the injection of certain restricted hazardous waste through the four Class I hazardous waste injection wells identified above.

Supplementary Information:

I. Background

A. Statutory and Regulatory Requirements

HSWA expanded the scope and requirements of RCRA. Under RCRA section 3004 (d), (e), (f), and (g), 42 U.S.C. 6924(d), (e), (f), and (g), as amended by HSWA, land disposal of untreated hazardous waste beyond specified dates is prohibited, unless EPA determines that the prohibition is not required in order to protect human health and the environment. Under RCRA section 3004(k), 42 U.S.C. 6924(k), land disposal includes any placement of hazardous waste into an injection well. After the effective date of the prohibition, hazardous waste may be disposed of in a Class I hazardous waste injection well when the owner or operator of such a well has demonstrated that, to a reasonable degree of certainty, there will be no migration of hazardous constituents from the injection zone for as long as the waste remains hazardous.

Applicants seeking an exemption from the land disposal restrictions must show that the hydrogeological and geochemical conditions at the site and the physicochemical nature of the waste stream(s) are such that reliable predictions can be made that: (a) injected fluids will not migrate within 10,000 years: (1) vertically upward out of the injection zone; or (2) laterally within the injection zone to a point of discharge or interface with a USDW (the no-migration standard); or (b) before the injected fluids migrate out of the injection zone or to a point of discharge or interface with USDW, the fluid will no longer be hazardous because of attenuation, transformation or immobilization of hazardous constituents within the injection zone by hydrolysis, chemical interactions or other means.

In addition, the petitioner must comply with the following requirements to demonstrate that there is no migration of hazardous constituents from the injection zone for as long as the waste remains hazardous: (a) establish an area of review (AOR) around the well bore with a minimum radius of two miles; (b) locate, identify, and ascertain the condition of all wells within the injection well's AOR; (c) submit a corrective action plan, if applicable; (d) submit the results of pressure and radioactive tracer tests; (e) identify the strata within the injection zone which will confine fluid movement above the injection interval; (f) show that the strata are free of known transmissive faults or fractures; and (g) identify a confining zone above the injection zone.

B. Facility Information and Operation

Ineos operates a chemical manufacturing facility in Lima, Allen County, Ohio. The facility disposes of wastewater generated in the production of acrylonitrile and associated products through four Class I hazardous waste injection wells. These wells are currently permitted and operated according to Underground Injection Control (UIC) regulations administered by the Ohio Environmental Protection Agency (Ohio EPA). In 2011, Ohio EPA reissued permits to Ineos to dispose of hazardous waste by deep well injection.

The operator has constructed four wells: #1, #2, #3, and #4. The proposed exemption is based on a long term combined maximum injection rate of 175 gallons per minute (gpm) through each well of wastes bearing the RCRA hazardous waste codes identified in Table 1. The rate at which Ineos injects into each well is also limited by the maximum allowable surface injection pressure at each well.

C. Submission

In August 2005, Ineos submitted a petition for reissuance of its exemption from the land disposal restrictions of HSWA. EPA reviewed this submission for completeness and accuracy. After reviewing Ineos's petition, EPA provided comments and requested additional information. EPA received a response to its comments and the additional information on May 15, 2007, December 14, 2010, September 20, 2011 and May 29, 2013.

II. Basis for Determination

A. Waste Identification, Analysis and Estimation Techniques (40 CFR §§ 148.22(a) and 148.21(a)(1) and (2)) – Under 40 CFR § 148.22(a)(1) and (2), any petition must include an identification of the specific waste or wastes, the specific injection well or wells for which the demonstration will be made and a waste analysis to describe fully the chemical and physical characteristics of the subject wastes. In its petition, Ineos identified the hazardous waste codes

and wells #1, #2, #3 and #4 for which its demonstration was made. Ineos included a waste analysis that describes the chemical and physical characteristics of all current hazardous waste codes. EPA proposes to limit Ineos's exemption to the waste codes identified in Table 1.

Under 40 CFR § 148.21(a)(1), all waste analysis and any new testing performed by the petitioner must be accurate and reproducible and performed in accordance with quality assurance standards. EPA evaluated Ineos's Quality Assurance Plan and determined it to be adequate. Under 40 CFR 148.21(a)(2), estimation techniques must be appropriate, and EPA-certified test protocols must be used where available and appropriate. When precise values necessary for the demonstration were not available, Ineos used appropriate estimates to generate conservative results and performed a sensitivity analysis to evaluate their importance.

B. Wells in Area of Review (40 CFR §§ 146.63, 146.64 and 148.20(a)(2)(i), (ii), and (iii)) – Under 148.20(a)(2)(i), the petitioner must show that the injection well's AOR complies with the substantive requirements of 40 CFR § 146.63 which requires that the AOR for Class I hazardous waste injection wells shall be a minimum 2-mile radius around the well bore. Ineos has demonstrated that the injection wells' AOR complies with 40 CFR § 146.63 by selecting a circular area with a 10-mile radius as the AOR. Ineos's decision to use a 10-mile radius rather than a 2-mile radius as the AOR is more protective of the environment because Ineos looked for penetrations into the confining zone within a larger area.

