Technical Guidance Committee Meeting

Draft Minutes

Thursday, August 8, 2013

Department of Environmental Quality
Conference Room C
1410 N. Hilton
Boise, Idaho

TGC ATTENDEES:

Tyler Fortunati, R.E.H.S., On-Site Wastewater Coordinator, DEQ
Joe Canning, P.E., B&A Engineers
Bob Erickson, Senior Environmental Health Specialist, South Central Public Health District
David Loper, Environmental Health Director, Southwest District Health Department
Michael Reno, Environmental Health Supervisor, Central District Health Department
George Miles, P.E., Advanced Wastewater Engineering, Inc. (via telephone and GoToMeeting)

GUESTS:

Chas Ariss, P.E., Wastewater Engineering Manager, DEQ
PaRee Godsill, Everlasting Extended Treatment, Inc.
Ryan Spiers, Alternative Wastewater Systems, LLC
Matt Gibbs, Infiltrator, Inc.
AJ Maupin, P.E., Wastewater Program Engineering Lead, DEQ
Kellye Eager, Environmental Health Director, Eastern Idaho Public Health Department (via telephone and GoToMeeting)
Raymond Keating, Environmental Health Specialist, Eastern Idaho Public Health Department (via telephone and GoToMeeting)
James Bell, Bio-Microbics, Inc. (via telephone and GoToMeeting)
Allen Worst, R.C. Worst & Company, Inc. (via telephone and GoToMeeting)
Janette Young, Administrative Assistant, DEQ

CALL TO ORDER/ROLL CALL:

Meeting called to order at 9:15 a.m.
Committee members and guests introduced themselves.

OPEN PUBLIC COMMENT PERIOD:

This section of the meeting is open to the public to present information to the TGC that is not on the agenda. The TGC is not taking action on the information presented.

No public comments were submitted during the allotted agenda timeframe.

ETPS SUBCOMMITTEE UPDATE:

Tyler Fortunati presented an update to TGC on what the ETPS Subcommittee has discussed and produced to date and what the TGC will be reviewing and approving today. He provided a brief overview of the process the Extended Treatment Package Subcommittee went through to create and revise the Extended Treatment Package System guidance documents that were presented to the TGC as part of this meeting.

NEW BUSINESS/DRAFT REVIEW:

4.2 Nonprofit Corporations

The Committee reviewed the proposed revisions and amendments to the Nonprofit Corporation guidance and structure. Tyler Fortunati stated that these changes will only impact newly proposed O&M Entities going forward and are not retroactive on previously approved O & M entities. Tyler Fortunati also stated it would be acceptable if existing O&M Entities decided to amend their bylaws to be in conformance with the program recommendations proposed in the revision of this guidance section. Discussion was held on whether DEQ could request Planning and Zoning Boards, or other similar County offices, to amend their subdivision ordinances to include a requirement that property owners notify O&M Entities of property ownership transfers through subdivision CC&Rs if the subdivision is engineered with ETPS septic systems.

Motion: Michael Reno moved that the TGC recommend preliminary approval of Section 4.2 Nonprofit Corporations and that DEQ issue the revised sections for public comment.

Second: Bob Erickson.

Voice Vote: Motion carried unanimously. See **Appendix A** and provide public comment to Tyler Fortunati at 208-373-0140 or by email at tyler.fortunati@deq.idaho.gov.

4.10 Extended Treatment Package Systems

The Committee reviewed the proposed revisions and amendments to the Extended Treatment Package System guidance. Michael Reno suggested that a requirement be added that the service provider must submit documentation that the ETPS unit and its associated components have been installed according to the manufacturer's recommendations prior to the installation permit being finalized. The health districts cannot verify this for each technology since they have not been trained by the manufacturer. Tyler Fortunati stated that this requirement could be supported by IDAPA 58.01.03.005.15 and should be written into the installation permit.

Mike Reno would also like to see the submission of annual reports be required to be done by mail. This provides an incentive not to falsify records, reports, or test results through the threat of prosecution for mail fraud.

The committee asked that a few adjustments be made to some of the figures in this proposed section that included the addition of risers on the septic and ETPS tanks and the correction of a spelling error.

Michael Reno voiced concern over the lag time between when an ETPS unit is sampled in November and the test results show that the unit is out of compliance and the receipt of the report on July 31 when no corrective action is taken by the out of compliance ETPS unit. The unit may be operating out of compliance for several months with no attempt at fixing the system. Michael Reno would like to be able to issue a Notice of Violation to the O&M Entity for not following the retesting requirements. Tyler Fortunati clarified the Attorney General's comments on issuing an NOV. An NOV cannot be issued against an O&M Entity and can only be issued to a property owner in relation to the status of the ETPS unit. Tyler Fortunati explained that in this type of situation the property owner's system would be considered a failing system if they were past the 90 day service and sampling period after the initial failed test result. If this is the case the district should issue the property owner an NOV and follow the failing system enforcement process.

10:50 a.m. Break

11:00 a.m. Meeting resumed.

4.10 Extended Treatment Package Systems (**Appendix B**) (Continued)

The committee discussed the responsible parties under Section 4.10.5 ETPS System Failure, Disapproval and Reinstatement. Tyler Fortunati clarified that only the manufacturer and property owner are responsible per IDAPA 58.01.03.002.04 according to the Attorney General's office. Instead of suspending Nonprofit O&M Entities the emphasis has shifted to a disapproval of a manufacturer's product. This happens if more than 10% of the manufacturer's ETPS units are out of compliance statewide instead of by the compliance status of individual O&M Entities. George Miles requested clarification on manufacturer product disapproval asking if one of the manufacturer's ETPS models is not working, do all the manufacturer's products become disapproved. Tyler Fortunati stated at this point that is the intent because of the concern that the products are not being operated in compliance or consistently functioning in compliance with the subsurface rules. The manufacturer would be provided the opportunity to hold a contested case hearing and may have their product approvals reinstated by following Section 4.10.5.3 of the proposed guidance. Tyler Fortunati will discuss the disapproval process and allowances with the Attorney General's office and the Water Quality Division Administrator to ensure the disapproval process is acceptable.

Motion: Michael Reno moved that the TGC recommend preliminary approval of Section 4.10 Extended Treatment Package System and that DEQ issue the revised sections for public comment.

Second: David Loper.

Voice Vote: Motion carried unanimously. See **Appendix B** and provide public comment to Tyler Fortunati at 208-373-0140 or by email at tyler.fortunati@deq.idaho.gov.

The meeting was adjourned for Lunch.
Lunch 12:00 p.m. – 1:10 p.m.

DEQ Service and Testing Reminder – Explanation Letter

The committee reviewed the letter to be sent out to homeowners from their O&M Entity. This letter would be provided to the O&M Entities on DEQ letterhead and is meant to be included in the annual O&M Entity mailings. The letter provides a reminder of service and testing requirements, and information on where a homeowner can access resources related to ETPS systems. Some small revisions were made by the committee.

Motion: Bob Erickson moved that the TGC recommend preliminary approval of DEQ Service and Testing Reminder – Explanation Letter, with the changes added today and that DEQ issue the revised letter for public comment.

Second: George Miles.

Voice Vote: Motion carried unanimously. See **Appendix C** and provide public comment to Tyler Fortunati at 208-373-0140 or by email at tyler.fortunati@deq.idaho.gov.

Letter 1 – It Has Come to Our Attention

Letter 1 is meant to be sent out by the regulatory agency when there is a refusal of service and/or testing, and includes the service reminder letter as an additional enclosure. This letter would go out after receipt of the annual report for a property owner. The annual report from the O&M Entity must include adequate documentation as outlined in Section 4.10 of the TGM prior to the regulatory agency issuing this letter. The letter is meant to be a pre-enforcement reminder letter to the property owner that informs them of their requirements associated with the ETPS unit through their septic permit. Contact information for their O&M Entity and service provider is included in the letter.

Motion: Michael Reno moved that the TGC recommend preliminary approval of Letter 1 with the changes added today and that DEQ issue the revised letter for public comment.

Second: Joe Canning.

Voice Vote: Motion carried unanimously. See **Appendix D** and provide public comment to Tyler Fortunati at 208-373-0140 or by email at tyler.fortunati@deq.idaho.gov.

Letter 2 – Voluntary Deadline to Comply

Letter 2 is meant to be sent out by the regulatory authority if there is no response or action initiated after a property owner's receipt of Letter 1. This letter is meant to be issued after 30 days of no response or action from Letter 1. The letter is more regulatory in tone and includes the IDAPA citations that the property owner is in violation of. It also includes a voluntary compliance date for the property owner to meet their responsibilities, and the notification that if the responsibilities are not met that the regulatory authority may pursue legal action against the property owner. This letter is copied to the O&M Entity and the County Prosecutor's office.

Motion: Joe Canning moved that the TGC recommend preliminary approval of Letter 2 with the changes added today and that DEQ issue the revised letter for public comment.

Second: George Miles.

Voice Vote: Motion carried unanimously. See **Appendix E** and provide public comment to Tyler Fortunati at 208-373-0140 or by email at tyler.fortunati@deq.idaho.gov.

1.4.2.2 Extended Treatment Package System Approvals

This proposed guidance addition was added to the agenda based on the TGC request from the July 18, 2013 TGC meeting. This section addresses a formal policy on ETPS product approvals in the State of Idaho. Discussion was held on how new systems will be evaluated and approved in the State of Idaho. James Bell provided background on the NSF/ANSI 360 standard.

Motion: Bob Erickson moved that the TGC recommend preliminary approval of Section 1.4.2.2 Extended Treatment Package System Approvals with the changes added today, and that DEQ issue the revised sections for public comment.

Second: Joe Canning.

Voice Vote: Motion carried with 4 ayes and 1 abstained. See **Appendix F** and provide public comment to Tyler Fortunati at 208-373-0140 or by email at tyler.fortunati@deq.idaho.gov.

2:20 p.m. Break

3:00 p.m. Meeting resumed.

Presentation of Drainfield to Surface Water Setback Determination Guidance

A.J. Maupin provided an overview of the guidance developed by DEQ that is to be used to determine acceptable site-specific drainfield setbacks to surface water. This guidance is used when an applicant is seeking a setback to surface water that is less than what is allowed by rule or guidance for a site based upon the native site soils. To pursue a reduced setback to surface water through this guidance an applicant would have to apply for a variance. The variance would be supported by the model results produced through use of the guidance. The reduction limitations of the model are based off of phosphorous impacts to the nearby surface water. Prior to utilizing this guidance an applicant would have to successfully pass a Nutrient Pathogen (NP) Evaluation. The minimum allowable setback to surface water will not be less than 100 feet regardless of site soils under this guidance. Drainfields are limited to pressurized designs and must be installed in the upper soil profile horizons which limits the system type to a drip-distribution system or a pressurized cap and fill design with maximum installation depths of 12 inches. DEQ will review the NP Evaluation and Phosphorous model and will send recommendations to the appropriate health district for their use in consideration of the variance approval.

A condition of the phosphorous guidance and model is that the site and soils will have an associated lifespan for the effective mitigation of phosphorous discharges in the septic system effluent. This results in a drainfield only functioning effectively for a guaranteed timespan. The model is conservative in its evaluation and lifespans may very but could be expected between 50-100 years. The committee raised the question as to what happens once the drainfield life is reached on both the primary and replacement areas. There was concern regarding the sites with limited space that would not have space for more than two drainfields and what is to be done after the point in time that both drainfields had reached their effective lifespan. AJ Maupin provided clarification that the mineralization of phosphorous in the soils would be expected to free up some additional sorption capacity over time. This would be expected to extend the useful life of the drainfield site beyond the model's conservative estimate.

Motion: Michael Reno moved that the TGC recommend preliminary approval of On-site Setback Distance Determination: Modeling Phosphorous in the Environment as the Critical Constituent and that DEQ issue the document for public comment.

Second: David Loper.

Voice Vote: Motion carried with 4 ayes and 1 nay. See **Appendix G** and provide public comment to Tyler Fortunati at 208-373-0140 or by email at tyler.fortunati@deq.idaho.gov.

NEXT MEETING:

The next committee meeting is scheduled to be on October 31, 2013, 9:15 a.m. – 4:30 p.m. at the DEQ State Office building.

Motion: Michael Reno moved to adjourn the meeting.

Second: Bob Erickson.

Voice Vote: Motion carried unanimously.

The meeting adjourned at 3:45 p.m.

TGC Parking Lot.

This is a running list of issues requested to be prepared and presented at a future TGC meeting.

- 4.20 Pressure Distribution System
    - Low Pressure Wastewater Handling System Guidance update
- Develop Operation and Maintenance requirements for section 4.22 Recirculating Gravel Filter and 4.28 Two-Cell Infiltrative System
- 4.7 Drip Distribution System
    - Adjust typical system components to minimum in section 4.7.1
- 4.9 Experimental System
    - Adjust the condition of approval relating to the site being acceptable for an approved alternative system to a basic alternative system
- Chapter 6
    - Update entire chapter and adjust section 6.5.2 to match the pumper rule requirements for permit renewal

Appendix A

4.2 Nonprofit Corporations

Revision: ~~November 21, 2000~~June 27, 2013

Nonprofit Corporations (Entities) to manage large soil absorption systems, extended treatment, ~~or~~ experimental systems, ~~clustered systems,~~ or any other ~~more~~ complex system~~s~~ the Director deems a maintenance entity is required to manage must guarantee that they will be responsible for the system and be available to provide operation and maintenance (O&M). The following guidance provides for a nonprofit corporation which can do that.~~:~~ If an O&M Entity is setup to provide operation and maintenance for Extended Treatment Package Systems (IDAPA 58.01.03.009.02 and 58.01.03.009.03) or Large Soil Absorption Systems (IDAPA 58.01.03.013.07.c) according to the following minimum elements, the maintenance entity will likely be approved by the Director. These minimum elements provide assurance that operation and maintenance, as conditioned for these particular systems by the Director, occurs. Other O&M Entity elements may be acceptable on a case-by-case basis depending upon the maintenance needs of an Entity. Other elements not included within this guidance section will be evaluated on a case-by-case basis.

4.2.1 Required Incorporation Elements

The following elements must be included within the Entity's Articles of Incorporation or Bylaws:

1. The nonprofit organization should be incorporated according to Idaho Code 30-3.
2. The Articles of Incorporation shall include a requirement that any changes to the Entity's Articles of Incorporation or Bylaws shall be approved by the Department of Environmental Quality's Water Quality Division Administrator (Director) or his/her designee per Idaho Code 30-3-99.
    a. The Director shall provide the Nonprofit Entity approval in writing of any changes to the Articles of Incorporation or Bylaws that are not in conflict with section 4.2 or 4.10 of the Technical Guidance Manual.
3. ~~2.~~ Membership should be limited to property owners only.
4. ~~3.~~ Voting should be limited to one parcel/one full membership/one vote.
5. ~~4.~~ Voting rights should be restricted to members with improved property.
6. Voting rights should not be cancelled.
    a. Exception to this is allowed in the event that an extended treatment package system is disconnected and removed from the property as approved by the Director.

7. Purposes of the organization should be clearly defined in the Articles of Incorporation.

~~5.~~8. The Nonprofit Entity should hold an annual meeting of the membership.

9. Funds generated are to operate specific functions and should be restricted for use to the specific purpose. Those purposes should be defined in the Bylaws or associated Membership Agreement.

   a. Annual financial reports should be made available to the membership upon request by individual members and through the annual membership meeting.

~~6.~~10. Multiple-purpose organization funds generated are to be separately maintained, and funds from one account should not be available for another account's use.

11. The ~~organization~~ Nonprofit Entity should either own the system(s) it intends to maintain or have an access easement in place.

   a. Access easements for extended treatment package systems should be executed through a membership agreement as outlined in section 4.2.3.

~~7. Mutually agreeable access to those systems owned by the entity should be provided by the property owner.~~

~~8.~~12. Membership (and shares) in the ~~entity~~ Nonprofit Entity must run with the land, and successive owners must acquire the preceding owner's membership or voting share(s).

~~9.~~13. The purchaser ~~or~~ and any new member should be provided by the Nonprofit Entity with a copy of the Articles of Incorporation, By-Laws, Covenants, and Contracts (i.e., membership agreement, etc.) with the ~~entity~~Entity.

~~10.~~14. There should be no provisions restricting ownership of improved property.

15. The ~~entity~~ Nonprofit Entity should be capable of raising revenue by ~~fixing~~ setting and collecting user charges.

16. Board of Director Requirements:

   a. For Extended Treatment Package System Nonprofit Operation and Maintenance Entities the Board of Directors should contain one permanent position required to be filled by a corporate officer, general partner, or owner of the manufacturer of the treatment technology.

      i. The only exemption to this requirement shall be for cases where manufacturers are no longer in business. In this case the existing Board Members and associated membership shall vote in a new Board Member to ensure that item 16.b is fulfilled.

b. The Board of Directors should include a minimum of three Board Member positions.

11.17. The Board of Directors should be able to raise revenue for emergency operation and maintenance of community owned systems without majority vote.

18. The organization Nonprofit Entity must be capable of suing and of being sued, maintain the capability to impose liens on those members (shareholders) who become delinquent in user charges, and suspend services, providing such suspension will not jeopardize other members' use.

12.19. The Nonprofit Entity should provide an operation and maintenance manual that shall be approved by the Director.

a. An The operation and maintenance manual shall should be approved by the Directorprovided to all new members for extended treatment package systems and shall include the monitoring requirements as outlined in the Section 4.10.2 "Extended Treatment Package System" Operation, Maintenance and Monitoring Conditions for Approval.

13.20. Conditions for dissolution of the organization Nonprofit Entity should be specified. Dissolution should be limited to connection to a municipal wastewater treatment facility or merger with another approved nonprofit Nonprofit corporation Entity having management capability.

14.21. Except as provided in item 1820, the entity Nonprofit Entity should not be able to vote itself out of existence.

22. A For Nonprofit Entities a third party (i.e., maintenance entity, service provider, etc.) should be identified to execute the specified operation and maintenance functions. in the event the operating entity is incapable of performance.

a. Service Providers for Nonprofit Entities overseeing extended treatment package systems should be certified in writing by the manufacturer for the servicing of their technology. The certification should be provided to the Director prior to approval.

15.23. The entity Nonprofit Entity should be able to plan and control how and at what time additional service functions will be extended or added.

16.24. The Articles of Incorporation and/or By-Laws should provide for proxy voting.

17.25. Proxies should not be binding on new purchasers.

18.26. The For community systems the developer of the project should be required to contribute to the operation and maintenance until such time as the nonprofit Nonprofit corporation Entity is self-sustaining. Consider either a specified period of time or when a specified number of lots has have been sold.

27. The ~~organization~~ Nonprofit Entity should have a defined service area boundary.

4.2.2 Notification Requirements

The Nonprofit Entity shall notify the Director for any of the following reasons:

1. Any content changes that occur to the Articles of Incorporation, Bylaws, or Membership Agreements that occur after initial approval by the Director shall be provided to the Director for review and approval prior to their implementation. Any changes that conflict with any portion of section 4.2.1 should not be approved.
2. Changes occur to the Board of Directors.
3. Service provider(s) are changed.
4. Sampling plan changes or adjustments are necessary.

4.2.3 Membership Agreements for Extended Treatment Package Systems

The membership agreement is separate from the Articles of Incorporation and Bylaws for the Nonprofit Entity but is a required element for membership in the Nonprofit Entity and to ensure that proper operation and maintenance will be performed (IDAPA 58.01.03.009.03). Membership agreements should contain the following elements:

1. Title of the membership agreement should include the words *lien notice, access easement, member agreement, and the name of the Nonprofit Entity*.
2. Contact information for the Nonprofit Entity should be listed including a mailing address and phone number.
3. A statement that annual fees will be assessed for services rendered by the Nonprofit Entity should be included.
4. The agreement should describe the exact services that are and are not included within the agreement (e.g., service, maintenance, annual testing, repairs, annual report submission, etc.).
5. The access easement language should be included.
6. A description of the lien process should be included.
7. The legal description of the property should be included.
8. A requirement that upon each sale of the property the buyer will sign an acknowledgement that they have reviewed the membership agreement and understand its requirements.
9. ~~1.~~ The agreement should state that the current property owner must disclose the terms of the membership agreement prior to any sales transaction of the property.

4.2.4 Sampling Plans for Extended Treatment Package Systems

Nonprofit Entities formed for the purpose of maintaining, servicing, and testing Extended Treatment Package Systems shall develop a sampling plan for the testing of effluent (IDAPA 58.01.03.009.03). Sampling plans should contain the following elements:

1. A signed letter from the manufacturer of the treatment technology certifying that the sampling method provided is acceptable for their technology.
2. A sampling location and design that is located after the secondary treatment unit for both gravity and pressurized systems.
3. Sample collection, preservation, and transportation techniques and methods that are in conformance with the latest edition of *Standard Methods for the Examination of Water and Wastewater*.
4. A way to collect all samples from a free flowing effluent pipe. Hose or portable water sources may be used to induce flowing condition but should be used as an option of last resort when access to a water source within the home is not available. If a hose or portable water source is used to induce a flowing condition the water source should discharge into the cleanout between the structure and primary septic tank. Cross connection and backflow prevention should be considered if hoses are used to induce flow.
5. Sample point cleaning and flushing procedures prior to sample collection.
6. Any necessary sampling device calibration techniques, equipment, and reagents.
7. ~~1.~~ Effluent field sample indicators that may be recommended for evaluation prior to collection of a grab sample. These indicators should provide indication that the treatment unit is operating properly.

Appendix B

4.10 Extended Treatment Package System

Revision: ~~January 4, 2011~~June 27, 2013

4.10.1 Description

Manufactured and *packaged* mechanical treatment devices that provide additional biological treatment to septic tank effluent. Such units may use extended aeration, contact stabilization, rotating biological contact, trickling filters, or other approved methods to achieve enhanced treatment after primary clarification occurs in an appropriately sized ~~primary clarifier (~~septic tank~~)~~. These systems provide secondary wastewater treatment capable of yielding high-quality effluent suitable for discharge in environmentally sensitive areas.

Extended Treatment Package Systems (ETPS) are required to have annual maintenance and effluent quality testing performed and reported to the Director as described within section 4.10 of the TGM (IDAPA 58.01.03.005.14). This maintenance is to be performed by an approved Operation and Maintenance Entity (O&M) (IDAPA 58.01.03.009.03). Property owners that install an ETPS unit must choose an O&M Entity capable of meeting their maintenance and effluent testing needs. Verification of the chosen O&M Entity shall be submitted with the subsurface sewage disposal permit application ensuring that the operation, maintenance, and monitoring (effluent quality testing) will occur (IDAPA 58.01.03.005.04.k). Property owners that do not want to meet these O&M requirements must meet the requirements of section 4.10.2(2) or choose another alternative system that will meet the conditions required for subsurface sewage disposal permit issuance.

4.10.2 ~~Operation, Maintenance, and Monitoring~~ Conditions for Approval

~~Procedures relating to operation, maintenance, and monitoring are required by IDAPA 58.01.03 (section 8.1) or may be required as a condition of issuing a permit, per IDAPA 58.01.03.005.14 (section 8.1) to ensure protection of public health and the environment.~~

1. A maintenance entity will be available to provide continued device operation and maintenance (O&M). Approval of the O&M Entity will be made by the Director ~~before~~ prior to the issuance of a permit. Approvable entities may include, but are not limited to, the following:

   a. Municipal wastewater treatment departments
   b. Water or sewer districts
   c. Nonprofit Corporations (see section 4.2)

   An O&M ~~Agreement~~ Entity membership agreement and an accompanying general access easement should be entered into between the property owner and the ~~Nonprofit~~ O&M Entity, as a necessary condition for issuing an installation permit (IDAPA 58.01.03.005.04.k). This agreement and the easement will be recorded with the County as a condition for issuing an installation permit.

2. Extended Treatment Package Systems (ETPS) may be used for single-family dwellingsproperties without an approved maintenance eO&M Entity **only under all of the following conditions**:

   a. The site is acceptable for a standard system. All separation distances from ground water, and surface waters, and limiting layers, and soil types shall be met.

   b. Enough land is available, and suitable, for two full-size drainfields. One complete full-size drainfield shall be installed.

   c. A state-approved effluent filter shall be used at the outlet of the package treatment system and before the drainfield.

3. Final effluent disposal through subsurface discharge will meet the following criteria:

   d. Surface discharge. System owner will apply for a National Pollution Discharge Elimination System Permit (NPDES) from the United States Environmental Protection Agency (EPA). Effluent quality will meet the applicable requirements of the “Water Quality Standards” (IDAPA 58.01.02), “Wastewater Treatment Requirements” (IDAPA 58.01.16), and all other applicable regulations.

   e. Ground water discharge. Effluent quality will meet the applicable requirements of the “Ground Water Quality Rule” (IDAPA 58.01.11), “Wastewater Rules” (IDAPA 58.01.16), and all other applicable regulations. Total Nitrogen discharge shall not exceed that specified in the development’s Nutrient–Pathogen (NP) Study in order to prevent the ground water from exceeding the “Ground Water Quality Standard” for nitrates (IDAPA 58.01.11.200.01.a) and to maintain and protect the existing and projected future beneficial ground water uses (IDAPA 58.01.11.006.02).

   a. Subsurface discharge. If an 85% reduction or better in Carbonaceous Biological Oxygen Demand ($CBOD_5$) and Total Suspended Solids (TSS) can be achieved, then the effluent may be discharged to a drainfield satisfying the Intermittent Sand Filter (section 4.23.5) or the Recirculating Gravel Filter Gravity Disposal Trenches (section 4.22.5) application rate criteria and vertical setback requirements.

      i. Otherwise, the effluent must be discharged to a standard drainfield, sized as directed in IDAPA 58.01.03.008 (section 8.1) and meeting the required effective soil depth for standard drainfields as directed in IDAPA 58.01.03.008.02.

      i.ii. Additional drainfield sizing reduction granted for use of gravelless trench products is not allowed.

   f.b. The 85% reduction is a qualitative criterion. The 85% reduction will be accepted as being met if the effluent exhibits a quantitative value obtained from laboratory analysis not to exceed 40 milligrams per liter (mg/L) (40 parts per million [ppm]) $CBOD_5$ and 45 mg/L (45 ppm) TSS.

g. c. Total Nitrogen (TN) reduction may be required for ETPS units located in an area of concern as determined through a Nutrient-Pathogen (NP) Evaluation. Permit specific TN reduction levels will be determined through the NP Evaluation. Results for TN are determined through the addition of TKN and Nitrate-Nitrite Nitrogen (TN = TKN + [NO_3+NO_2-N]). TN reduction will be accepted as being met if the effluent exhibits a quantitative value obtained from laboratory analysis not to exceed the TN level stipulated on the subsurface sewage disposal permit.

4.10.3 Operation, Maintenance, and Monitoring

Procedures relating to operation, maintenance, and monitoring are required by IDAPA 58.01.03.009.03 (section 8.1) or may be required as a condition of issuing a permit, per IDAPA 58.01.03.005.14 (section 8.1) to ensure protection of public health and the environment.

1. Operation and Maintenance

   a. Annual maintenance shall be performed on the ETPS unit as described in the ETPS manufacturer's operation and maintenance manual for the ETPS model as submitted under section 4.2.19.

   b. Additional maintenance not specified in the operation and maintenance manual may be required to ensure the ETPS functions properly.

   c. Records of each maintenance visit shall be kept and should include the following information for the primary maintenance visit:

      i. Date and time.

      ii. Observations for objectionable odors.

      iii. Observation for surfacing of effluent from the treatment unit or drainfield.

      iv. Notation as to whether the system was pumped since the last maintenance visit including the portions of the system pumped, pumping date, and volume.

      v. Sludge depth and scum layer thickness in the primary septic tank and treatment unit.

      vi. If responding to an alarm event provide the cause of the alarm and any maintenance necessary to address the alarm situation.

      i. vii. Field testing results for any system effluent quality indicators included in the approved sampling plan as submitted under section 4.2.4 or as recommended in section 4.10.3.2.b.

      viii. Record of any cleaning and lubrication.

      ix. Notation of any adjustments to control settings or equipment.

x. Test results for pumps, switches, alarms, blowers, etc.

xi. Notation of any equipment or component failures.

xii. Equipment or component replacement including reason for replacement.

xiii. Any recommendations for future service or maintenance and reasoning.

d. Any maintenance visit occurring after the primary annual maintenance visit should only record and address the reason for the visit and the associated activities that occur.

2. Monitoring

a. Annual effluent monitoring will be required for all ETPS units that discharge to a reduced size drainfield, to a drainfield with a reduced separation distance to ~~ground water~~limiting layers, and/or to a drainfield located in an environmentally sensitive area (area of concern).

i. Annual monitoring included in the Annual Report must occur within the reporting period.

b. It is recommended that prior to collecting effluent samples from the treatment unit for laboratory analysis that effluent quality indicators be field tested as described in the approved sampling plan for the O&M Entity. All recommendations included in 4.10.3.2.b are recommendations only and should be verified with the treatment technology manufacturer as acceptable with their field sampling plan and as suitable effluent quality indicators. Field testing is recommended to include, but may not be limited to:

i. Visual examination for wastewater color, odor, and effluent solids.

ii. The following constituents:

Constituent	Acceptable Range
pH	6 to 9
Dissolved Oxygen (DO)	≥ 2 mg/L
Turbidity	≤ 40 NTU

Table 4-5. Recommended field testing constituents for effluent quality indication.

c. Monitoring samples provided to a laboratory will analytically quantify that the units are operating in compliance, provided samples do not exceed 40 mg/L (40 ppm) for $CBOD_5$ and 45 mg/L (45 ppm) for TSS.

i. Results for $CBOD_5$ and TSS that exceed these levels indicate the ~~pretreatment device~~ ETPS unit is not achieving the required reduction levels. ~~*$CBOD_5$ monitoring will replace Biological Oxygen Demand (BOD_5) monitoring effective January 1, 2008.*~~

~~b.~~d. For those systems installed in areas of concern, including nitrogen sensitive areas, or are used to fulfill NP ~~Study~~ Evaluation results and requirements, the following additional constituents may be monitored as stipulated on the permit:

i. ~~a)~~ Total Kjeldahl Nitrogen (TKN)
ii. ~~b)~~ Nitrate-Nitrite nitrogen (NO3+NO2-N)
iii. ~~c)~~ Results for Total Nitrogen (TN = TKN + [NO3+NO2-N]) that exceed the levels stipulated on the installation permit, in the subdivision approval for sanitary restrictions release, or the approved NP ~~Study~~Evaluation, indicate that the device is failing to achieve the required reductions

~~c. Laboratory results that exceed the numerical Total Nitrogen values specified in the Total Nitrogen column of Table 8-1 (section 8.6) indicate that the treatment device is not achieving the required percent nitrogen reduction, specified in the Total Nitrogen Reduction (%) column of Table 8-1.~~

e. Samples will be collected, stored, transported, and analyzed according to the latest version of *Standard Methods for the Examination of Water and Wastewater* ~~(Rice et. al 2012)~~ and other acceptable procedures.

i. Each sample will have a Chain-of-Custody sheet, identifying, at a minimum, the sample's source (street address or installation permit number), date and time of collection, and the person who extracted the sample(s).

ii. The Chain-of-Custody sheet should also specify the laboratory analyses to be performed on the sample(s).

~~i.~~iii. Sample storage and transport will take place in appropriate containers under appropriate temperature control.

~~d.~~ Samples will be required to be analyzed by a certified laboratory capable of analyzing wastewater according to the acceptable standards identified below, and the monitoring results will be submitted as part of the Annual Report to the local health district. ~~The annual report shall be submitted no later than July 31 of each year for the preceding 12-month period. Reporting period is from July 1 of the preceding year through June 30 of the reporting year.~~

i. Analysis of ETPS effluent shall be performed using the following standards from the *Standard Methods for the Examination of Water and Wastewater* (NSF utilizes the same standards in their Standard 40 and 245 evaluations):

Analysis	**Standard Method Number**
Total Suspended Solids (TSS)	SM 2540 D
Carbonaceous Biological Oxygen Demand ($CBOD_5$)[a]	SM 5210 B
Total Kjeldahl Nitrogen (TKN)	SM 4500-NH_3 C
Nitrate-Nitrite Nitrogen (NO_3 + NO_2-N)	SM 4500-NO_3^- F

a – Person requesting the analysis from the lab must specify the $CBOD_5$ on the Chain-of-Custody paperwork.

Table 4-6. Standard methods required to be utilized for the analysis of ETPS effluent in annual testing.

ii. Annual reports submitted with laboratory analysis results differing from these standard methods will be rejected.

g. Samples failing to achieve the required effluent constituent levels shall require:

i. Additional operations and maintenance ~~will be required~~ for devices that fail to achieve the above reductions.

ii. Additional sampling ~~will be required~~ to demonstrate the operation and maintenance performed successfully restored the treatment system to proper operation.

1. Sample extraction and analysis should occur within 30 days after servicing the system.

~~1.~~2. A maximum of three ~~servicing and subsequent monitoring~~sampling events, within 90 days, will be allowed to return the system to proper operation. Failure to correct the system within this time frame will result in the system being classified as a *failing system* (Figure 4-8).

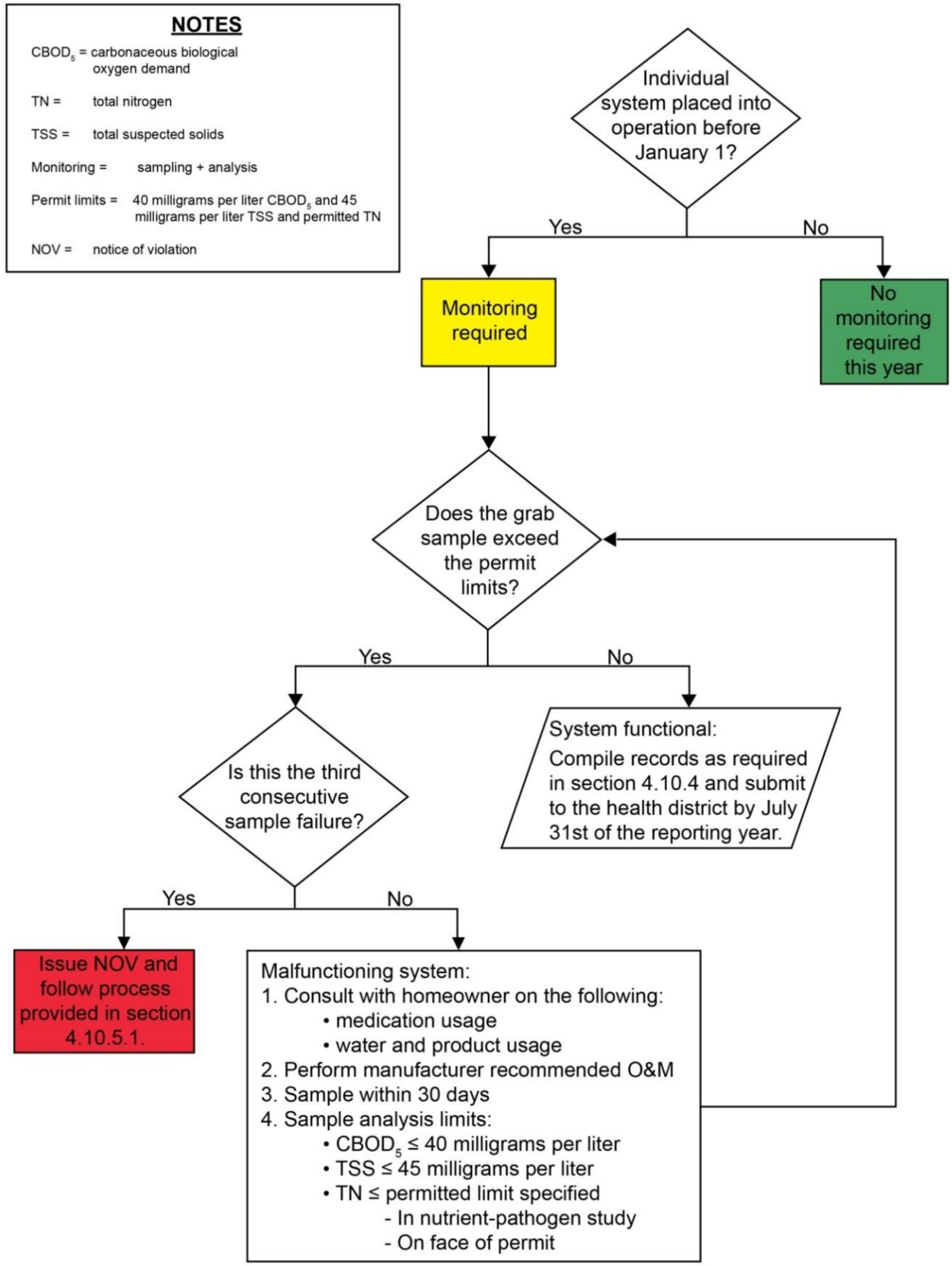


Figure 4-8. ETPS unit individual system sampling process.

4.10.4 Annual Report

The reporting period is from July 1 of the preceding year through June 30 of the reporting year. Annual reporting is the responsibility of the property owner (member), it is recommended that the property owner have their O&M Entity compile and submit their annual report. The property owner responsible under the Individual/Subsurface Sewage Disposal Rules for the ETPS unit shall ensure that the following annual reporting requirements are met:

1. The Annual Report for each property owner shall include the following items:
    a. A copy of all maintenance records for the reporting period as required under section 4.10.3.1.
    b. A copy of all certified laboratory records for effluent sampling.
    c. A copy of each Chain-of-Custody record associated with each effluent sample.
2. If the O&M Entity is fulfilling annual reporting requirements for their members it is recommended that the following additional information be included within the annual report:
    a. A current list of all members of the O&M Entity within the health district to which the Annual Report was submitted.
    b. The member list should clearly identify which members the O&M Entity is contracted with for annual reporting requirements and the status of each member in regards to completion of the Annual Reporting requirements.
    c. If Annual Reporting requirements are not complete for any given member for whom the O&M Entity is responsible for providing the Annual Report an explanation should be included with that member's records within the Annual Report.
3. Annual Report Exemptions:
    a. A member may be exempt from effluent testing based upon extreme medical conditions.
        ~~The member's Annual Report must include a doctor's note indicating that a resident of the property has been prescribed medication for the reporting period that will prevent the ETPS unit from testing correctly.~~
        i. Annual service and maintenance on the member's ETPS unit shall not be exempt due to medical conditions and record of annual service and maintenance shall still be submitted with the member's Annual Report.
    b. An O&M Entity contracted by a member to fulfill Annual Reporting requirements may be exempt from reporting annual service and testing results for individual members if that member's activities fall under section 4.10.6 of this manual.

i. The O&M Entity should still report the activities described under section 4.10.6 of this manual for each member exempt from annual reporting through this section.