Under 40 CFR § 148.20(a)(2)(ii), the petitioner must locate, identify, and ascertain the condition of all wells within the injection well's AOR that penetrate the injection zone or the confining zone and meet the substantive requirements of 40 CFR § 146.64. Substantive requirements of 40 CFR § 146.64 include corrective action if wells are improperly plugged, completed, or abandoned. Under 40 CFR § 148.20(a)(2)(iii), the petitioner must submit a corrective action plan. Ineos conducted a well search within a 15-mile radius circle (significantly larger than the AOR) and found that there are five wells penetrating the top of the confining zone within this area, four of which are Ineos's own wells. Ineos provided completion reports showing that these four wells are properly constructed. The fifth well is outside the area within which pressure could cause fluids to contaminate the lowermost USDW (the zone of endangering influence). Accordingly, under 40 CFR § 148.20(a)(2)(iii) and 40 CFR § 146.64, Ineos does not need to submit a corrective action plan.

C. Mechanical Integrity Test Information (40 CFR § 148.20(a)(2)(iv)) – Under 40 CFR § 148.20(a)(2)(iv), the petitioner must submit the results of pressure and radioactive tracer tests performed within one year prior to submission of the petition demonstrating the mechanical integrity of the wells' long string casing, injection tubing, annular seal, and bottom hole cement[1]. In cases where the petition has not been approved or denied within one year after the initial demonstration of mechanical integrity, EPA may require the owner or operator to perform the tests again and submit the results of the new tests. Ineos conducted these tests as shown in the table below.

Well	1	2	3	4
Pressure Test	10/6/14	4/13/15	8/20/14	5/20/15
Radioactive Tracer Survey	10/6/14	4/13/15	8/20/14	5/20/15

[1] "Bottom hole cement" refers to the cement at the bottom of the casing which seals the space between the base of the casing and the rock which surrounds it.

Each year, Ineos submits mechanical integrity and other test results to Ohio EPA and each year the wells have passed the tests.

D. Site-Specific Information (40 CFR §§ 148.20(b) and 148.21(b)) – Under 40 CFR § 148.20(b), the petitioner must identify the strata within the injection zone which will confine fluid movement above the injection interval and include a showing that these strata are free of known transmissive faults or fractures. The petitioner must also show that there is a confining zone above the injection zone. Under 40 CFR § 148.21(b), the petitioner must provide sufficient site-specific information to support the demonstration that there will be no migration of hazardous constituents from the injection zone for as long as the waste remains hazardous. Ineos identified the Lower Black River Group, the Wells Creek Formation, the Knox Dolomite and the Upper Eau Claire Formation as the strata within the injection zone which will confine fluid movement and, as discussed below, showed that these strata are free of transmissive faults or fractures. In support of its demonstration, Ineos provided site-specific geologic, hydrologic, and geochemical information, including descriptions of the depositional environments of the formations, well logs, cross-sections, well and formation tests, and geologic maps. A summary of the site-specific information is provided below.

1. Identification of Underground Sources of Drinking Water (USDW) – The lowermost USDW at the site is within the undifferentiated rocks of Silurian age, the base of which is at approximately 400 feet below ground level (see Figure 1). There are approximately 2,230 feet of rock between the lowermost USDW and the Injection Interval, where the waste is emplaced. This separation zone is composed of dolomites, shales, sandstones and siltstones which are predominantly characterized by low permeability at this location.

2. Injection Zone – The injection zone is defined at 40 CFR § 146.3 as "a geological 'formation', group of formations, or part of a formation receiving fluids through a well." The injection zone must have sufficient permeability, porosity, thickness, and extent to contain the injected fluids. The injection zone is composed of the injection interval and the overlying arrestment interval (Figure 1). The waste is directly emplaced into the injection interval, which is composed of the Lower Eau Claire Formation, the Mt. Simon Sandstone and the Upper Middle Run Formation. It is located at depths between 2,631 and 3,241 feet below ground level. (All depths are from well #4, the most recently drilled well. Depths in the other wells are similar. Note that depths in the petition are measured from the Kelly bushing, which was nine feet above ground level when well #4 was being drilled. Therefore, depths in the petition appear to be nine feet deeper than those cited in this decision.) The injection interval can accept the waste because of its high permeability, porosity and the extent and thickness.

The arrestment interval is the portion of the injection zone into which the waste will move by diffusion and pressure-driven permeation. At the Ineos site, it is composed of the Lower Black River Group, the Wells Creek Formation, the Knox Dolomite and the Upper Eau Claire Formation and ranges from 1,631 to 2,631 feet below ground level. These formations are continuous rock formations of low vertical permeability, and are free of known transmissive faults or fractures over an area sufficient to prevent the upward movement of waste.

3. Confining Zone –The regulations which specify the minimum criteria for siting Class I hazardous waste injection wells require that the injection zone must be overlain by at least one additional formation which can confine the injected fluids. This formation is known as the confining zone, and it must be (1) laterally continuous, (2) free of transecting, transmissive faults

or fractures over an area sufficient to prevent fluid movement, and (3) of sufficient thickness and lithologic and stress characteristics to prevent vertical propagation of fractures. The confining zone at the Ineos facility is composed of the Upper Black River Group and is found between 1,427 and 1,631 feet below ground level (Figure 1). It is 204 feet thick, has no known transmissive faults or fractures within the AOR, and will resist vertical migration because of its low natural permeability.

The confining zone must be separated from the lowermost USDW by at least one sequence of permeable and less permeable strata that will provide added layers of protection by either allowing pressure bleed-off (permeable units), or by providing additional confinement (low permeability units). The primary "bleed-off" unit at the Ineos facility is the Trenton Limestone found between 1,253 and 1,427 feet below ground level. The Trenton Limestone includes layers that have sufficient porosity and permeability to be capable of accepting significant amounts of fluid without developing excessive hydrostatic pressure. Overlying the Trenton Limestone is the Cincinnati Group which is found between 364 and 1,253 feet below ground level. The Cincinnati Group provides additional confinement because it has much lower porosity and permeability than the Trenton Limestone. These rock formations are laterally continuous for hundreds of square miles and provide the required additional layers of protection.

4. Absence of Known Transmissive Faults – There are no known transmissive faults in the formations within the injection zone that will confine fluid movement (the arrestment interval) or in the overlying Black River Group. In addition, evaluation of the seismic reflection survey conducted from 1988 to 1991 indicated that there is no vertical faulting within this area.

E. Predictive Model

1. Model Development– Ineos used the Sandia Waste-Isolation Flow and Transport (SWIFT/98) Model for Fractured Media for Windows, a subsurface flow and pressure computer modeling program, to simulate migration of injected fluid from its four injection wells. Ineos used site specific data from logs, core, and other testing carried out during drilling and operation of these wells and site-specific information (i.e., hydrogeologic properties of the various rock layers and formation brines and characteristics of the injected fluid) in its model. When site-specific information was not available, Ineos used data from peer-reviewed literature or data from facilities injecting hazardous waste into wells with similar site conditions.

2. Time Period – Ineos used two simulated time periods for its demonstration: a 20-year operational period and a 10,000-year post-operational period. The operational period included actual historical injection rates through January 31, 2005 and a combined maximum injection rate of 700 gpm through January 31, 2025. This rate history determined the plume size and maximum pressure build up in the injection zone. The post-operational period predicts the maximum vertical molecular diffusion and the horizontal drift of the waste plumes.

3. Vertical Migration –Vertical migration is governed by pressure-driven movement during the operational life of the facility and diffusion during the 10,000-year post-operational period. Ineos made conservative assumptions based on the maximum pressure increase of 1,046 pounds per square inch at the end of the facility's operational life, based on the maximum permitted pressure at this depth (the top of the injection interval). Ineos assumed that this pressure existed during the entire historical operational period and an additional 20-year post-operational period, instead of only until the end of injection. (Pressure will begin to drop when injection ceases, so

this is a conservative assumption.) Ineos also assumed that vertical movement begins at the base of the arrestment interval (which is the top of the injection interval) which is located at 2,631 feet below the surface. The vertical permeability of the rocks in the arrestment interval was measured and it is low. Low vertical permeability is crucial in order to prevent fluid from moving upward. Based on measured values and the assumptions used in the model, Ineos predicted vertical movement due to pressure-driven flow to be 30.5 feet above the base of the arrestment interval at the end of the future operational period. The vertical distance due to diffusion over 10,000 years is conservatively predicted to be 613 feet. This is 387 feet below the top of the 1000-foot thick arrestment interval at 1,631 feet below ground surface.

4. Lateral Migration – Ineos used conservative assumptions to maximize the distance of the plume for the 10,000-year post-operational period. Ineos determined the distance at which the concentration of any constituent would be reduced to one-billionth (1×10^{-9}, referred to as the concentration reduction factor) of its concentration when it enters the well. The contour of the 10^{-9} reduction defines the edge of the plume.

Ineos used this concentration reduction factor and the health-based standards for hazardous chemicals to determine the maximum allowable concentration when the waste enters the well. These limits are shown in Table 2. The Health-Based Limits are taken from the compilation by EPA Region 6, revised in 2005.

The simulation of the distance and direction that the plume will flow during the 10,000-year post-operational period included buoyancy and the natural flow within the Mt. Simon Sandstone as well as dispersion and diffusion. Predictions based on literature values indicated that the rate of regional flow is less than 0.5 ft/year. Because of uncertainty of the direction of regional flow, Ineos used a circular boundary of the greatest extent of flow caused by regional flow. For conservatism, the model does not incorporate the possibility of chemical and physical processes which are likely to retard movement of hazardous constituents. The final plume boundary is shown in Figure 2. The boundary is 5.2 miles from the injection wells and represents the likely maximum distance of waste migration within 10,000 years. (Note that the plume boundary is not the same as the AOR.) By simulating the migration of the injected fluid, Ineos was able to predict the pressure in the injection interval and the vertical and lateral movement of waste constituents.