4. The annual reporting process:

a. The annual report shall be submitted by the property owner or the O&M Entity on behalf of their member no later than July 31 of each year for the preceding 12-month period to the local health district.

i. The Annual Reports shall be submitted to the local health district that issued the subsurface sewage disposal permit for, and has jurisdiction over, the ETPS unit.

b. The local health district shall provide the O&M Entity a written response within 30 days of receipt of the Annual Report detailing compliance or non-compliance with septic permit requirements.

i. The O&M Entity should inform individual members of their compliance status.

ii. All correspondence from the health districts regarding a noncompliant Annual Report shall be copied to DEQ.

5. Delinquent Annual Reports:

a. If the property owner or their O&M Entity contracted to submit the member's Annual Report does not submit the Annual Report by July 31st of the reporting year the local health district shall send the property owner, or O&M Entity contracted to submit the member's Annual Report, a reminder letter providing a secondary deadline for annual report submission of August 31st of the reporting year. The reminder letter shall detail the report requirements and that failure to submit the Annual Report by the secondary deadline will result in the district forwarding a notice of non-report to DEQ. DEQ may seek any remedy available under the Individual/Subsurface Sewage Disposal Rules, including without limitation requiring the property owner to replace the ETPS unit with another system, as outlined in section 4.10.5.

~~ii.~~i. All correspondence from the health district regarding delinquent Annual Reports shall be copied to DEQ.

4.10.5 ETPS System Failure, Disapproval, and Reinstatement

Commercially manufactured wastewater treatment components must be approved by DEQ (IDAPA 58.01.03.009.01). Manufactured ETPS units are subject to this approval. In addition, the installation of an ETPS unit requires a subsurface sewage disposal permit pursuant to IDAPA 58.01.03.005. ETPS units are alternative systems that must be approved by the Director pursuant to IDAPA 58.01.03.004.10. As part of the alternative system approval for ETPS units DEQ defines the specific circumstances under which the ETPS units may be installed, used, operated, and maintained within section 4.10 of the TGM (IDAPA 58.01.03.009.03 and 58.01.03.005.14).

If an ETPS product is not shown to be installed, used, operated, or maintained as described within section 4.10 of the TGM DEQ may pursue enforcement against a property owner and seek those remedies available under IDAPA 58.01.03. Enforcement and remedies against a property owner may include a determination that the ETPS system has failed and the requirement that the property owner replace the ETPS unit with a different system authorized by DEQ. This may include the installation of another ETPS unit approved by DEQ or the engineering and installation of another alternative system that is capable of meeting the requirements of the property owner's subsurface sewage disposal permit. If an ETPS product is not shown to be in compliance or to consistently function in compliance with IDAPA 58.01.03 and the operation and maintenance requirements outlined in section 4.10 of the TGM, DEQ may disapprove the ETPS unit. Reasons for DEQ enforcement, which may include seeking remedies against a property owner or disapproval of an ETPS manufacturer's technology as outlined herein, but are not limited to, the following:

1. Failure to submit an Annual Report by the secondary deadline of August 31st.
2. If ~~an O&M Entity's~~the Annual Reports for a particular ETPS technology identifies a malfunctioning system rate~~s~~ of 10% or more.~~,~~
    a. Malfunctioning systems are defined as any system that fails to receive annual maintenance or exceeds the effluent reduction levels for any constituent required as part of the septic permit (i.e., TSS, $CBOD_5$, or TN).
3. If a property owner's ETPS unit has been determined to be a failing system.
    a. Failing ETPS units are defined in section 4.10.3(2)(g).

4.10.5.1 Failing System Enforcements

The regulatory authority shall follow the following procedures upon determination that an ETPS unit is a failing system (Figure 4-9):

1. When the regulatory authority is notified that a system is failing a Notice of Violation (NOV) shall be issued to the property owner. The property owner shall have the opportunity to hold a compliance conference with the regulatory authority to enter into a consent order.
2. Consent orders should allow a property owner a 12 month period in which to return the system to proper operation or replace the failing system.
    a. Over this 12 month period the property owner should have their O&M Entity service the ETPS unit at least monthly.
    b. Monthly effluent samples should be required to be taken by the O&M Entity until the ETPS unit passes 3 consecutive monthly samples.

i. Three consecutive passing monthly samples taken one month apart from one another would be cause for the regulatory authority to terminate the consent order and NOV, and reclassify the system as compliant.

c. Operation and Maintenance records as described in section 4.10.3.1, certified laboratory records, and Chain-of-Custody records for each sample should be submitted to the regulatory authority on a monthly basis as part of the consent order.

d. If the ETPS unit is not capable of producing 3 consecutive monthly samples over the 12 month period the system shall be replaced with another alternative system capable of meeting the effluent quality requirements based upon applicable site conditions.

~~a.~~e. Appropriate replacement systems may include a sand mound with 24 inches of sand beneath the absorption bed, intermittent sand filter, recirculating gravel filter, or a different ETPS unit that is approved and has an active O&M Entity.

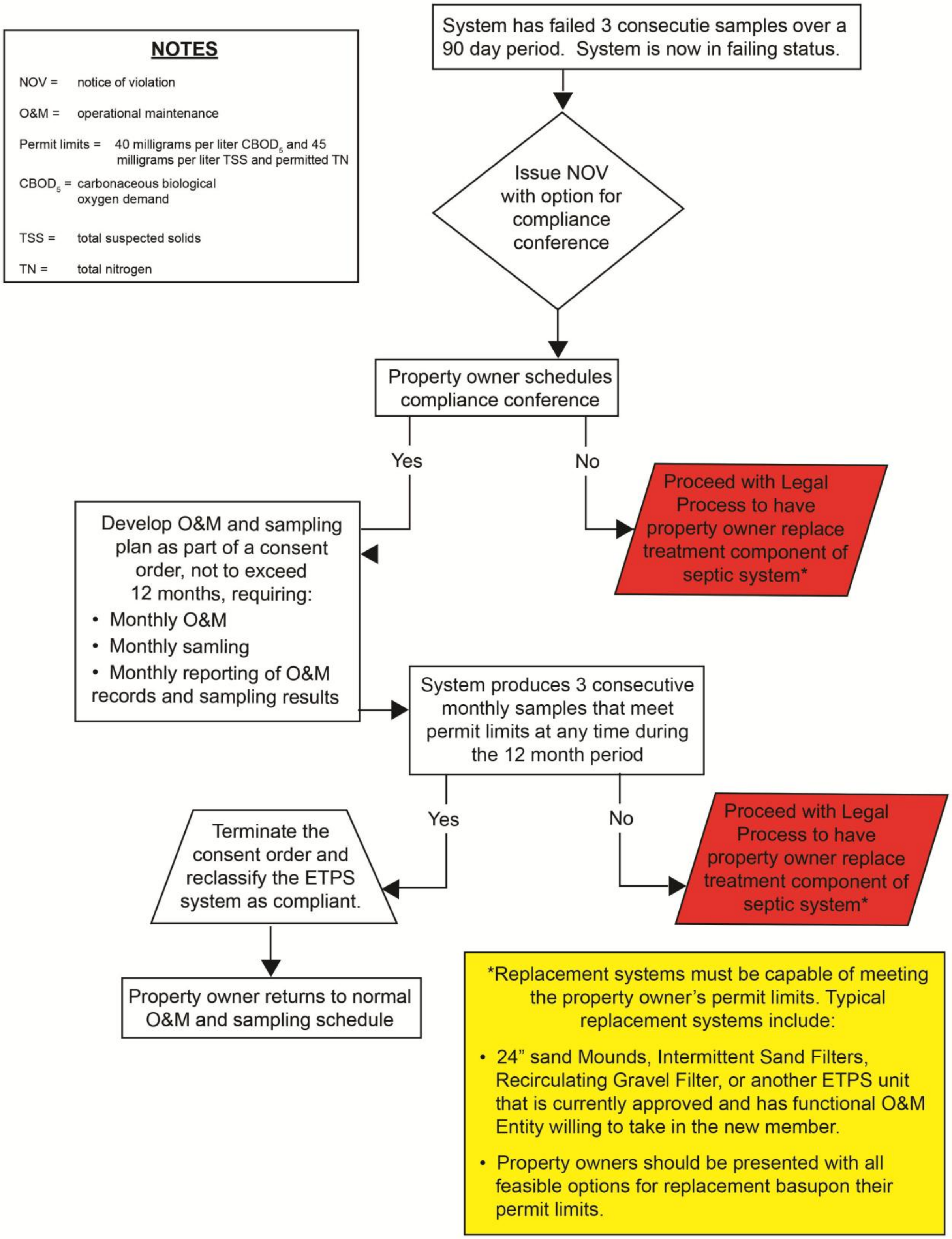


Figure 4-9. ETPS failing system enforcement flowchart.

4.10.5.2 ETPS Product Disapproval

In addition to determining a particular system is a failing system as set forth in section 4.10.5.1, if DEQ determines that an ETPS unit cannot consistently function in compliance with IDAPA 58.01.03, DEQ may disapprove the product (IDAPA 58.01.03.009.04). A notice of DEQ's intent to disapprove the product will be detailed in writing following Idaho Code, title 67, chapter 52, and sent to the ETPS product manufacturer, O&M Entity, and the health districts. The ETPS manufacturer will be allowed an opportunity to respond prior to product disapproval. Upon disapproval of an ETPS product the health districts shall not issue septic system permits on new applications for ETPS systems from the disapproved product manufacturer supplied by a specific O&M Entity. Monitoring, reporting, and servicing requirements of existing ETPS unit installations will not be affected by the product disapproval (Figure 4-10).

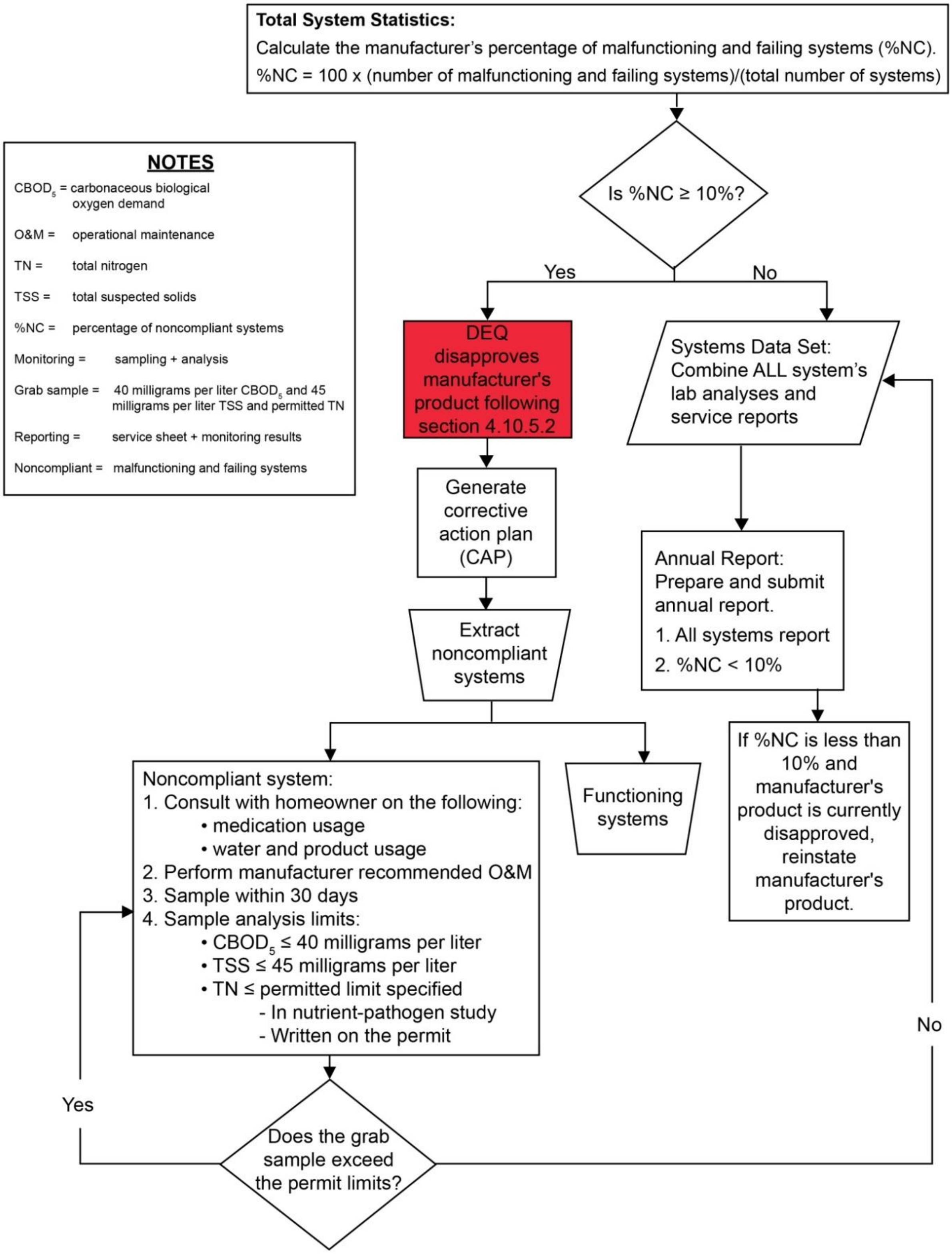


Figure 4-~~9~~10. ETPS product disapproval process based upon annual reports.

4.10.5.3 ETPS Product Reinstatement

Upon ETPS product disapproval DEQ will provide the opportunity for the ETPS product manufacturer to enter into a Corrective Action Plan (CAP) for the purposes of product reinstatement. The CAP should establish the time frame to return the noncomplying or failing systems to proper operation. The ~~suspension~~product disapproval will remain in effect until the malfunctioning and failing system rate for the ETPS manufacturer's technology is below 10%.

4.10.6 Member Refusal of Maintenance or Testing Requirements

It is the responsibility of the individual Nonprofit O&M Entity members (property owners) to ensure the O&M Entity is capable of performing the necessary annual maintenance and effluent testing required for their ETPS unit. Failure of an individual member to permit the O&M Entity from carrying out the required services is considered a violation of IDAPA 58.01.03.012.01. The following activities from a property owner toward their O&M Entity may be considered as refusal of service actions by a member, and may not be limited to:

1. Refusal to allow annual maintenance or effluent quality testing (e.g., refusal to pay annual dues preventing the financial capability of service, denial of property access, etc.).
2. Refusal to maintain the ETPS unit in operating condition (e.g., refusal to replace broken components, refusal to provide electricity to the unit, etc.).
3. If the refusal of service continues through the Annual Reporting Period the Nonprofit O&M Entity should substitute the following documents in the Annual Report for members refusing service that the O&M Entity is contracted with to submit their Annual Report:
    a. Copies of all correspondence and associated certified mail receipts documenting the property owner's receipt of the correspondence regarding the refusal of service. Refusal of service by a member through non-payment should include documentation of a lien being placed on the member's property.
        i. If the documentation is not included within the Annual Report, there will be insufficient documentation of the property owner's refusal to allow maintenance and monitoring, and therefore, the lack of maintenance and monitoring may count against the malfunctioning rate for the ETPS technology.

4.10.6.1 Refusal of Service Enforcement Procedures

Upon receipt of an Annual Report that shows that individual O&M Entity members have refused to allow maintenance and monitoring as set out in section 4.10.6 of this guidance the following guidelines shall apply:

1. The regulatory authority shall issue Letter 1 and the associated enclosure that was provided in the DEQ Program Directive dated xxxx.

   a. This letter shall be sent to the property owner via certified mail and copied to the associated O&M Entity.

   b. It is the property owner's responsibility to work with the regulatory authority and their O&M Entity to address their delinquent responsibilities. The O&M Entity should contact the regulatory authority and associated property owner 30 days after receipt of Letter 1 informing the regulatory authority of the property owner's voluntary compliance status.

2. If the property owner fails to voluntarily comply within the 30 day timeframe the regulatory authority shall issue Letter 2 that was provided in the DEQ Program Directive dated xxxx.

   a. This letter shall be sent to the property owner via certified mail and copied to the associated O&M Entity.

   b. It is the property owner's responsibility to work with the regulatory authority and their O&M Entity to address their delinquent responsibilities. The O&M Entity should contact the regulatory authority and associated property owner by the voluntary compliance date provided within Letter 2 informing the regulatory authority of the property owner's voluntary compliance status.

3. If the property owner fails to voluntarily comply by the date provided in step 2 of this process the regulatory authority shall issue a Notice of Violation to the property owner to ensure compliance with the property owner's subsurface sewage disposal permit requirements in regards to the ETPS unit.

1. ~~DEQ will suspend the O&M Entity and require that the O&M Entity, affected homeowners, and service provider, in cooperation with the local health district, enter into a Corrective Action Plan (CAP). The CAP should establish the time frame to return the noncomplying systems to proper operation. The suspension will remain in effect until the malfunctioning system rate is below 10%. Suspension will only prevent issuing additional O&M agreements. Existing system monitoring, reporting, and servicing requirements will not be affected by a suspension (Figure 4-9).~~

4. ~~If the system is experimental, the system owner will provide a waiver of liability absolving the Department and the health districts of any liability arising from operation or malfunction of the system.~~

~~4.10.3~~4.10.7 Design of ETPS Units

Procedures relating to design are required by IDAPA 53.01.03 (section 8.1) or may be required as permit conditions, as appropriate, to ensure protection of public health and the environment.

1. All materials will be durable, corrosion resistant, and designed for the intended use.
2. All electrical connections completed on site shall comply with the National Fire Protection Association (NFPA) Standard NFPA 70, National Electrical Code, as required by the Idaho Division of Building Safety, Electrical Bureau.
3. Design for each specific application should be provided by a PE licensed in the State of Idaho ~~specializing in environmental or sanitary engineering~~.
4. The system's aerobic treatment section will be preceded by ~~a primary clarifier~~an appropriately sized septic tank. The ~~primary clarifier~~septic tank may be either a separate septic tank, a volume integral with the system's package, or a combination of internal clarifier volume coupled with an external tank. The ~~primary clarifier~~septic tank shall provide the minimum tank capacity for residential facilities as specified in IDAPA 58.01.03.007.07.a, or for nonresidential facilities a minimum of 2-days hydraulic residence time (HRT) as stipulated in IDAPA 58.01.03.007.07.b. Timed dosing from the clarifier to the aerobic treatment unit is preferred, and highly recommended, to maintain a constant source of nutrients for the system's aerobic microbes.
5. ~~4.~~Manufactured and *packaged* mechanical treatment devices will be required to prove that the specified equipment model meets the ETPS product approval policy outlined in section 1.4.2.2.~~:~~
   - ~~a. Has successfully completed National Sanitary Foundation (ANSI/NSF) standard 40 testing, or~~
   - ~~b. Has successfully completed an EPA-sanctioned Environmental Technology Verification (ETV) test, or~~
   - ~~c.~~d. ~~Was designed by a PE licensed in the State of Idaho specializing in sanitary or environmental engineering~~.