5. Model Verification, Validation, Calibration and Appropriateness (40 CFR § 148.21(a)(3)) – Under 40 CFR § 148.21(a)(3), predictive models must be: (1) verified and validated; (2) appropriate for the specific site, waste streams, and injection conditions of the operation; and, (3) calibrated for existing sites. The SWIFT computer codes have been used in previous no-migration demonstrations and have been verified extensively by prior testing which showed that the codes accurately represents the mathematical model.

Based on EPA's review of the information provided by Ineos, review of the geology by Ohio EPA, and review of the model by Lawrence Berkeley National Laboratory, EPA concluded that Ineos's simulation model is a valid representation of the geology, physical processes and boundary conditions at the site.

Ineos calibrated the SWIFT model for its site by adjusting certain parameters such as the permeabilities of various layers to reflect the observed data from pressure transient tests conducted between 1991 and 2004 and to waste concentrations encountered during the drilling

for well #4 in 1991. The model is appropriate for this site because Ineos used conservative values for the properties of the individual rock layers (e.g., permeability and porosity), the injection pressure, injection rate and waste stream characteristics (e.g., specific gravity and viscosity).

F. Quality Assurance and Quality Control (40 CFR § 148.21(a)(4)) – Under 40 CFR § 148.21(a)(4), a quality assurance and quality control plan must address all aspects of the demonstration, which Ineos did in its petition. For example, it addressed investigating artificial penetrations, integrity of geological data and core analysis, and reservoir modeling. The quality of the data is indicated by the consistency of the values. Ineos followed an appropriate protocol for locating records for penetrations in the AOR, for collection and analyses of geologic and hydrogeologic data, for waste characterization, and for all tasks associated with the modeling demonstration.

G. Conservative Values (40 CFR § 148.21(a)(5)) – Under 40 CFR § 148.21(a)(5), the petitioner must use reasonably conservative values whenever values taken from the literature or estimated on the basis of known information are used instead of site-specific measurements. As described above, when parameters were uncertain, Ineos chose conservative values.

H. Sensitivity Analysis (40 CFR § 148.21(a)(6)) – Under 40 CFR § 148.21(a)(6), the petitioner must conduct a sensitivity analysis to determine the effect that significant uncertainty may contribute to the demonstration. The demonstration must be based on conservative assumptions identified in the analysis. Ineos conducted a sensitivity analysis to determine the effect that uncertain parameters may have on its predictive model. Ineos used a range of conservative input values for specific gravity, permeability, dispersitivity, porosity and effective dispersion coefficient. In its sensitivity analysis, Ineos demonstrated that the uncertainty in these parameters does not significantly change the predictions for pressure build-up in the injection interval or significantly affect waste migration or waste confinement predictions. Though the uncertainty of the parameters does not have significant effect on the migration of injected fluids, Ineos used the conservative assumptions identified in its sensitivity analysis to simulate migration of injected fluid in Wells #1, #2,# 3, and #4.

I. Other information in support of petition (40 CFR § 148.22(a)(3)) – Under 40 CFR § 148.22(a)(3), EPA may require additional information to support the petition. Ineos provided documentation related to the most recent mechanical integrity tests and radioactive tracer surveys of the Ineos wells after receipt of the petition. Ineos also provided a report on the most recent pressure fall-off test performed in the Ineos wells. This information showed that the wells are operating as intended.

III. Conclusion

After a detailed and thorough review of the submitted petition and supporting documents, Ineos's predictive model, and other information contained in the administrative record, EPA has determined that Ineos has demonstrated, to a reasonable degree of certainty, that hazardous constituents will not migrate vertically out of the injection zone or laterally to a point of discharge in a 10,000-year period. Therefore, EPA proposes to reissue Ineos's land ban exemption.

IV. Conditions of Petition Approval

This proposed reissuance of the land ban exemption for the continued injection of restricted hazardous waste is subject to the following conditions, which are necessary to assure compliance with the standard in 40 CFR § 148.20(a). EPA may terminate this exemption under 40 CFR § 148.24(a) for noncompliance by Ineos with any condition of this exemption. EPA may also terminate this exemption for any causes identified under 40 CFR § 148.24(a) and (b). If Ineos wants to modify any of the conditions placed on the exemption, it must submit a petition for reissuance to EPA as required by 40 CFR § 148.20(e) and (f).

1) The exemption applies to the four existing hazardous waste injection wells, #1, #2, #3, and #4 located at the Ineos facility at 1900 Fort Amanda Road, Lima, Ohio;

2) Injection of restricted hazardous waste is limited to the parts of the Lower Eau Claire Formation, the Mt. Simon Sandstone and the Middle Run Formation at depths between 2,631 and 3,241feet below ground level;

3) The only RCRA-restricted wastes that may be injected are those designated by the RCRA waste codes found in Table 1;

4) Maximum concentrations of chemicals that are allowed to be injected are listed in Table 2;

5) The average specific gravity of the injected waste stream must be between 1.00 and 1.05 over a three month period;

6) Ineos may inject up to 175 gallons per minute through each of its four wells, based on a monthly average;

7) This exemption is approved for the 20-year modeled injection period, which ends on January 31, 2025. Ineos may petition EPA for reissuance of the exemption beyond that date, provided that a new and complete petition and no-migration demonstration is received at EPA, Region 5, by June 30, 2024;

8) Ineos must submit a quarterly report containing the fluid analyses of the injected waste and indicate the chemical and physical properties, including the concentrations, of all the injected hazardous constituents listed in Table 2 to EPA;

9) Ineos must submit an annual report containing the results of a bottom hole pressure survey (fall-off test) performed on one well each year to EPA. The survey must be performed after shutting down the well for sufficient time to conduct a valid observation of the pressure fall-off curve under 40 CFR § 146.68(e)(1). The annual report must include a comparison of reservoir parameters determined from the fall-off test with parameters used in the approved no-migration petition;

10) Ineos must submit the results of radioactive tracer surveys and annulus pressure tests for its four wells to EPA annually;

11) Ineos must notify EPA in writing if any well loses mechanical integrity and prior to any workover or plugging;

12) Ineos must fully comply with all requirements set forth in Underground Injection Control Permits #UIC 03-02-003-PTO-1, UIC 03-02-004-PTO-1, UIC 03-02-005-PTO-01 and 03-02-006-PTO-1 issued by Ohio EPA;

13) Upon the expiration, cancellation, reissuance, or modification of the permits referenced above, this exemption is subject to review; and

14) Whenever EPA determines that the basis for approval of a petition under 40 CFR §§ 148.23 and 148.24 may no longer be valid, EPA may terminate this exemption and will require a new demonstration in accordance with 40 CFR § 148.20.

Date: The EPA requests public comments on today's proposed decision. Comments will be accepted until OCT 13, 2015. Comments postmarked after the close of the comment period will be stamped **"Late"**. Late comments do not have standing and will not be considered in the decision process.

Addresses: Submit written comments by mail to:

Stephen Roy, Lead Petition Reviewer
United States Environmental Protection Agency, Region 5,
Underground Injection Control Branch (WU-16J)
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Comments may be submitted by email to roy.stephen@epa.gov.

For Further Information: Contact Stephen Roy, Lead Petition Reviewer, at the address above, by telephone at (312) 886-6556, or by email at roy.stephen@epa.gov.

Signed and Dated: 8/13/2015

Acting for Tinka G. Hyde
Director, Water Division

Table 1. Waste Codes Approved for Injection Through Ineos Wells

D001	D002	D003	D004	D005	D006	D007	D008	D009	D010	D011	D018
D019	D035	D038	F039	K011	K013	K014	P003	P005	P030	P063	P069
P098	P101	P106	P120	U001	U002	U003	U007	U008	U009	U019	U031
U044	U053	U056	U057	U080	U112	U122	U123	U124	U125	U129	U140
U147	U149	U151	U152	U154	U159	U161	U169	U188	U191	U196	U211
U213	U219	U220	U239								

These waste codes are identified in 40 CFR Part 261, Subpart C and Subpart D.

Table 2. Maximum concentrations of chemical contaminants that are hazardous at concentrations less than 0.001 mg/L.