~~4.10.4~~4.10.8 Construction

Procedures relating to construction are required by IDAPA 58.01.03 (section 8.1) or may be required as permit conditions, as appropriate, to ensure the protection of public health and the environment.

1. Installation
   - a. ~~The system shall be installed by an appropriately qualified installer. IDAPA 58.01.03.003.35 defines system as "Beginning at the point of entry~~

~~physically connected piping, treatment devices, receptacles, structures, or areas of land designed, used or dedicated to convey, store, stabilize, neutralize, treat, or dispose of blackwaste or wastewater." Consequently, the system includes the drainfield.~~

a. A licensed complex system installer shall be required to install an ETPS unit and all other portions of the septic system connected to the ETPS unit, or that the ETPS unit discharges to (IDAPA 58.01.03.006.01.b).

b. A public works contractor may install an ETPS unit if they are under the direct supervision of a PE licensed in the State of Idaho.

c. Licensed plumbers and electricians will be required to install specific devices and components for proper system operation. If the device requires any on-site fabrication or component assembly, a public works contractor should be used.

~~c.~~d. A sample port will be installed in the effluent line after the aerobic treatment unit.

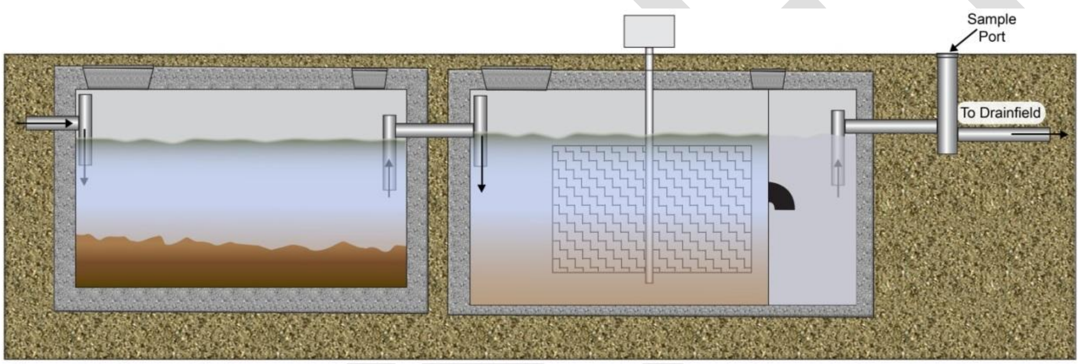


Figure 4-11. Sampling port example.

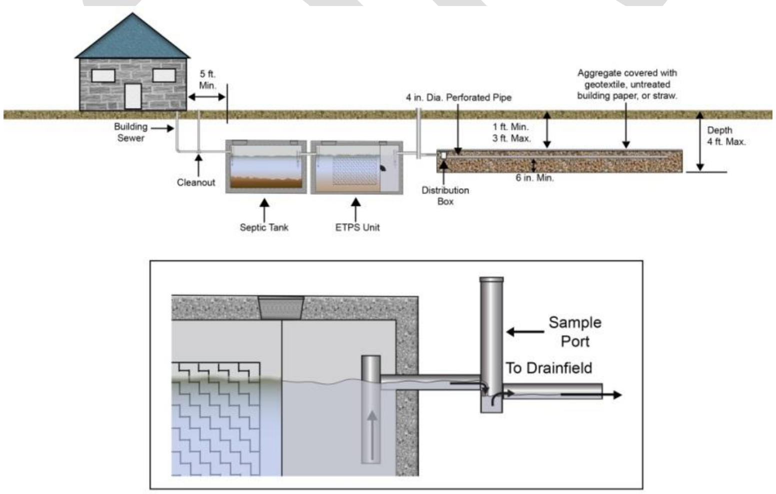


Figure 4-12. Sampling port and drainfield.

2. Within ~~90~~ 30 days of completing the installation the property owner shall provide certification to the regulatory authority, from their O&M Entity, that the system has been installed and is operating in accordance with ~~design and/or~~ the manufacturer's recommendations (IDAPA 58.01.03.005.15).

   a. A statement requiring the submission of the installation verification form described above shall be written on the face of the subsurface sewage disposal permit.

   ~~a.~~b. The regulatory authority shall hold the finalization of the subsurface sewage disposal permit until the certification of proper installation and operation is received.

~~*Note*: If a health district has questions regarding application of this guidance document to a proposed system, contact DEQ.~~

Figure 4-8 shows the ETPS sampling process for an individual system, ~~and~~ Figure 4-9 shows the ~~reporting~~ enforcement process for ~~an O&M Entity~~a failing system, Figure 4-10 shows the ETPS product disapproval process, Figure 4-11 shows the placement of a sampling port after the ETPS unit, and figure 4-12 shows the sample port and drainfield after the septic and treatment tank.

Appendix C

Dear Extended Treatment Package System Owner,

The Department of Environmental Quality (DEQ) would like to take this opportunity to provide some information about the treatment component of your septic system. This is a reminder of the annual service and testing of the treatment unit that is vital to your system's performance, drainfield life, and required as a condition of your septic permit. Improper operation and maintenance could lead to premature failure and costly replacement of your drainfield. The issuance of the septic permit for your property required a treatment component in order to install the drainfield. Without the septic permit the construction of buildings necessitating sewer connections on your property would not be possible.

Extended Treatment Package Systems provide pretreatment to your wastewater prior to its discharge to the drainfield portion of your septic system. These treatment units reduce waste strength and nutrients (particularly nitrogen) in wastewater. For more information on these systems and your drainfield please view the *Aerobic Treatment Systems and Drainfields: What You Need to Know* brochure on the DEQ website located at
http://www.deq.idaho.gov/media/657393-aerobic_treatment_systems_and_drainfields_brochure.pdf.

Per your member agreement contract you are required to work with your Operation and Maintenance Entity and Service Provider to ensure that annual servicing and testing of your treatment unit is scheduled. Protection of public health and the environment is a team effort. Your participation in this program is a critical aspect to its success and is a requirement of the septic system permit for your property.

Thank you for your cooperation.

Sincerely,

The Idaho Department of Environmental Quality

State of Idaho
Department Of Environmental Quality
Technical Guidance Committee

Appendix D

August 20, 2013 [Certified Mail No.]

[Name]
[Address]
[City, State]

Re: Extended Treatment Package System Service, Maintenance, and Testing

Dear [Name],

It has come to our attention that you have not had your [insert manufacturer's name] extended treatment package system (ETPS) [maintained and/or tested] for this reporting year. The subject property is located at [address or legal description]. It is a requirement of the septic permit issued for your property that the ETPS unit has annual maintenance performed and the effluent quality tested through your Operation & Maintenance Entity (O&M Entity) and the O&M Entity's associated Service Provider. According to our records your O&M Entity and Service Provider contacts are:

O&M Entity:
Entity Contact Name
Entity Business Name
Entity Address
Phone Number

Service Provider:
SP Name
SP Business
SP Address
Phone Number

Your ETPS unit is under contract with this O&M Entity through a Member Agreement. This agreement is recorded with your County. It is the homeowner's responsibility to ensure the ETPS unit is provided with maintenance, and that the effluent quality discharged from the unit is tested annually. Failure to have annual maintenance performed and effluent quality tested for your ETPS unit places you in violation of the Subsurface Sewage Disposal Rules. Please work with your O&M Entity to schedule your annual maintenance and effluent quality testing. If you have any questions regarding your Member Agreement or the necessary requirements to schedule your maintenance and testing appointment please contact your O&M Entity. If you have questions concerning regulatory requirements regarding your ETPS system please contact [insert health district name] at [insert phone number]. Your cooperation in meeting the requirements of your septic permit is appreciated.

Sincerely,

[Regulator Name]
[Regulator Title]

c: [O&M Entity]

Enclosure

Dear Extended Treatment Package System Owner,

The Department of Environmental Quality (DEQ) would like to take this opportunity to provide some information about the treatment component of your septic system. This is a reminder of the annual service and testing of the treatment unit that is vital to your system's performance, drainfield life, and required as a condition of your septic permit. Improper operation and maintenance could lead to premature failure and costly replacement of your drainfield. The issuance of the septic permit for your property required a treatment component in order to install the drainfield. Without the septic permit the construction of buildings necessitating sewer connections on your property would not be possible.

Extended Treatment Package Systems provide pretreatment to your wastewater prior to its discharge to the drainfield portion of your septic system. These treatment units reduce waste strength and nutrients (particularly nitrogen) in wastewater. For more information on these systems and your drainfield please view the *Aerobic Treatment Systems and Drainfields: What You Need to Know* brochure on the DEQ website located at
http://www.deq.idaho.gov/media/657393-aerobic_treatment_systems_and_drainfields_brochure.pdf.

Per your member agreement contract you are required to work with your Operation and Maintenance Entity and Service Provider to ensure that annual servicing and testing of your treatment unit is scheduled. Protection of public health and the environment is a team effort. Your participation in this program is a critical aspect to its success and is a requirement of the septic system permit for your property.

Thank you for your cooperation.

Sincerely,

The Idaho Department of Environmental Quality

Appendix E

August 20, 2013 [Certified Letter No.]

[Name]
[Address]
[City, State]

Re: Voluntary Deadline to Comply with ETPS Maintenance and Effluent Testing Requirements

Dear [Name],

[Regulatory Agency Name] has been informed that you are refusing to meet your responsibility and requirements surrounding your [insert manufacturer's name] extended treatment package system (ETPS). As described in this Department's letter sent to you dated [insert letter 1 date] you are responsible for having annual maintenance performed on your ETPS unit and for annual testing of effluent quality discharged by the unit. Per *IDAPA 58.01.03.002.04.a.i* it is the responsibility of the property owner to treat and dispose of wastewater generated on their property in accordance with their subsurface sewage disposal permit.

You are responsible for the completion of your unit's annual maintenance and effluent quality testing. The results of the annual maintenance and testing are required to be submitted to this Department by July 31st of each year. As of the issuance of this letter you are delinquent in meeting these requirements by [insert number of days past July 31st]. This Department is providing you a 30 day window to voluntarily meet the requirements and responsibilities of your septic permit (see enclosure). You have until [insert voluntary compliance date] to accomplish your required annual maintenance and effluent quality testing. **After this date this Department may issue a Notice of Violation to you for failure to meet the requirements of *IDAPA 58.01.03.002.04.a.i, 58.01.03.004.01, 58.01.03.005.14, and 58.01.03.012.01-03*.** To view the requirements of these Rules please reference the Individual/Subsurface Sewage Disposal Rules located at http://www.deq.idaho.gov/water-quality/wastewater/septic-systems.aspx.

Please contact your O&M Entity to schedule your required annual maintenance and testing of effluent quality.

O&M Entity:

Entity Contact Name
Entity Business Name
Entity Address
Phone Number

Your O&M Entity should report the status of the completion and compliance of these activities on [insert voluntary compliance date]. Your cooperation in meeting the requirements of your septic permit is appreciated.

Sincerely,

[Regulator Name]
[Regulator Title]

c: [O&M Entity]
[County Prosecuting Attorney]

Enclosure (septic permit and member agreement)

Appendix F

1.4.2.2 Extended Treatment Package System Approvals

Manufacturers seeking approval of an Extended Treatment Package System (ETPS) technology shall submit product information to the DEQ On-Site Wastewater Coordinator for review by DEQ. In addition to product information (i.e., engineering designs and product manuals) manufacturers seeking approval on their ETPS units for reduction of Total Suspended Solids (TSS) and Carbonaceous Biological Oxygen Demand ($CBOD_5$) will need to submit National Sanitation Foundation (NSF)/American National Standards Institute (ANSI) Standard 40 and 360 approvals, reports, and associated data. Manufacturers also seeking approval on their ETPS units for reduction of Total Nitrogen (TN) will need to submit NSF Standard 245 approvals, reports, and associated data. Any additional third party standards evaluated for the ETPS unit will also need to be submitted including approvals, disapprovals, reports, and associated data.

DEQ will issue ETPS product approval in conjunction with associated reduction levels for TSS, $CBOD_5$, and TN. Reduction levels will be determined through statistical analysis of the data included in the third party standards. Third party reports average reduction values will not be accepted to establish system performance approvals. The third party data will be statistically evaluated to determine a resulting value that corresponds to the 95% upper confidence limit. The resulting value that corresponds to the 95% upper confidence limit will be used as the system's initial performance limit.

ETPS units that have not undergone third party testing and wish to be approved for reduction in TSS, $CBOD_5$ and TN must be permitted and installed under the Experimental System guidance in Section 4.9. ETPS units installed under the Experimental System guidance in an attempt to gain approval for effluent reduction levels shall follow the minimum operation, maintenance, and effluent testing procedures outlined in Section 4.10.3, and be installed in an area suitable for a standard system with no reduction in drainfield sizing or separation distance requirements. Operation, maintenance, and effluent testing requirements shall be written into the experimental system's permit.

To obtain approval for TSS, $CBOD_5$, or TN reduction without third party data, or to lower reduction levels from initial approval for any constituent, the manufacturer of the ETPS unit or their representative must submit data from their ETPS units installed in Idaho. Data from other states will not be considered under this approval process. Any data submitted must be specific to a particular ETPS make and model. Data submission must include information on 30 installations with a minimum of 3 full years of operational data on each system. All maintenance and effluent testing records, as described in Section 4.10.3, obtained over this period must be submitted for review. For adjustment in reduction levels of effluent constituents to be approved the data must show that 90% of the installed units have successfully maintained effluent reduction levels at or below the desired reduction approval level during the entire testing period.

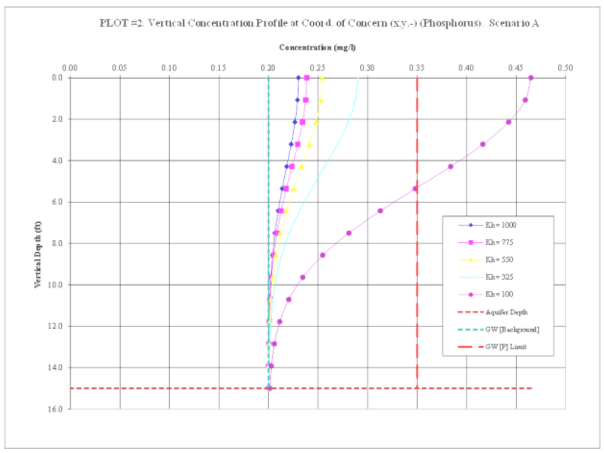
Prior to product approval manufacturers must have an Operation and Maintenance Entity setup for their ETPS units as described in section 4.2 of the TGM prior to any non-experimental permits being issued for system installation. The Operation and Maintenance Entity must be capable of fulfilling the requirements of section 4.2 and 4.10 of the TGM prior to product approval.

Appendix G

See the following pages for the On-Site Setback Distance Determination: Modeling Phosphorous in the Environment as the Critical Constituent document.

On-Site Setback Distance Determination

Modeling Phosphorus in the Environment as the Critical Constituent



State of Idaho
Department of Environmental Quality
Technical Services Division

June 2013

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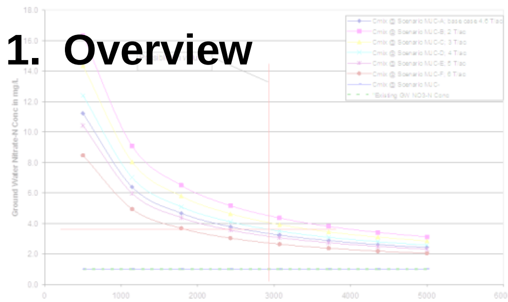
1. Overview



1.1 Synopsis

The *Phosphorus-Based On-Site Setback Determination Model* (POSDM) is a technical and scientific means to determine setback distances from surface water for domestic subsurface sewage disposal (SSD) systems. This software tool takes into account effluent quality, drainfield characteristics, aquifer characteristics, ground water quality, and surface water body characteristics to calculate an appropriate setback distance from surface water. The model only addresses phosphorus (P) as the constituent of concern. Prior to using this model, landowners and/or their consultants must consider other wastewater constituents, such as nitrate and pathogens, and obtain a determination from the Idaho Department of Environmental Quality (DEQ) that the other wastewater constituents are deemed insignificant.

The model consists of three *stages* corresponding to the effluent (and thus the contaminate transport) flow path:

1. Effluent application to the drainfield and soil sorption (removal) of P from effluent
2. Mixing of percolate discharging from the drainfield with ground water, and the subsequent transport along the ground water flow path
3. Mixing of ground water discharging into the receiving surface water body.

The first stage of the model predicts how much P can be sorbed to the soils beneath the distribution field before the soil P sorption capacity is fully utilized. The model also estimates the P concentration and volume of percolate discharging to ground water. The higher the P fixing capacity of the soil, the longer the site can be utilized.

The second stage of the model predicts resulting P concentrations as ground water and percolate from the drainfield mix. As ground water travels downgradient from the drainfield, P concentrations change both with distance and depth.

The resulting P concentration in ground water as it encounters a surface water body is used for the third stage of the model. The third stage of the model consists of estimating the resulting P impacts to the surface water body as ground water discharges into, and mixes with, the surface water body.

Several possible compliance points can be considered with this model. These include (a) a drainfield site life based on the P sorption capacity of the soils; (b) a maximum P concentration of percolate discharging from the drainfield; (c) a maximum ground water P concentration a specified distance downgradient of the drainfield; (d) a mass discharge amount into a surface water body; or (e) a maximum P concentration in a surface water body after mixing with discharging ground water.

The POSDM design is a series of user-friendly spreadsheets where the required information can be easily entered, and determination of appropriate setback distances to surface water calculated and clearly displayed. The theory behind the model is complex. Consequently, parameter selection and model use should only be pursued by environmental professionals (such as a professional engineer or geologist) with expertise in environmental system modeling.

1.2 Introduction

Many properties in Idaho that are adjacent to surface water are not near municipal wastewater collection and treatment facilities. Furthermore, some of these properties may not be large enough to place an on-site wastewater drainfield the required distance away from the surface water. This situation hinders installation of, or access to, suitable wastewater treatment facilities, which prohibits building a structure supplied with pressurized water. It may be possible, however, to utilize shorter setbacks that still appropriately protect public health and water quality.

Recognizing the ever-advancing technology related to sewage disposal, the "Individual/Subsurface Sewage Disposal Rules" (Idaho Administrative Procedures Act (IDAPA) 58.01.03) state that alternative systems may be permitted if in accordance with the Technical Guidance Committee's recommendation and approved by the Director. (IDAPA 58.01.03.004.10.) Disposal via a pressurized drainfield is an approved alternative system under the Individual/Subsurface Sewage Disposal Rules. The Director may grant a variance from the dimensional or construction requirements for a system in certain circumstances, e.g., where the variance will not have an adverse impact on the public health or the environment (IDAPA 58.01.03.010.06(c)). This guidance document therefore assists real property owners and/or their consultants in complying with the requirements for seeking a variance from the Individual/Subsurface Sewage Disposal Rules' separation distances (IDAPA 58.01.03.008.02(d)) for a system utilizing a pressurized drainfield. (IDAPA 58.01.03.010.) The modeling results will help inform DEQ's setback determinations based on site specific information.

The site and proposed system must not adversely impact the adjacent surface water. This requires that the facility and wastewater system adequately address the following wastewater constituents:

1. Total nitrogen
2. Pathogens
3. Phosphorus

Current permitting procedures adequately address nitrogen and will not be addressed in this document. Refer to the current revision of the Nutrient-Pathogen (NP) Evaluation Program for On-Site Wastewater Treatment Systems (DEQ 2002) for these topics. Be aware that an NP evaluation, required to assess a system's impact on ground and surface waters, may identify site limitations that require a nitrogen-reducing system be installed. Nitrogen-reducing systems do not reduce P in the wastewater stream.

This model will address P sorption in the soils beneath an appropriately sized pressurized drainfield. An appropriately sized drainfield is one that adheres to IDAPA 58.01.03.008.03 specified sizing, without drainfield reduction. This guidance is not intended to be used to establish reductions in drainfield size, but rather to assess the capacity of the soil beneath the drainfield to sequester P, so that any potential reduction in setback distance to surface water can be realized. Drainfields may be configured with capping fill trenches, or drip distribution fields, and must be pressure dosed. The intent for using pressurization is to place the effluent as near to the soil's surface as possible, in order to use all available soil sorption sites, and to evenly distribute the effluent over the entire drainfield. Application of this model should be preceded by a thorough site evaluation performed in conjunction with the local health district. Appropriate soil sampling protocols (Appendix A) and soil P sorption analytical methods (Appendix B) must be used. The physical system modeled is shown in Figure 1-1.

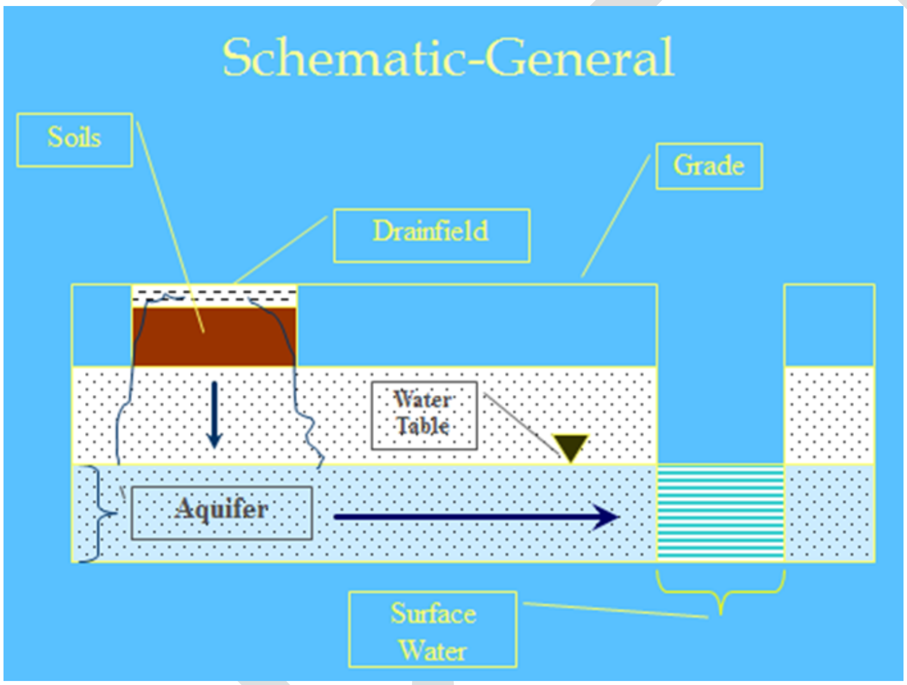


Figure 1-1. General schematic of the modeled flow path.

Three contaminant pathways are modeled as shown in Figure 1-2:

1. Phosphorus (P) movement through, and sorption in soils and resulting generation of P-bearing percolate
2. Mixing of percolate with ground water and subsequent P advection and dispersion during aquifer transport
3. Ground water mixing with surface water (either stream/river or lake/reservoir).

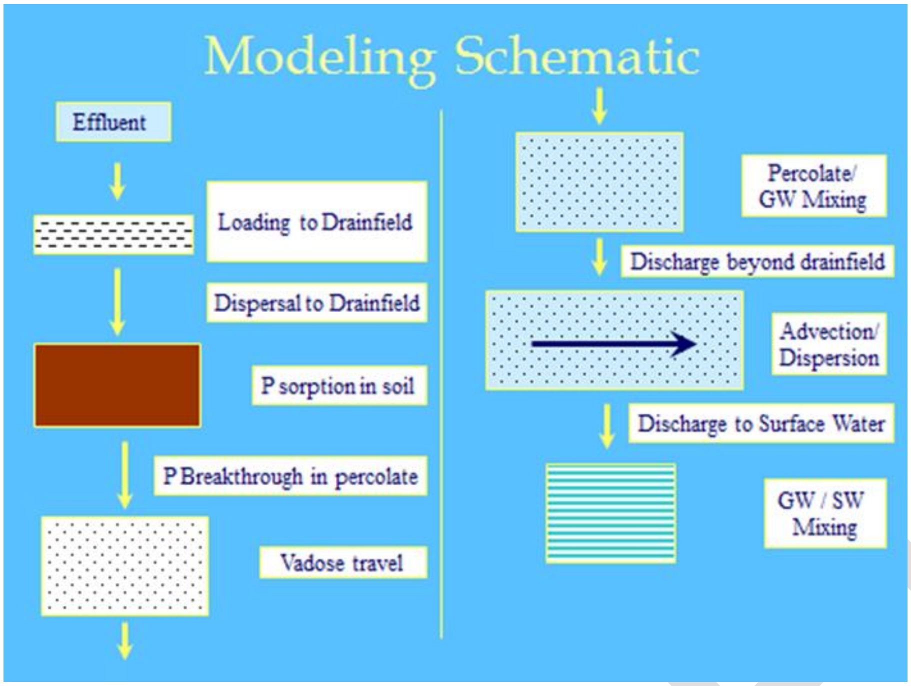


Figure 1-2. Schematic of the modeling steps.

The regulatory role is to (1) determine the point(s) of compliance, (2) set qualitative and quantitative criteria at the point(s) of compliance, (3) evaluate numerical model outputs to determine compliance with the established criteria, and (4) determine acceptability of a proposed project. Points of compliance may include but may not be limited to the following:

a. A site life (years) of a drainfield given its sorption capacity, P loading rate, and number of years to reach its capacity.
b. A threshold percolate concentration exiting the drainfield soil profile, in milligrams of P per liter (mg-P/L), that the system can reach before exceeding this threshold.
c. A threshold ground water concentration (milligrams per liter [mg/L]) at a distance from the drainfield that the installation must meet.
d. A mass discharge (pounds per year [lb/yr]) limit into a surface water body
e. A surface water mixing concentration limit (mg-P/L) that must not be exceeded.

1.3 Preliminary Considerations

This section describes appropriate uses of the model, expertise required to run the model, the *Tier I* nature of this simple model, and considerations for more complex *Tier II* modeling. Additionally, system compliance criteria will be presented.

1.3.1 Appropriate Uses of the Model

Until further notice, any use of this model for satisfaction of regulatory requirements, whether for characterization, design, or estimation of impact as a result of ongoing operation of a facility, for which output is submitted to the DEQ for review and approval, shall be preapproved by DEQ before use. Submittals to DEQ including nonapproved uses of this model shall not be accepted.

1.3.2 Tier I (Conservative) Model

As with any tool, there are limitations and appropriate uses. This model is what we will term a *Tier I* model, meaning it is *relatively* simple mathematically, and it has internally set defaults that are meant to yield conservative estimations and predictions of P impacts to the environment. If a site-specific application of the model yields acceptable values that meet DEQ compliance criteria, the acceptability of the project should be reasonably assured.

The Tier I model is applicable for relatively straightforward scenarios. Increasing nonconformance to existing rule, guidance, or technology may necessitate more than a Tier I analysis (section 1.3.3). This model would be inapplicable for use in hydrogeologic scenarios that are inadequately characterized and do not present extremely limiting or unusual conditions. Such conditions may be cause for DEQ *to deem as inapplicable* the use of this model. Such conditions as generally described in this paragraph must be determined on a case-specific basis.

1.3.3 Approaches for a Tier II Analysis

If the Tier I outputs show predicted noncompliance at specified compliance points, more sophisticated, time-consuming approaches requiring additional expertise may be resorted to in order to conduct more detailed analyses. Such approaches will be called *Tier II* analyses. Tier II analyses may involve approaches that are outlined further in Appendix C.

1.3.4 Tier I Parameter Selection

Model output is only as good as the input parameters chosen. The modeler must have sufficient expertise, or access to such expertise, in parameter selection for the different media being modeled, such as the following:

- Drainfield design and operation
- Soils
- Hydrogeology
- Surface water hydrology
- Water quality issues

As discussed in detail below, documentation for all parameters selected must be provided to adequately document the modeling effort and the corresponding results. Documentation includes parameter sources and reasons why particular values were chosen.

The data utilized as inputs to the model should meet reasonable standards of quality. Contact DEQ for further guidance on data quality requirements and other details regarding quality assurance and quality control (QA/QC) that are pertinent for this application.

1.3.5 Compliance Criteria

Various site and system limitations must be taken into account prior to implementing this model to determine surface water setback reduction for drainfield placement. Some of these criteria and limitations include but are not necessarily restricted to the following:

- Drainfields may not be placed closer than 100 feet from surface water.
- Soil horizons that encounter seasonally high ground water are not suitable for evaluation.
- Drainfields that are increased in size to utilize the P sequestering capacity of the extra soil to justify placement closer to surface water than IDAPA 58.01.03.008.02.d allows, does not justify future wastewater flow increases (adding bedrooms, increasing commercial wastewater flows).

1.4 Model Description

As discussed in section 1.2, the model incorporates three pathways and their corresponding removal/attenuation mechanisms Figure 1-1:

1. P movement through and sorption in soils, and resulting generation of P-bearing percolate
2. Mixing of percolate with ground water and subsequent P advection and dispersion during aquifer transport
3. Ground water mixing with surface water (either stream/river or lake/reservoir).

How these mechanisms are built into the model is discussed in this section. The general structure of the tool uses several Excel spreadsheets in one workbook. Each spreadsheet deals with a particular media that is being modeled, and inputs are placed on the top of the sheet, while outputs of the particular sheet are below the inputs. The sheets and their function are described below. Their interrelationships are shown in Figure 1-3.

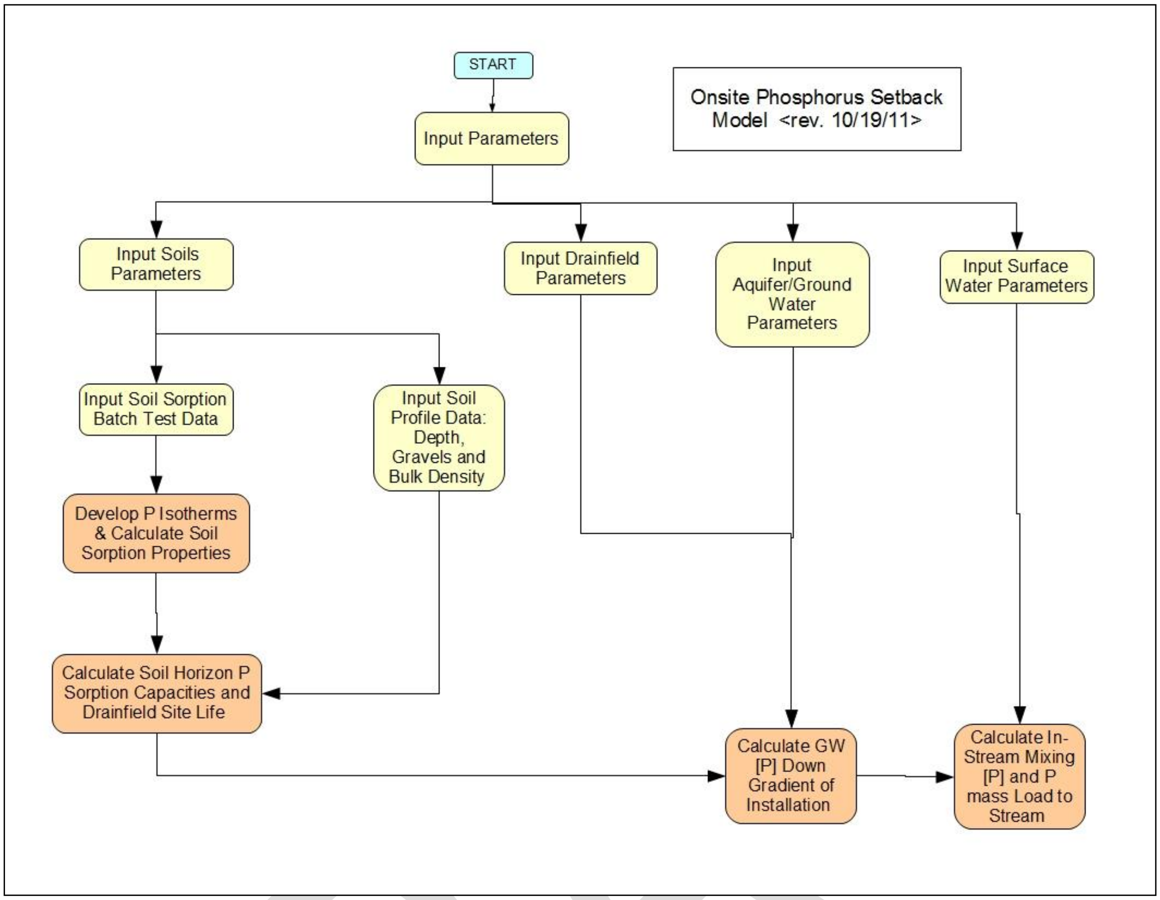


Figure 1-3. Model data input flow and subsequent output calculations.

Isotherm sheet—This sheet is where data from P sorption isotherm batch testing of soils is entered. Sorption isotherms are plotted and P sorption capacities of soils are calculated.

Sorption sheet—Soil horizon information is entered here, in addition to wastewater P concentrations [P]. Soil P sorption of the drainfield is calculated, along with a projected site-life.

Drainfield sheet—Soil class, number of bedrooms, wastewater flow, drainfield dimensions and orientation along ground water flow path, and proposed setback distance to surface water are entered.

Surface Water Mixing sheet—River or lake is entered, depth of water body, stream flow and other parameters related to mixing of ground water and surface water are entered.

GW Transport sheet—Ground water quality information, aquifer parameters, and model domain information are entered.

All Plots tab—All the graphics generated from the model appear in this tab.

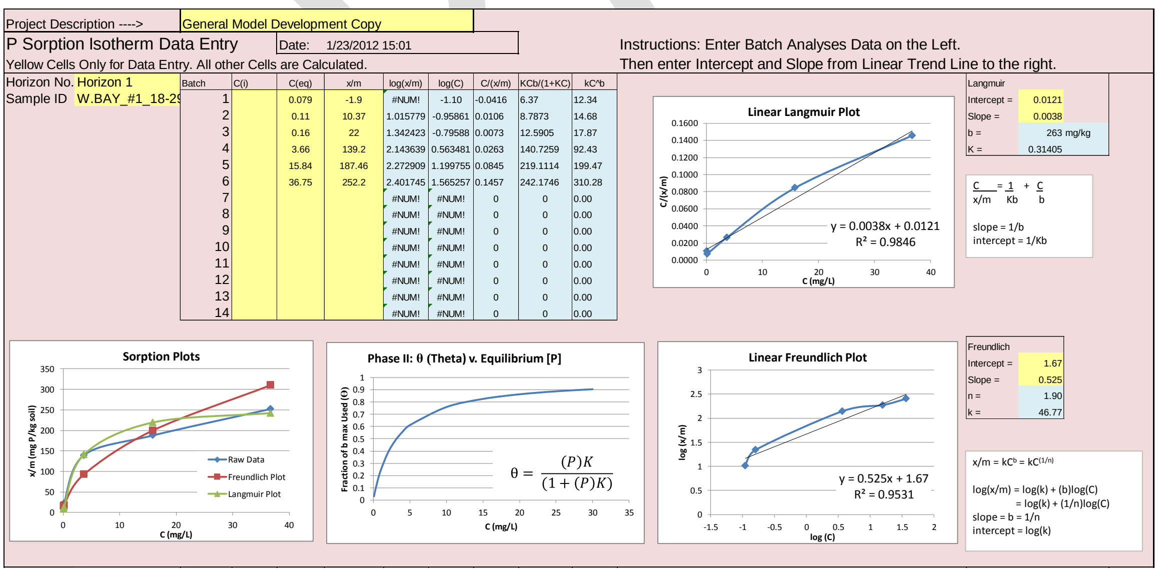
Plot Data sheet—Most of the data utilized to create graphics in the All Plots tab are in this sheet. This sheet is protected and not available for modification by the user.

Utility Sheets tab—This tab indicates that the sheets beyond this tab relate to the inner workings of the model. No inputs are in these sheets, and only intermediate outputs that do not need to be displayed to the general user of the model are shown. These sheets are protected and not available for modification by the user.

2. Isotherm Sheet

2.1 Description

The Isotherm sheet, shown in Figure 2-1, is where soil P sorption batch test data are entered, and where sorption isotherms are in turn generated from the data. This sheet has capacity to enter five sets of data, presumably enough data sets to accommodate up to five soil horizons being considered as the drainfield's sorptive matrix (adsorbent). Figure 2-1 shows both the inputs and outputs for one soil horizon. In brief, inputs of analytical data are shown in the yellow-colored columns to the center left of the table. Calculations based upon those data appear in the blue columns of the table. These calculations are used to create the four plots seen in the upper right and along the bottom of Figure 2-1. As described below, these plots represent various forms of two sorption isotherms—the Langmuir and Freundlich types (Bohn et al. 1979). The data, it is hoped, will fit one or the other of these isotherm types. Estimates of sorption capacity from the best fitting isotherm can then be made. The data inputs and outputs are described below:



Batch	C(i)	C(eq)	x/m	log(x/m)	log(C)	C/(x/m)	KCb/(1+KC)	kC^b
1		0.079	-1.9	#NUM!	-1.10	-0.0416	6.37	12.34
2		0.11	10.37	1.015779	-0.95861	0.0106	8.7873	14.68
3		0.16	22	1.342423	-0.79588	0.0073	12.5905	17.87
4		3.66	139.2	2.143639	0.563481	0.0263	140.7259	92.43
5		15.84	187.46	2.272909	1.199755	0.0845	219.1114	199.47
6		36.75	252.2	2.401745	1.565257	0.1457	242.1746	310.28
7				#NUM!	#NUM!	0	0	0.00
8				#NUM!	#NUM!	0	0	0.00
9				#NUM!	#NUM!	0	0	0.00
10				#NUM!	#NUM!	0	0	0.00
11				#NUM!	#NUM!	0	0	0.00
12				#NUM!	#NUM!	0	0	0.00
13				#NUM!	#NUM!	0	0	0.00
14				#NUM!	#NUM!	0	0	0.00

Figure 2-1. Soil sorption data input and P Isotherm generation sheet.