Chemical Constituent	Waste Code	Health Based Limit (mg/L)	Concentration Limit at the Wellhead (mg/L) (Note 2)	Concentration Reduction Factor (C/C_0)
Acetaldehyde	U001	0.11	2,000	5.5×10^{-5}
Acetamide	Note 2	1.0×10^{-5}	10,000	1.0×10^{-9}
Acetic acid	Note 2	6.0×10^{-6}	6,000	1.0×10^{-9}
Acetone	U002	3.5	2,000	1.75×10^{-3}
Acetone cyanohydrin	P069	0.005	6,000	8.33×10^{-7}
Acetonitrile	K011, K013, K014, U003	0.21	100,000	2.1×10^{-6}
Acrolein	P003	0.005	2,000	2.5×10^{-6}
Acrylamide	K011, K013, K014, U007	8×10^{-6}	6,000	**1.33×10^{-9} Note 1**
Acrylic acid	U008	17.5	60,000	2.92×10^{-4}
Acrylonitrile	K011, K013, K014, U009	6.0×10^{-5}	24,000	2.5×10^{-9}
Allyl alcohol	P005	0.175	2,000	8.75×10^{-5}
Antimony	F039	0.006	100	6.0×10^{-5}
Arsenic	D004	0.05	100	5.0×10^{-4}
Barium	D005	2	100	$2.0 \text{ X } 10^{-2}$
Benzene	D018, K011, K013, K014, U019	0.005	400	1.25×10^{-5}
1,3-Butanediol	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
1,4-Butanediol	Note 2	1.4×10^{-5}	14,000	1.0×10^{-9}
Butanetriol	Note 2	4.0×10^{-6}	4,000	1.0×10^{-9}
Butanol	U140	3.5	4,000	8.75×10^{-4}
Butyrolactone	Note 2	5.0×10^{-6}	5,000	1.0×10^{-9}
Cadmium	D006	0.005	100	5.0×10^{-5}
Carbon tetrachloride	D019, U211	0.005	100	5.0×10^{-5}
Chloroform	U044	0.006	100	6.0×10^{-5}
Chromium	D007	0.1	100	1.0×10^{-3}
Cobalt	Note	1.0×10^{-7}	100	1.0×10^{-9}
Crotonaldehyde	U053	0.002	200	1.0×10^{-5}
Crotonitrile	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
Cyclohexane	U056	9.0×10^{-5}	100	9.0×10^{-7}
Cyclohexanone	U057	180	100	1.8
Diethylenetriamine pentaacetic acid	Note 2	$1.0\text{x } 10^{-6}$	1,000	1.0×10^{-9}

Dimethylhydantoin	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
Ethanol	Note 2	2.0×10^{-6}	2,000	1.0×10^{-9}
Ethyl acetate	U112	31.5	100	3.15×10^{-1}
Ethylenediamine tetracetonitrile	Note 2	4.0×10^{-6}	4,000	1.0×10^{-9}
Formic acid	U123	0.01	20,000	5.0×10^{-7}
Formaldehyde	U122	7	4,000	1.75×10^{-3}
Formamide	Note 2	4.0×10^{-6}	4,000	1.0×10^{-9}
Fumaronitrile	Note 2	4.0×10^{-6}	4,000	1.0×10^{-9}
Furan	U124	3.5×10^{-3}	100	3.5×10^{-4}
Furfural	U125	0.11	100	1.1×10^{-3}
Glyconitrile	Note 2	7.0×10^{-6}	7,000	1.0×10^{-9}
HCN (Free)	K011, K013, K014, P030, P063, P098, P106	0.2	3,200	6.25×10^{-5}
HCN (Total)	K011, K013, K014, P030, P063, P098, P106	0.7	21,200	3.3×10^{-5}
Hexamethylenetetramine (or acid)	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
Iminodiacetonitrile	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
Isobutanol	U140	11	200	5.5×10^{-2}
Isopropyl alcohol	Note 2	1.2×10^{-6}	1,200	1.0×10^{-9}
Lead	D008	0.001	100	1.0×10^{-5}
Lindane	U129	2.0×10^{-4}	1,000	2.0×10^{-7}
Maleic anhydride	U147	3.5	100	3.5×10^{-2}
Maleonitrile	Note 2	2.0×10^{-5}	20,000	1.0×10^{-9}
Malonitrile	U149	0.005	2,000	2.5×10^{-6}
Mercury	D009, U151	0.002	100	2.0×10^{-5}
Methanol	U154	17.5	40,000	4.38×10^{-4}
Methyacrylonitrile	U152	0.0035	400	8.75×10^{-6}
Methylethylhydantoin	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
Methylene chloride	U080	5.3×10^{-3}	100	5.0×10^{-5}
Methyl ethyl ketone	D035, U159	21	1,000	2.1×10^{-2}
Methyl isobutyl ketone	U161	2.0×10^{-3}	100	2.0×10^{-5}
2-Methylpyridine	U191	2.0×10^{-3}	1,000	2.0×10^{-6}
3-Methylpyridine	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
Nickel	F006	0.001	100	1.0×10^{-5}
Nicotinonitrile	Note 2	6.0×10^{-6}	6,000	1.0×10^{-9}
Nitrilotiracetonitrile	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
Nitrobenzene	U169	1.8×10^{-2}	100	1.8×10^{-4}
Oleic acid	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}

Oleoylsarconsinate	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
Phenol	U188	21	100	2.1×10^{-1}
1,2-Propanediol	Note 2	6.0×10^{-8}	60	1.0×10^{-9}
1,3-Propanediol	Note 2	2.0×10^{-6}	2,000	1.0×10^{-9}
Propanol	Note 2	$2,0 \times 10^{-6}$	2,000	1.0×10^{-9}
Propionitrile	P101	0.005	2,000	2.5×10^{-6}
Propylenediamine tetracetonitrile	Note 2	1.0×10^{-6}	1,000	1.0×10^{-9}
Pyroazole	Note 2	4.0×10^{-6}	4,000	1.0×10^{-9}
Pyridine	D038, U196	0.035	2,000	1.75×10^{-5}
Selenium	D010	0.05	100	5.0×10^{-4}
Silver	D011	0.175	100	1.75×10^{-3}
Sodium cyanide	D003, K011, K013, P030, P063, P106	1.4	1,200	1.17×10^{-3}
Strontium	Note 2	1.0×10^{-7}	100	1.0×10^{-9}
Succinic acid	Note 2	8.0×10^{-7}	800	1.0×10^{-9}
Succinotrile	Note 2	6.0×10^{-6}	6,000	1.0×10^{-9}
Tetrahydrofuran	U213	0.002	5,000	4.0×10^{-7}
Thiourea	U219	1.0×10^{-2}	100	1.0×10^{-4}
Toluene	U220	1	100	1.0×10^{-2}
Vanadium	P120	0.004	100	4.0×10^{-5}
Vanadium pentoxide	P120	0.315	400	7.88×10^{-4}
Xylene	U239	10	100	1.0×10^{-1}
Zinc	Note 2	10.5	400	2.63×10^{-2}

Note 1 – Worst-case constituent. Health Based Limit (HBL) contour for no-migration boundary set at 1.0×10^{-9} for this constituent. The HBL values are from the compilation by EPA Region 6, revised 2005.

Note 2 – Constituents not associated with an EPA RCRA waste code or listed in HBL guidelines are assigned the minimum C/C_0 of 1.0×10^{-9}. A provisional "HBL" for these constituents is then derived from the product of C/C_0 and the concentration limit at the wellhead. If a RCRA waste code is promulgated for any of these constituents, the HBL selected by EPA will be compared to the provisional "HBL" on this table. If the EPA HBL is more stringent, the Concentration Limit at the Wellhead will be reduced or migration of the constituent will be reconsidered in detail.

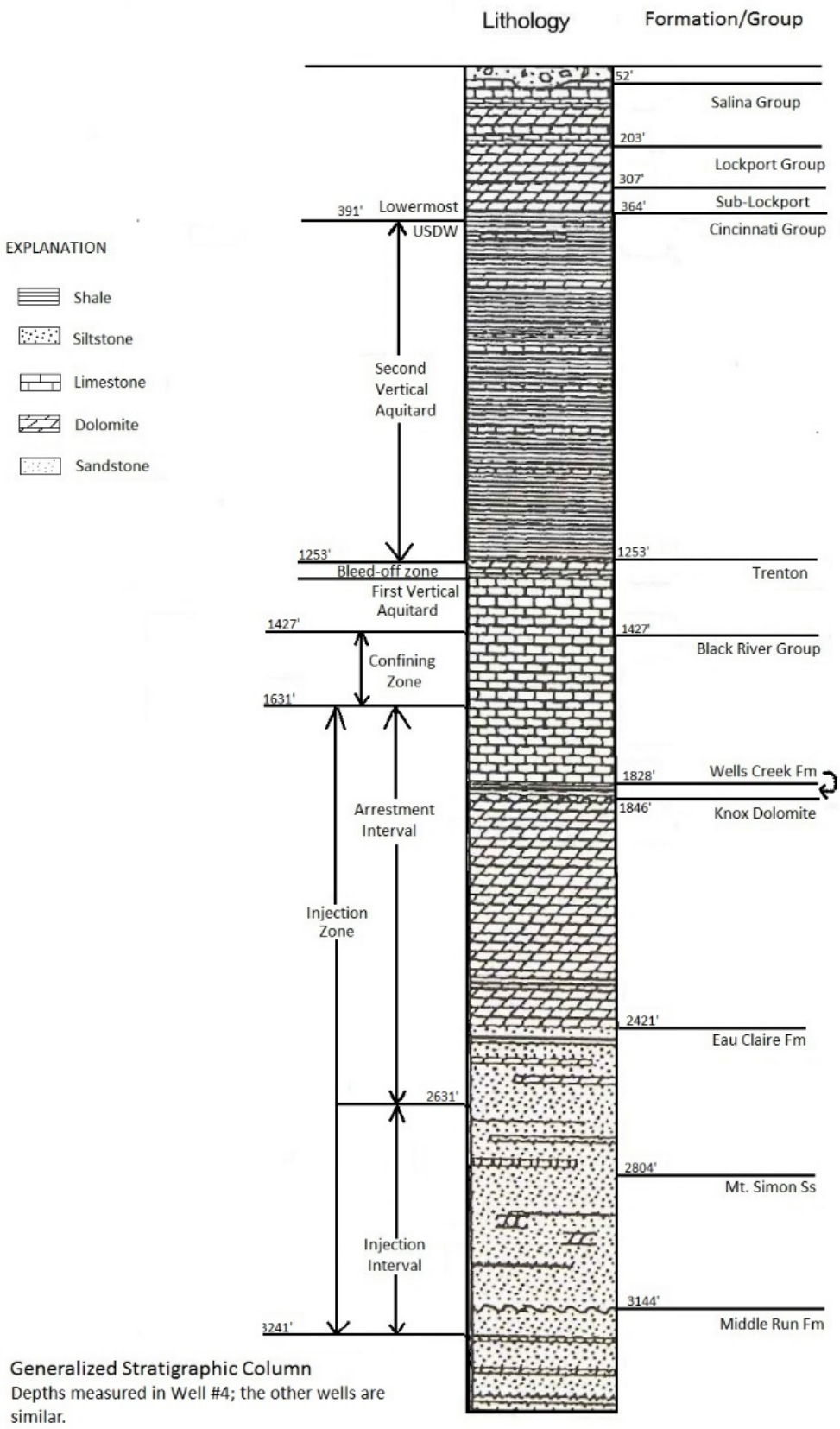

Figure 1. Stratigraphic column of the Ineos site. All depths in this figure are relative to ground level.