2.2 Instructions for Use

2.2.1 Isotherm Sheet Inputs

The following describes the input parameters for this sheet. As with the other sheets, cells used for inputs are colored yellow with red font.

1. **Project Description**: Enter a brief description of the project or scenario being modeled.
2. **Horizon No. (upper left of Figure 2-1):** The number or other designation of the horizon in the soil profile from which the sample was taken is entered here.
3. **Sample ID:** The unique sample ID, as given by the sampler or the analytical laboratory, is input below the Horizon No. input.
4. **Batch (number):** The batch number is pre-entered in the first column of the data/calculation table (appearing in the upper left of Figure 2-1) in the column labeled Batch. The batch represents a particular soil sorption test with a given aliquot containing a specific predetermined initial concentration (C_i) of phosphorus (P) (the adsorbate). Depending on the method used, and the initial aliquot concentration ranges to be employed, a variable number of batches may be analyzed. Utilization of five or more batches is common (Appendix B), but academic studies may employ numerous batches (Leytem and Westermann 2003).
5. **Initial Aliquot P Concentration (C_i) (mg/L):** In this column, enter the initial P concentration (C_i) (mg/L) (the adsorbate concentration) of the aliquot for each batch. These cells are not currently involved in any calculations, but minor spreadsheet modification may be employed to calculate the term, x/m, described in section 2.2.1(7). This is not anticipated to be necessary because the laboratory normally does this calculation and typically reports x/m to the client.
6. **Final (Equilibrium) Aliquot P Concentration (C_{eq} or C):** In this column, enter the final (equilibrium) P concentration (C_{eq}) (mg/L) of the aliquot for each batch. These cells are involved in this sheet's calculations for the linearized Langmuir plot as well as for plotting raw sorption data. These two plots are described in section 2.2.3.
7. **Phosphorus Sorbed onto the Soil (x/m) (mg/kg):** In this column, enter the amount of P sorbed onto the soil sample (the adsorbent). The variables are defined as follows: x is the mass of P (mg) sorbed onto the mass of soil (adsorbent) in kilograms (kg). The resulting ratio, x/m, is reported in units of mg P/kg soil.
8. **Langmuir Intercept (1/Kb):** The y intercept of the linear trendline plotted in the linearized Langmuir plot (Figure 2-2) is entered in the upper right input area. The Langmuir K is a constant related to the binding strength (Bohn et al. 1979). For further discussion of the Langmuir equation and its linear form, see Bohn et al. 1979 and the inserted text box in the upper right of Figure 2-1.
9. **Langmuir Slope (1/b) (kg soil/mg P):** The slope of the linearized Langmuir trendline is entered below the Langmuir intercept. The reciprocal of the Langmuir slope (b) is the maximum amount of adsorbate that can be adsorbed onto the soil (the adsorbent) (Bohn et. al 1979).
10. **Freundlich Intercept (log(k)):** the y intercept of the linear trendline plotted in the linearized Freundlich plot (Figure 2-4) is entered in the lower right input area. The value k is an empirical Freundlich constant. For further discussion of the Freundlich

equation and its linear form, see Bohn et al. 1979, as well as the inserted text box in the lower right of Figure 2-1.

11. **Freundlich Slope (b or 1/n):** The slope, b, of the linearized Freundlich trendline is the reciprocal of the Freundlich empirical constant, n (Bohn et al. 1979). The slope, b, is entered below the Freundlich intercept.

2.2.2 Isotherm Sheet Calculated Outputs

1. **Calculation: Log(x/m)**—A calculation whose values are plotted against Log(C) so that a linearized Freundlich isotherm may be plotted (Figure 2-4).
2. **Calculation: Log(C)—**A calculation whose values are plotted against Log(x/m) so that a linearized Freundlich isotherm may be plotted (Figure 2-4).
3. **Calculation: C/(x/m)—**A calculation whose values are plotted against C so that a linearized Langmuir isotherm may be plotted (see Figure 2-2 below). This expression is actually the reciprocal of the solution/solid partition coefficient, K_d (K_d being (x/m)/C).
4. **Calculation: KCb/(1+KC)—**A calculation whose values are plotted against C so that a Langmuir isotherm for the particular soil sample analyzed may be plotted (see Figure 2-5 below).
5. **Calculation: kC^b**—A calculation made so that a Freundlich isotherm may be plotted (Figure 2-5).

2.2.3 Isotherm Sheet Graphical Outputs

1. **Linearized Langmuir Plot:** This plot (Figure 2-2) is semiautomatically generated by plotting C versus C/(x/m). See the linearized equation on the middle right of Figure 2-1. The user must decide what data to utilize and then select the data set (i.e., the x and y coordinate pairs) by editing the data set information. It is recommended that P desorption data pairs (i.e., those with negative x/m values) be omitted. It is also recommended that data pairs having initial P concentrations (C_i) greater than 200 mg/L not be used (Appendix B). The reason for this is to standardize the allowable concentrations employed when plotting the linearized Langmuir isotherm. This is important because the calculated sorption maximum (section 2.2.3(3)) will often increase when higher C_i batch test values are used.

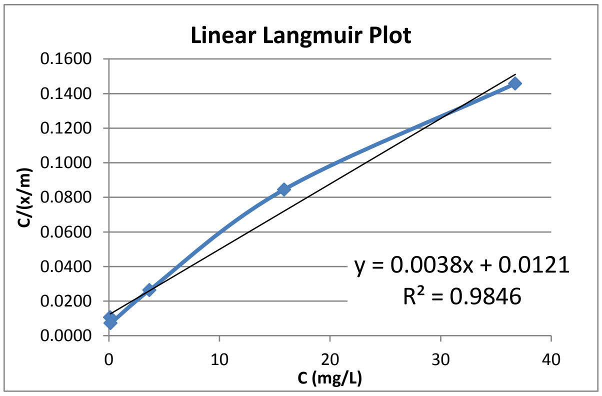


Figure 2-2. Linearized Langmuir isotherm [C/(x/m) versus C] with best fit trendline.

2. **Linearized Langmuir Plot Trendline – R^2 Value:** A linear trendline and its equation are automatically plotted along with the data as shown in Figure 2-2. Take note of three items: R^2 value, slope, and intercept. The R^2 associated with *goodness of fit* of the data to a linear trendline will appear in the plot area. It is often the case that the closer the goodness of fit parameter is to 1.0, the better the linear trendline matches the isotherm derived from the data, which increases one's confidence in using the linear trendline. In Devore (1995) correlation is considered strong, moderate, and weak where the R^2 is 0.8–1, 0.5–0.8, and <0.5 respectively. This is not always the case however, and other diagnostics may be necessary. See the important discussion in Helsel (1992). If the Langmuir isotherm is not an adequate fit, try another isotherm such as the Freundlich.
3. **Linearized Langmuir Plot Trendline – b_{max} or Reciprocal Intercept:** The y intercept (1/b) of the trendline appears in the equation in the plot area. The value b or b_{max} calculated is the Langmuir b_{max} or the sorption maximum of the analyzed soil matrix. It is the reciprocal of the y intercept and is expressed as mg-P/kg. The calculated value appears in the upper right of Figure 2-1. This parameter is an important input into the Phase I P sorption model in the Sorption sheet (section 3.2).
4. **Linearized Langmuir Plot Trendline – K or Affinity of the Sorption Matrix:** The K value is a constant related to the binding strength of the adsorbate (P in this case) to the adsorbent (the soil matrix) (Bohn et al. 1979). It is equal to the slope (1/b) divided by the intercept (1/Kb). The slope of the trendline is calculated and appears in the linear equation in the plot area. The K value is utilized in the Sorption sheet to generate a theta versus. [P]eq curve, which is a *normalized* curve constructed by plotting C versus. KC/(1+KC) as shown in Figure 2-3. The y axis is the fraction of soil P sorption capacity utilized (a proportion) and the x axis is C (i.e., the equilibrium P concentration). The significance of this plot will be explained in the Sorption sheet documentation in section 3.4.

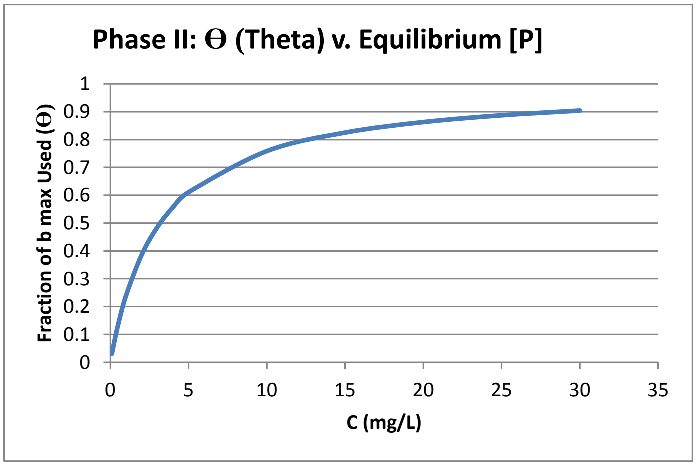


Figure 2-3. Normalized Langmuir isotherm [Theta (θ) versus C].

5. **Linearized Freundlich Plot:** This plot (Figure 2-4) is semiautomatically generated by plotting the log(C) versus. log(x/m). See the linearized equation on the lower right of Figure 2-1. The user must decide what data to utilize and select the data set (i.e., the x and y coordinate pairs) by editing the data set information. Phosphorus desorption data pairs (i.e., those with negative x/m values) cannot be used (the log of a negative number is undefined). It is recommended that data pairs with initial P concentrations (C_i) greater than 200 mg/L be omitted from the data to be plotted. The reason for this is twofold. First, such a limit serves to keep initial concentrations no more than an order of magnitude higher than expected in effluent concentrations. Raw wastewater effluent [P] ranges from 4–15 mg P/L (Lombardo 2006). Secondly, this limit serves to standardize the allowable concentrations employed when plotting the linearized Freundlich isotherm.

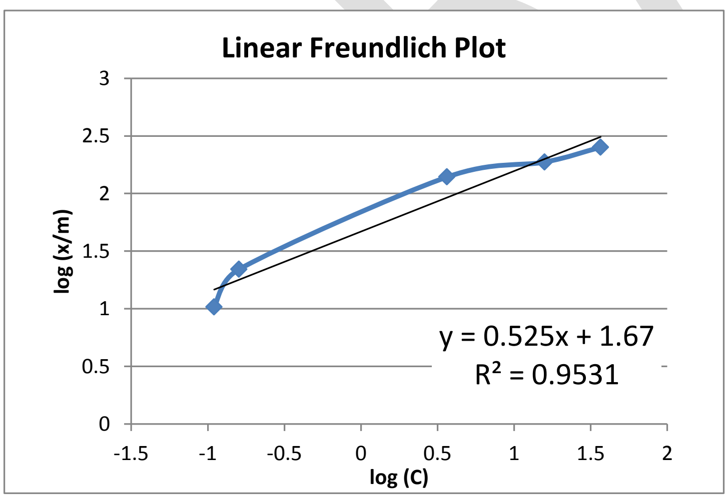


Figure 2-4. Linearized Freundlich isotherm [log(x/m) versus log(C)] with best fit trendline.

6. **Linearized Freundlich Plot Trendline – R^2 Value:** The trendline is automatically plotted along with the data. Take note of three items: R^2 value, slope, and intercept. The R^2 associated with *goodness of fit* of the data to a linear trendline will appear in the plot area. It is often the case that the closer the goodness of fit parameter is to 1.0,

the better the linear trendline matches the isotherm derived from the data, which increases one's confidence in using the linear trendline. In Devore (1995), correlation is considered strong, moderate, and weak where the R^2 is 0.8–1, 0.5–0.8, and <0.5 respectively. This is not always the case however, and other diagnostics may be necessary. See the important discussion in Helsel (1992). If the Freundlich isotherm is not an adequate fit, another isotherm such as the Langmuir should be chosen. One thing to note when comparing R^2 values of linearized Langmuir and Freundlich plots is that the Freundlich is a log/log plot and may result in better fits all other things being equal.

7. **Linearized Freundlich Plot Trendline – Intercept (b or 1/n):** The y intercept of the trendline appears in the equation in the plot area and is b or 1/n.
8. **Linearized Freundlich Plot Trendline – k:** The slope of the linearized Freundlich plot is log(k) from which the value of k is derived.
9. **Sorption Plots:** In the lower left corner of Figure 2-1, a graphic contains three sorption plots. This plot is reproduced below in Figure 2-5. The plots are semiautomatically generated. The raw data sorption curve plots equilibrium P concentration versus the amount of P sorbed onto the soil (C versus. x/m) (i.e., the data as are generally reported from a laboratory). The Freundlich curve plots C versus kC^b (an expression of x/m with the data fitted to the Freundlich isotherm). The Langmuir curve plots C versus KCb/(1+KC). The latter term is an expression of x/m with the data fitted to the Langmuir isotherm. Notice the additional b term in the numerator, which makes this curve a sorption curve rather than the *normalized* curve discussed in section 2.2.3 (Figure 2-3) and section 3.4. Plotting all three curves here enables the user to not only utilize the R^2 values in determining a best fitting isotherm, but enables the user to visually see which isotherm best fits the *raw data*. In certain cases, the user will be looking at what part of an isotherm appears to be fitting best with the raw data, such as in the case where a particular P equilibrium concentration is selected and calculations of the sorption capacity at that concentration are being estimated.

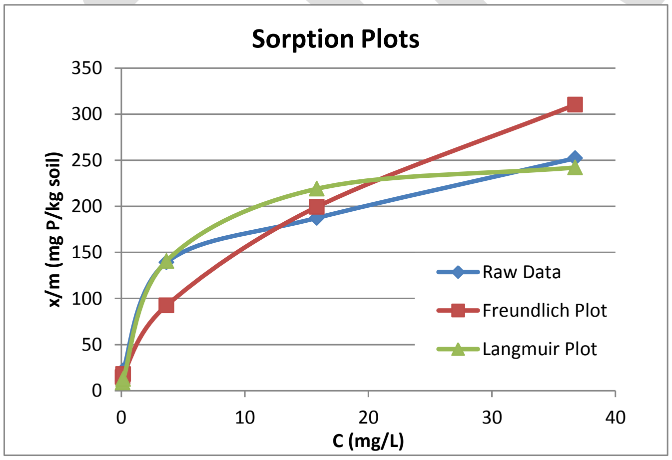
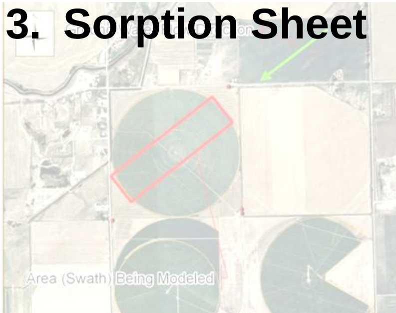


Figure 2-5. Sorption plots of soil sorption data, Langmuir and Freundlich isotherms [x/m versus C].

3. Sorption Sheet



3.1 Description

The Sorption sheet takes soil P sorption capacities calculated in the Isotherm sheet and determines P sorption capacities for soils in a drainfield and adjacent soils. Several subparts in this sheet have different functions. These subparts are discussed separately. In brief, they are

1. **Phase I: Site-Life P Sorption Maximum Tool.** This tool utilizes P sorption Langmuir maximums (b_{max}) calculated for each soil horizon in the Isotherm sheet, as well as the wastewater P loading rate to calculate a drainfield 'site-life'. This site-life is the time it takes to use up the P sorption capacity at the rate of P addition to the system.
2. **Phase II: Sorption/Percolate-P C_{eq} Estimator for On-Site Drainfields Tool.** This tool estimates percolate P concentrations (C_p) throughout the operation period of the drainfield. The longer the drainfield is in use the closer the C_p approaches wastewater phosphorus concentration (C_{ww}). Percolate P concentrations change in response to the amount of P that is sorbed, such that a given soil having little sorbed P, will have a low equilibrium P concentration exiting the soil profile. As the amount of P sorbed increases, the soil will exhibit increasingly a higher C_p. Eventually the soil reaches that P sorption capacity which is at an equilibrium concentration equal to the C_{ww}. Since the percolate concentration changes over time, the time-weighted average percolate concentration is calculated and that value is used for ground water mixing and contaminant transport calculations described in section 6.1 and following.
3. **P Desorption Capture Tool.** This tool calculates an estimated mass of P that will be desorbed from the soil matrix in a given number of years after drainfield abandonment, assuming a given percolate volume and P concentration. This estimated mass of desorbed P can be utilized in the model in one of three ways:
    a. This mass may be added to the mass of P calculated to be sorbed onto the soil in the Phase I analysis.
    b. This mass of P may be added to the mass of P calculated to be sorbed onto the soil in the Phase II analysis.
    c. This mass of P may be ignored and not added to either Phase I or Phase II sorption estimates.

3.2 Phase I: Site-Life P Sorption Maximum Tool—Instructions for Use

As summarized above, this tool utilizes P sorption maximums (b_{max}) calculated for each soil horizon in the Isotherm sheet, as well as the wastewater P loading rate to calculate a drainfield *site-life*. This site-life is the time it takes for the drainfield and adjacent area to exhaust (use up) the predicted P sorption capacity at the given rate of P addition to the system. Three important simplifying assumptions of the Phase I tool are

1. It assumes that the Langmuir isotherm fits the soil data analyzed, which is necessary because only the Langmuir isotherm yields a b_{max}.
2. It assumes that all P applied to the system is sorbed and no P exits the system with percolate until the maximum sorption capacity (b_{max}) is exceeded.
3. Once b_{max} is exceeded, it is assumed that the system at that point has failed and the percolate P concentration ([P]) is assumed to be equal to the septic tank effluent [P] being discharged to the drainfield.

A critical limitation of the Phase I tool is its inability to calculate a percolate P concentration ([P]), and subsequently to calculate mixed ground water [P] downgradient. This prevents the Phase I tool from estimating a setback distance to surface water. Yet, the Phase I tool is able to provide an estimate for the soil's P sorption life, that is, how long the site will be able to be used to sorb P discharged at the rate specified concentration in the effluent (C_{ww}) assuming no percolate P losses.

This is not a besetting limitation if the Phase I tool is utilized in concert with the Phase II tool by allowing a b_{max} sorption capacity for only a portion of the total soil profile, and then reverting to the Phase II tool to set sorption capacities based on varying C_{eq} in the percolate. See Figure 3-1 and section 3.4 for further discussion.

Phase I: Site-Life P Sorption Max Tool for On-site Drainfields					
Wastewater [P] (mg/L) [same for Phases I and II]	8.6		Sorption Multipliers		
P removal (precipitation) in Septic Tank (20 - 30 %)	0%		1.5	Estimate 5 d results from 1 d test	
WW vol/yr (million gallons/yr)	0.110			(1.5 recommended)	
WW vol/yr (million gallons/ac-yr)	3.407		1.5	Est of long term sorption from 5 d test	
Drainfield & Adjacent Area (acres)	0.032			(1.5 recommended)	
Regulatory Site life Min (yr) [set @ 0 to bypass Phase I]	10		2.25	Composite Sorption Multiplier	
P loading from WW/yr (lb/ac-yr) [both Phases I and II]	244.4				
Soil Parameters	Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 5
(Db) Soil bulk density (g/cm3	1.45	1.45	1.45	1.45	1.45
Rock fragment content - > 2 mm by volume (a proportion)	0	0	0	0.2	0.4
(d) horizon depth (inches)	8	32	30	25	5
(d) Corrected horizon depth (inches)	8.0	32.0	30.0	20.0	3.0
(b) P Sorption max (mg/kg)	592	1500	900	1184	726
P Sorption Capacity per acre (lb/ac)	1545	15660	8809	7727	710
P Sorbed lb/ac at Regulatory Site Life	1545	898	0	0	0
Depth of Horizon Used (in) Reg Site Life	8.0	1.8	0.0	0.0	0.0
Total P Sorption (lb/ac)	34452				
Site life (years)	141.0				
Are Regulatory Site Life Criterion Satisfied?	Yes				

Figure 3-1. Phase I site life P sorption maximum calculation tool.

3.2.1 Sorption Phase I Sheet Inputs

The following describes the input parameters for this sheet. As with the other sheets, cells used for inputs are colored yellow.

1. **Wastewater Phosphorus Concentration (C_{ww}) (mg/L):** Enter the P concentration ([P]) of the wastewater effluent being discharged to the drainfield. Typical values for C_{ww} to septic tanks range from 1.2 to 16 mg-P/L according to Lombardo (2006) and from 6 to 12 mg-P/L according to the Technical Guidance Manual (TGM) (section 3.2.1, Table 3-1) (DEQ 2013). Idaho's Domestic Wastewater Phosphorus Concentration Report (DEQ 2012) identified the upper confidence limit, at the 95% confidence level, for the average total phosphorus concentration discharging from a septic tank to the drainfield as 8.6 mg-P/L. This input is used for both Phase I and Phase II analyses.
2. **P Removal (Precipitation) in Septic Tank (typically 20%–30%) (percent):** Enter an estimate for the percentage of effluent P that is precipitated in the septic tank prior to distribution in the drainfield. Typical values range from 20% to 30% (Lombardo 2006). This field should only be used where the data are from raw wastewater entering the septic tank. For cases where the model input utilizes data representing clarified effluent post septic tank (8.6 mg-P/L), this value must be set to zero (0).
3. **Regulatory Site Life (years):** This input reflects the regulatory agency's expectation of how long the drainfield installation should effectively sorb effluent P loading. Since SSD permits are permits to construct, and not operating permits, site-life issues must be characterized during permitting, and the regulatory expectations for site life must be established and stipulated as a criterion by the regulatory agency. Since regulatory controls are only implemented prior to and during construction, it is here that design criteria must demonstrate site-life capabilities with respect to P sorption. If site-life criterion cannot be demonstrated, this would be grounds for permit denial to construct.

   If the modeler wants to by-pass the Phase I tool in order to use the Phase II tool, zero should be set for this input. If the modeler wishes to allow maximum sorption for a portion of the soil profile, the site life can be set at a desired time for which this is to be allowed. The *excess* P not sorbed via the Phase I conditions passes to the Phase II tool for sorption at an attenuated rate.

4. **Soil Bulk Density (D_b) (g/cm^3):** Enter the soil bulk density here. Consult Natural Resources Conservation Service (NRCS) soil databases such as the NRCS Web Soil Survey (WSS) for typical values for the soil series represented at the installation site. See the following website: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.

   Soil bulk densities can also be determined by laboratory analysis. The D_b value is necessary to convert soil volume into soil mass, since it is on a mass basis that P sorption is calculated from isotherm batch analyses.

5. **Rock Fragment Content (a proportion):** Enter the rock fragment content of the soil horizon here. The rock fragment content is that fraction of the soil that does not pass a #10 mesh sieve (i.e., materials >2 mm in diameter [NRCS 2002]). This is estimated on a volume basis, and the fraction includes coarse sand, gravel, cobbles, stones, and

boulders. It is estimated on a volume basis as observed in the soil profile (NRCS 2002). For example, if half the volume of the soil is gravel, enter a value of 0.5. If the coarse fragment content is determined by weighing what passes and does not pass through a #10 sieve, this will be on a weight basis and can be converted to a volume basis using NRCS guidance designed for that purpose (USDA-SCS no date).

6. **Soil Horizon Depth (inches):** Enter the soil horizon depth for each horizon being considered in this analysis. Horizon depth information is obtained from measurements done in the test pit(s).
7. **Sorption Multiplier—estimating 5-day results from 1-day test:** The sorption values obtained from a 5-day isotherm batch test are generally greater than those obtained from a 1-day test (Tofflemire and Chen 1977). Furthermore, values for P sorption over a 14-month period including wet/dry cycles and time, are considerably greater than those of the 5-day test. DEQ is adopting a method utilizing a 1-day test (Graetz and Nair [2000] and University of Idaho [no date]) (Appendix B) since this test is commonly done at many commercial laboratories. It is therefore important to convert 1-day test values to 5-day test values, so that, in turn those extrapolated 5-day values can be further converted to longer-term (14 month) estimates discussed in Tofflemire and Chen (1977). From limited data available, it is estimated that a factor around 1.5 is appropriate to convert 1-day test values into 5-day test values (Tofflemire and Chen 1977).
8. **Sorption Multiplier—estimating long-term sorption values from a 5-day test:** The sorption values obtained from long-term (14 month) studies are significantly greater than a 5-day isotherm batch test. As mentioned above, this is due to slow mineralization of the rapidly sorbed P due to wet/dry cycles, time, and other factors. Five-day test values can be used to derive longer-term estimates as these latter values reflect more of the reality of P sorption than do 5-day tests. Column studies for a limited number of soils having varying pHs and clay contents were conducted in Tofflemire and Chen (1977). From these limited data, *mineralization factors* appear to increase with increasing pH and silt plus clay content, as shown in Table 3-1.

Table 3-1. Soil properties summary and P mineralization factors.

Soil Property	Soils A and B	Soil C
pH	5.5–6.5	8
% course> 2 millimeters (mm)	2–20	16
% silt + clay < 0.62 mm	1–16	44
% clay < 0.002 mm	~1	7
Mineralization factor	1.9	5

A conservative *mineralization factor* (Tofflemire and Chen 1977) suggests a value of 1.90. Interpolation of these limited data must be done with caution.

3.2.2 Sorption Phase I Sheet Calculated Outputs

1. **Wastewater Vol (million gallons/year):** This calculation is the volume of wastewater applied per year to the drainfield system. This calculation comes from wastewater volume inputs entered in the Drainfield sheet as gallons/day.

2. **Wastewater Vol (million gallons/acre-year):** This calculation normalizes the wastewater loading rate on a per acre basis. The drainfield and adjacent buffer area (inches per square feet [in./ft^2]) comes from the inputs entered in the Drainfield sheet and depends upon the soil classification and the number of bedrooms in the proposed home.
3. **Drainfield and Adjacent Area (acres):** The drainfield and adjacent buffer area comes from the inputs entered in the Drainfield sheet as square feet in that sheet. Note that for pressurized drip systems no *adjacent area* and associated soil P sorption capacity are included.
4. **P Loading from Wastewater per Year**: A calculation based on the effluent volume per year and the wastewater P concentration (C_{ww}). This loading rate is used in both Phase I and Phase II analyses.
5. **Corrected Soil Horizon Depth (inches):** Each soil horizon depth is corrected for coarse fragment content on a volume basis utilizing horizon depth inputs and coarse fragment content. For example, if a soil volume is half course fragments and has a depth of 10 inches, only 5 inches of soil is present once coarse fragments are removed. Coarse fragments have negligible P sorption capacity necessitating this correction.
6. **P Sorption max (b or b_{max}) (mg P/kg soil):** This value is calculated for the soils in each horizon by taking the reciprocal of the linearized Langmuir isotherm slope to obtain the b_{max} (section 2.2.3(3)) and then applying the Composite Sorption Multiplier factor to the b_{max} (section 3.2.2(7)).
7. **Composite Sorption Multiplier:** This cell calculates the composite multiplier by combining the multiplier for the 1- to 5-day test (section 3.2.1(7)) and the multiplier of the 5-day test to the 14-month column study discussed in section 3.2.1(8) (i.e., long-term conditions). These are combined by multiplying them together. This composite multiplier is applied to the Langmuir b_{max} calculated in the Isotherm sheet, (section 2.2.3(3)). The resulting calculated P sorption max appears in the cells labeled, P sorption max, described in section 3.2.2(6).
8. **P Sorption Capacity per Acre (lb/acre):** This cell calculates a normalized value for maximum P sorption on a per acre basis for the entire depth of each soil horizon, using the P sorption max value (section 3.2.2(6)), acreage for the drainfield area (and adjacent buffer area if applicable) (section 3.2.2(3)), and soil bulk density (D_b) (section 3.2.1(4)) to convert soil horizon depth, a volume basis, to a mass basis. In other words, this cell calculates the maximum P sorption capacity for each soil horizon. These calculated values, as discussed below, are shown graphically, along with the P sorption capacity predicted to be utilized (section 3.2.3(1)).
9. **P Sorption at Regulatory Site Life (lb/acre):** This cell calculates how much of the maximum P sorption capacity (determined in section 3.2.2(8)) is utilized given the mass of P applied during the site life stipulated in section 3.2.1(3). These calculated values, as discussed in section 3.2.3(1), are shown graphically in Figure 3-2, along with the maximum P sorption capacity estimated in section 3.2.2(8).
10. **Depth of Horizon Used During Regulatory Site Life (inches):** This cell calculates the depth of each corrected soil horizon that has been filled to capacity with sorbed P during the stipulated regulatory site life (section 3.2.1(3)).

11. **Total P Sorption (capacity) (lb/acre):** This cell calculates the total P sorption capacity (at b_{max}) by summing all soil horizon values (on a lb/acre basis) calculated as described in section 3.2.2(8).
12. **Site Life (years):** This cell calculates the site life of the system by dividing the total P sorption (capacity) (section 3.2.2(11)) by the annual P loading from wastewater (section 3.2.2(4)).
13. **Site Life Satisfy Regulatory Criterion? (Yes/No):** This cell compares the stipulated site life (section 3.2.1(3)) and calculated site life (section 3.2.2(12)). If the former is greater than the latter, this cell yields a No response. If the latter is greater than the former (i.e., that the calculated site life exceeds that required by regulatory interests), then the cell yields a Yes response.

3.2.3 Sorption Phase I Sheet Graphical Outputs

The Sorption Phase I sheet has two graphic outputs associated with it, the P sorption maximum site-life histogram (Figure 3-2) and the site life versus wastewater effluent P concentration C_{ww} plot (Figure 3-3).

1. **P sorption Maximum Site-Life Histogram:** This histogram (Figure 3-2) has two sets of bars on the x-axis. The blue bar on the left represents the maximum P sorption capacity for the particular soil horizon in lb/acre. The red bar on the right shows how much of each soil horizon's P sorption capacity has been utilized for the scenario modeled. Figure 3-2 shows five soil horizons ranging in capacity from approximately 1,750 lb/acre to approximately 3,750 lb/acre. It also shows that only the top four horizons are being utilized, the top three utilized to their capacity, and horizon four to less than half of its capacity.

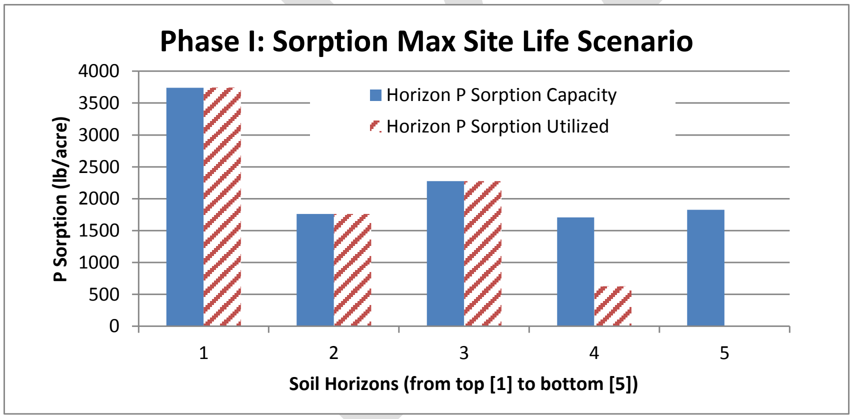


Figure 3-2. Phase 1 sorption capacity utilization histogram.

2. **Site Life Versus Wastewater Effluent Phosphorus Concentration C_{ww}:** This graph (Figure 3-3) is created from a data table function and shows how changes in wastewater effluent P concentration affect the predicted system site life. As C_{ww} increases, a higher P loading rate results and the maximum sorption capacity is filled sooner. This in turn results in a shorter site life.

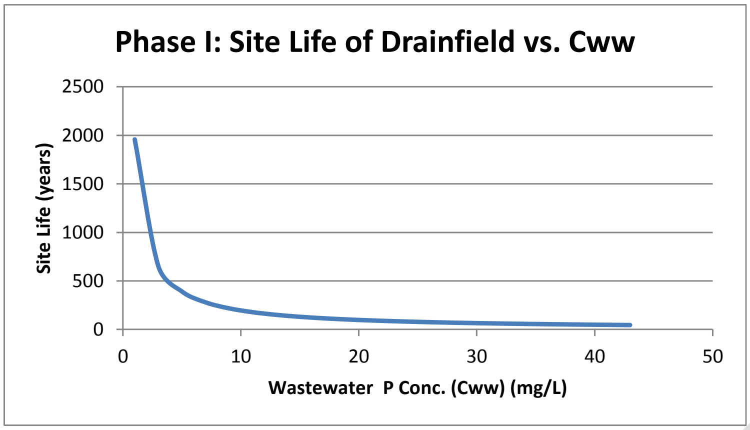


Figure 3-3. Phase I site life of drainfield versus wastewater P concentration (C_{ww}).

3.3 Desorption Tool—Instructions for Use

As summarized above and shown in Figure 3-4, this tool makes a rough estimate of the mass of P that might be desorbed from a drainfield after the installation has been decommissioned for a given number of years. This mass of P can be compared to the remaining sorption capacities of each lower soil horizon to determine how many inches of each horizon would be needed to capture (sorb) the soil P that is desorbing from upper horizons. As presented in section 3.1(3), this mass of P may be added to the sorbed P totals for either Phase I or Phase II analyses. Reasons for choosing to add or not to add are discussed in the footnote to section 3.3.1(4).

Capturing Desorbed P After Decommission of Drainfield		
Time After Decommissioning	50	yr
Est. Annual Percolation	14	inches/acre
Est. Desorption Perc [P]	1	mg/L
P Loss for Decom Period	158.5	lb/acre
Add Desorbed P to Total P Applied? (y/n)	No	
Which Phase to Add Desorbed P?	Phase II	
Reserve Depth for Phase I Perc P Capture	inches/acre	in avail. for desorp
Horizon 1	0.7	21.6
Horizon 2	0.5	0.9
Horizon 3	0.4	0.6
Horizon 4	0.3	0.8
Horizon 5	0.6	0.9

Figure 3-4. Phosphorus desorption estimating tool.

3.3.1 Desorption Tool Inputs

The following describes the input parameters for this sheet. As with the other sheets, cells used for inputs are colored yellow.

1. **Time After Decommissioning (years):** Enter the number of years after the drainfield decommissioning over which one wants to estimate the mass of P desorbed.

2. **Estimate of Annual Percolation Rate (inches/acre):** Enter an estimate of the amount of percolate (leaching) that would be expected under *natural* or irrigated conditions as the case may be, after decommissioning. Such an estimate may be calculated by conducting a hydraulic balance for the area. See the instructions for the hydraulic/nutrient balance sheet in the spreadsheet model described in wastewater reuse system modeling instructions *(*DEQ 2009).
3. **Estimated Percolate P concentration [P] Perc (mg/L):** Enter an estimate of the P concentration of the percolate. This parameter depends on many factors including pH, soil texture and mineralogy, carbonate content, initial P content of the soil, infiltration rate, elapsed time since start of infiltration, and conditions under which a particular study was conducted. Zurawsky et al. (2004) studied drainfield P leachability in soils both near infiltration zones (zone soils) and in soils at depth (~3 feet) below the infiltration zones (deep soils). In *tension saturated* (field capacity) conditions, acid soils yielded [P] ~0.01 mg/L for both *zone* and *deep* soils; neutral soils varied from 1.5 mg/L (zone) to 0.38 mg/L (deep); and calcareous soils varied from 6.5 (zone) to 2.2 (deep). Since P accumulated in zone soils, it might be thought that desorption phenomenon at abandoned installations might yield [P] more reflective of deep soils. McDowell and Sharply (2001, Figure 5) show that lysimeter drainage waters vary in [P] from ~0 to 1.5 as soil test P (STP) varies from low to high (~10 to 600 mg-P/kg). Parkhurst et al. (2003, Figure 7) conducted column studies with contaminated drainfield sediments. As increased pore volumes of uncontaminated water pass through contaminated sediments, desorbed [P] in eluent decreases from an initial concentration of 0.77 mg/L to 0.15 mg/L and gradually decreases to <0.03 mg/L. Lentz and Westerman (2001) observed percolate [P] in an agricultural setting ranging from 0.1 to 2.0 mg/L, averaging 0.58 mg/L.
4. **Add Desorbed P to Total P Applied (Yes/No):** This input cell is a toggle switch, either enabling or disabling the *desorption function*. This function estimates the mass of P that would desorb over a given number of years after drainfield abandonment. This toggle switch allows the user, when choosing Yes, to add this mass of P as a *lump* quantity to the soil matrix so that it occupies a certain P sorption capacity of the final amount of P added to the system. If the user chooses No, this estimated P desorbed mass is not added to the total P applied to the system.[1]
5. **Which Phase to Add Desorbed P:** From the drop-down list, enter which operational phase the desorbed P will be added to; either Phase I or Phase II.

3.3.2 Desorption Tool Outputs

1. **Reserve Horizon Depths for Phase I Percolate P Capture (inches):** This calculation yields the number of inches in each soil horizon that would be necessary to capture the mass of P that is estimated to be desorbed during the decommissioned period. These calculations are based on calculated Langmuir b_{max} capacities.

1 The reason for not including desorbed P is to avoid double-counting applied and sorbed P. The desorbed P was applied once and sorbed on the soil matrix. That same P, via desorption, is solubilized and translocated elsewhere in (or below) the soil profile. The reason for including the desorbed P is determining whether enough sorption capacity is left in the soil matrix, below the depth where P sorption ceased during operation, which can sorb and thus capture the desorbed P mass after decommissioning.