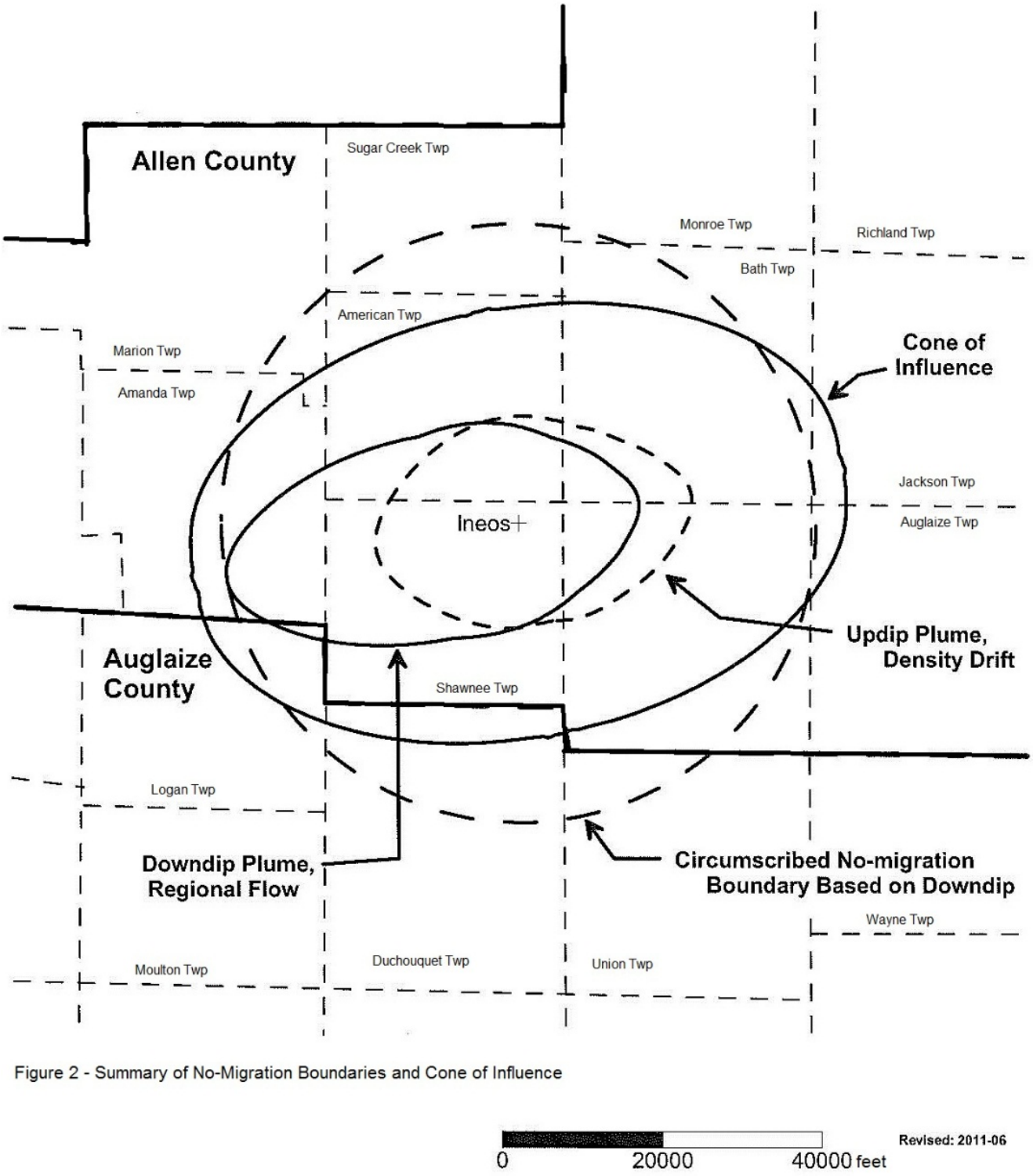

Figure 2 - Summary of No-Migration Boundaries and Cone of Influence

Figure 2. Lateral waste movement in the injection interval at 10,000 years. The radius of the Circumscribed No-Migration Boundary is 5.2 miles. Ineos searched for wells within a circle with a 15-mile radius, much larger than the plume boundary or the zone of endangering influence.