2. **Available Horizon Depths for Phase I Percolate P Capture (inches):** The column to the right of *reserve horizon depths* shows how many inches of each soil horizon remain available for P sorption (i.e., that part of the soil horizon not having its sorption capacity exhausted). These values are calculated as the difference between corrected soil horizon depth (section 3.2.2(5)) and depth of horizon used (filled) during site life (section 3.2.2(10)).

3.4 Phase II: Sorption/Percolate P C_{eq} Estimator for On-Site Drainfields—Instructions for Use

As summarized above, the Phase II sorption/percolate-P C_{eq} estimator for the on-site drainfield tool estimates percolate P concentrations (C_p, or C_{eq}) throughout the operational period of the drainfield. The longer the drainfield is in use the closer the C_p approaches C_{ww}. Percolate P concentrations change in response to the amount of P that is sorbed, such that a given soil having little sorbed P, will have a low equilibrium P concentration. Increasing the amount of P sorbed, the soil will exhibit increasingly higher percolate equilibrium P concentrations until the soil reaches that P sorption capacity that is at an equilibrium concentration equal to the effluent P concentration (Figure 3-5). Since the percolate concentration changes over time, the time-weighted average percolate concentration is calculated, and that value is used for ground water mixing and contaminant transport calculations described in section 6.1 and following.

Changing percolate concentration as a result of increasing P sorption of the soil is best explained by examining Figure 3-5.

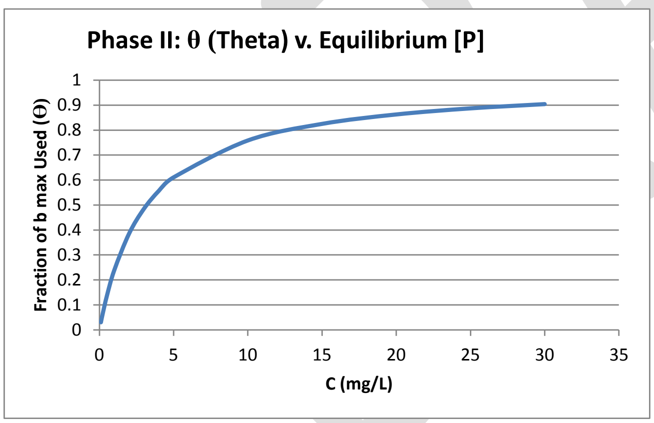


Figure 3-5. Normalized Langmuir isotherm [Theta (θ) versus C].

The x-axis in Figure 3-5 is the P concentration (C_{eq}) that is in equilibrium with a corresponding amount of P sorbed on the soil (y-axis). The y-axis is a normalized scale—from 0 to 1—that represents the fraction of the soil sorption capacity that is filled and is represented by the symbol theta (θ). If $\theta = 0.5$, this means 50% of the sorption capacity is filled. If $\theta = 1$, this means that 100% of the sorption capacity is filled—meaning that b_{max} has been reached. The curve on this plot shows that the fraction of the b_{max} that is occupied by sorbed P (y-axis) increases as the amount of P available for sorption increases. As the amount of P available for sorption increases, the C_{eq}, after the sorption reaction takes place, will also be higher, and this increase in C_{eq} is what is seen on the x-axis. The theta curve in Figure 3-5 is calculated by utilizing Equation 3-1:

$$\theta = KC_{eq}/(1 + KC_{eq})$$

Equation 3-1. Normalizing the Langmuir isotherm.

As will be discussed in section 3.4.1(2), this plot will be used in determining the C_{eq} of the system during its operational life for purposes of determining a percolate concentration that will then serve as an input into the ground water mixing and contaminant transport part of the model. After the percolate mixes with ground water, the constituents in the mixed percolate/ground water subsequently undergo advection and dispersion along the ground water flow path and presumably attenuate to an acceptable ground water P concentration at distance downgradient from the source. The following is an example of how this plot would be used in a Phase II analysis.

A facility treats an effluent with a [P] of 9 mg/L, and it operates for 30 years. At, or sometime before, the end of its operational life, the percolate concentration (C_{eq} or C_p) comes to an equilibrium of 9 mg/L (in this case the same concentration as the effluent). Reading up from the value of 9 on the x-axis shows a θ value of ~ 0.75. If the b_{max} value is 100 mg-P/kg soil, then the sorption capacity at this equilibrium concentration is 0.75 * 100 = 75 mg-P/kg. *It is assumed—and this is the fundamental assumption in the Phase II analysis—that the operational site life will determine the amount of P sorbed (i.e., the fraction of b_{max} utilized) and the amount of P sorbed will in turn determine the eventual percolate concentration.*

Figure 3-6 provides the Phase II sorption/percolate-P C_{eq} estimator for on-site drainfields.

Phase II: Sorption / Percolate-P Ceq Estimator for On-site Drainfields

Operation Period under Phase II Assumptions (years)	20		
Operation Period under Phase II Assumptions (re-enter above value)	20	Sorption Multipliers	
Time-Weighted Percolate [P] (mg/L) over Op Period	0.21	1.5	Estimate 5 d results from 1 d test
Maximum Percolate [P] (mg/L) over Op period	0.645		(1.5 recommended)
Enter Time-Weighted or Maximum Percolate [P] ->	1.71	1.5	Est of long term sorption from 5 d test
			(1.5 recommend)
		2.25	Composite Sorption Multiplier

Soil Parameters	Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 5
Isotherm Best Fit Choice	Langmuir	Freundlich	Freundlich	Freundlich	Langmuir
(d) corrected horizon depth avail (inches)	0.0	30.2	30.0	20.0	3.0
(C/(x/m) Langmuir y axis (L/mg)	0.014551	0.0088675	0.0142125	0.0063255	0.0172995
(b) P Sorption (Langmuir) (mg/kg)	100	164	102	229	84
(b) P Sorption (Freundlich) (mg/kg)	84	127	207	191	81
P Sorption Capacity per acre (lb/ac)	0	1247	2029	1249	82
P Sorbed lb/ac	0	1247	2029	1249	82
Depth of Horizon Utilized (inches)	0.0	30.2	30.0	20.0	3.0
Total P Sorption (lb/ac)	4607				
Operating Time (years) till Max Perc [P] is reached	18.9				

Figure 3-6. Phase II sorption/percolate P concentration (C_{eq}) estimating tool for on-site drainfields.

3.4.1 Sorption Phase II Sheet Inputs and Outputs

The following describes the input parameters for this sheet. As with the other sheets, cells used for inputs are colored yellow. It will be noted at the outset that all of the output cells in the Phase

II analysis have the same definitions as those in the Phase I analysis, and their calculated values are carried from the Phase I to the Phase II analysis. Certain cell values that are inputs to the Phase I analysis—effluent wastewater P concentration (C_{ww}), soil bulk density (D_b), coarse fragment content, and observed soil horizon depths—are utilized in the Phase II analysis since these parameter values do not change with Phase I or Phase II analyses.

Two input cells in the Phase I analysis—the sorption multipliers— remain as input cells in the Phase II analysis. This allows the modeler the flexibility to choose different multipliers for either Phase I or Phase II analyses, if necessary.

There are three additional input parameters in the Phase II analysis, Phase II operation period, percolate [P], and isotherm form. These parameters are described below:

1. **Operation Period under Phase II Assumptions (years):** Enter the expected time that this drainfield will be in operation. This input reflects the regulatory agency's expectation as to how long the drainfield installation should effectively sorb the P loading from wastewater under Phase II sorption conditions/capacities. It may be decided that the site life will be split between Phase I and Phase II operation. For example, it may be allowed for an installation to operate for 10 years under Phase I sorption capacities, and then for 20 years at Phase II capacities (totaling 30 years). If this is the case, then one would enter the remaining years (e.g., 20 years) that operation is expected under Phase II parameters. If Phase I is bypassed (by entering zero, see section 3.2.1(3)), then enter the regulatory site life here (e.g., 30 years). Re-Enter Operation Period under Phase II Assumptions (years): Re-enter the value entered in 1 above (in order to avoid a circular reference in data table functions).

2. **Percolate [P] (i.e., C_p) Selected for Ground Water Mixing and Contaminant Transport Calculations (mg/L):** Enter the percolate [P] (i.e., C_p) that will be used in ground water mixing and contaminant transport calculations as described in section 6.1 and following. Output cells (described below) provide two *recommended* values. The first is a time-weighted average percolate concentration value. This is an average of all the equilibrium percolate P concentrations that have been generated by the system for the operation period input above, based on the amount of time that the percolate was at a given concentration. The second value provided is the maximum percolate P concentration that resulted during the operation period. The time-weighted value may better express the dynamic nature of the percolate quality and *gives credit* to the sorptive capacity of the soil to mitigate and reduce P loss.

3. **Isotherm Best Fit:** Choose from the drop-down list either a Langmuir or a Freundlich isotherm to use in calculating P sorption capacity for each horizon under consideration. To make this choice, the modeler must examine the isotherm plots on the Isotherm sheet (section 2.2.3, Figure 2-2, Figure 2-4, and Figure 2-5) for each horizon being considered. Those plots will help determine which of the isotherms is the better fit to the raw data *at the particular C_{eq} range being considered*. The concentration range under consideration is typically governed by the effluent concentration. For example, if the effluent concentration is 9 mg-P/L, the range under consideration would be from 0 to 9 mg-P/L. Note that for the Phase I analysis no

isotherm choice is provided. This is because only the Langmuir isotherm with its ability to calculate a b_{max} is utilized.

3.4.2 Sorption Phase II Sheet Outputs

The Sorption Phase II sheet has two outputs associated with it, not otherwise defined in Phase I descriptions:

1. **Time-Weighted Percolate [P] (C_{eq}) over the Operational Life (mg/L):** This is the calculated time-weighted percolate [P] (C_{eq}) that will result over the operational life of the facility. See the explanation in section 3.4, introduction and in section 3.4.1(2).
2. **Maximum Percolate [P] (C_{eq}) over the Operational Life (mg/L):** This is the calculated maximum percolate [P] (C_{eq}) that will result over the operational life of the facility. See the explanation in section 3.4, introduction and in section 3.4.1(2).

3.4.3 Sorption Phase II Sheet Graphical Outputs

The Sorption Phase II sheet has two graphic outputs associated with it:

- The Phase II soil horizon P sorption capacities and utilization for the selected operational life (Figure 3-7)
- P percolate concentration (C_{eq}) maximums and time-weighted values throughout the site operational life (Figure 3-8).

1. **Phase II Soil Horizon P Sorption Capacities and Utilization for Selected Operational Life:** This histogram, like the Phase I graphic, has two sets of bars on the x-axis, the blue and red bar representing the P sorption capacity, and the P sorption capacity utilized respectively (in lb/ac). Both of these values are determined for each soil horizon for a selected operational life under Phase II assumptions. The operational life determines the particular C_{eq} that will develop over the operational life, and the C_{eq}, as discussed in section 3.4, introduction, will reflect the mass of sorbed P in the soil. That being the case, both the P sorption capacity (blue bar) and the P sorption capacity utilized (red hatched bar) will be identical (i.e., the predicted and utilized capacities are the same). Figure 3-7 shows five soil horizons ranging in capacity from ~950 lb/acre in the upper horizon to ~320 lb/acre in lower horizons.

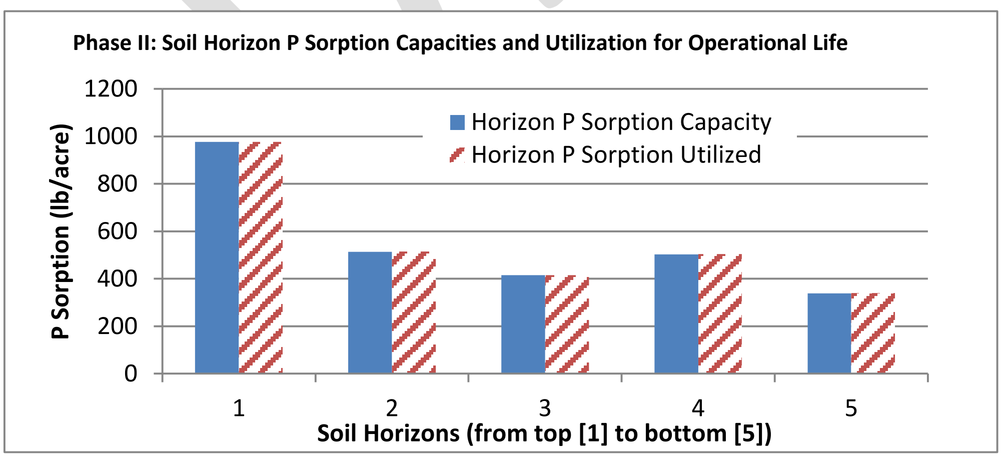


Figure 3-7. Phase II soil horizon P sorption capacities and utilization for selected operational life.

2. **Phosphorus Percolate Concentration (C_{eq}) Versus Operational Life:** This graphic (Figure 3-8) shows how the percolate P concentration (C_{eq}) changes during the operational life of the drainfield. This phenomenon is shown in Figure 3-5. As the proportion of the sorption capacity is filled, or as θ increases (y axis), the equilibrium concentration (C_{eq}) increases. Thus, as the facility is operated throughout its operational life, there is a calculated increase in C_{eq}, shown in the blue solid line in Figure 3-8. If the facility is operated long enough, there will come a time when the predicted equilibrium concentration (C_{eq}) will reach that of the effluent (C_{ww}). At that point, the C_{eq} cannot become greater than the C_{ww} , the amount sorbed to the soil will not increase, and the C_{eq} will plateau, as is seen in Figure 3-8.

   The red dashed line in Figure 3-8 is labeled *time-weighted* C_{eq}. For every year that the facility is in operation, a C_{eq} is calculated that will reflect—not the maximum as in the blue line—a value that consists of an average of the concentrations that the facility has been discharging, weighting them on a time basis. A time-weighted calculation is thought to be more representative than the maximum percolate concentration that the facility has been discharging over the operational life. The modeler may then select from either of these values to represent the percolate concentration in the ground water mixing/contaminant transport model.

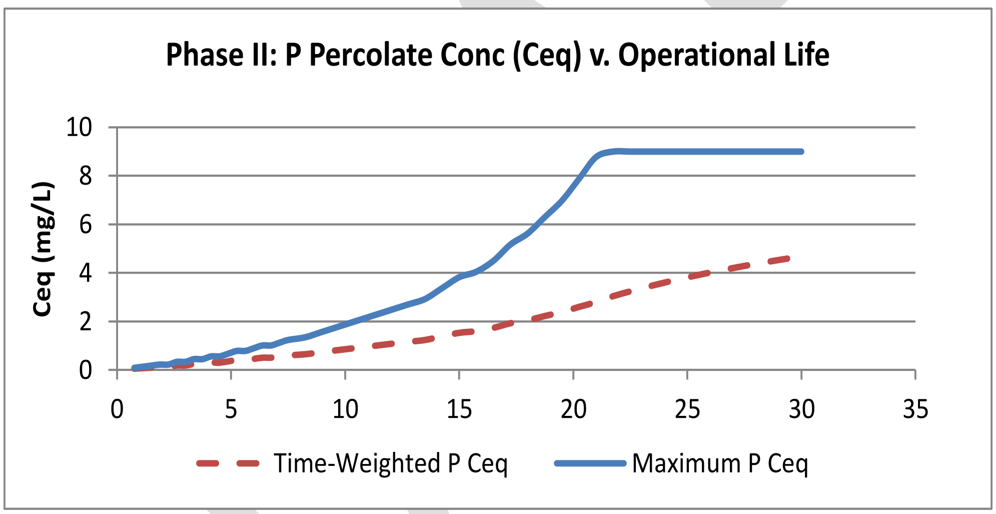


Figure 3-8. Phase II site life of drainfield versus maximum and time-weighted equilibrium [P] (C_{eq}).

4. Drainfield Sheet

4.1 Description

The Drainfield sheet is shown in **Error! Reference source not found.**. It contains all the input parameters and outputs pertinent to the design and proposed operation of the on-site system being modeled. The inputs pertain primarily to wastewater flow, soil type, setback distances, and drainfield geometry and orientation. Certain critical outputs (i.e., outputs that are compared with allowable limits) include flow to drainfield, and ground water concentration at the discharge point to surface water.

Drainfield configurations are limited to pressurized dispersal areas installed as shallow as possible in the soil column. The two acceptable pressurized dispersal configurations include drip dispersal systems and capping fill trenches. Drip dispersal places the effluent in the plant's root zone, providing nutrient uptake to help limit phosphorus transport to the aquifer. It should be noted that no credit for nutrient uptake by plants is allowed in the model, or will be granted on the installation permit, because it is not feasible to regulate harvested vegetative materials above a residential subsurface disposal system (e.g., the homeowner may mulch the grass and DEQ cannot require lawn clipping removal from the property). Additionally, placement of the effluent this high in the soil column maximizes the soil available for sorption. Finally, using a pressurized dispersal system ensures that the effluent will be dispersed evenly over the entire drainfield during each dosing event. Capping fill trenches also provide these attributes but may not support plant nutrient uptake as well as drip dispersal systems can. Reference to one dispersal area configuration does not preclude use of the alternative configuration.

Drip dispersal systems are documented in the TGM, chapter 4. The area requirements depend upon the soil classification and the number of bedrooms in the home. Furthermore, to maximize the available soil and ensure that the drainfield undergoes periodic wetting and drying, which enhances the phosphorus sequestration, both primary and replacement dispersal fields will be required to be installed if a reduced separation distance to surface water is being assessed/requested. Additionally, primary and replacement dispersal fields may be increased in size to provide additional phosphorus sorption sites, since IDAPA 58.01.03.008.03 specified drainfield area is a minimum value. No matter what the proposed drainfield ends up looking like, the model must reflect the proposed system configuration.

A drip dispersal field for a 4 bedroom (300 gallons per day [gpd] wastewater) home located on a type B-1 soil (0.6 gpd/ft^2) will require 1,000 ft^2 for the distribution area. This amount of area is arrived at using Equation 4-1:

$$Area = (300\ GPD) * (2\ dispersal\ fields)/(0.6\ GPD/ft^2\ )\ = 1{,}000 ft^2$$

Equation 4-1. Calculation of drip dispersal field area.

Drainfield coverage is ensured due to the requirement that the drip lines are placed 2 feet on center across the entire drainfield. Drip dispersal field construction requirements are fully described in the TGM, Section 4.7, Drip Distribution System.

On-Site Drainfield Inputs
Enter Inputs in Yellow Cells. 'Critical' Calculation Results Appear in Blue Cells
Go to Transport Inputs and Enter Parameters

Project Description ----------------------------------->	Martin Subdivision, Lot 5, Twin Falls ID		
Date --->	6/13/2013 15:44		
Parameter	Units	Value	Comments
Soil Class	none	B-2	Martindale 9/2011 (AJ Dwngrd from B-2)
Residential (select # of bedrooms) / Commercial (select 86)	none	4	Martindale 9/2011
Select System Type	none	Drip	Eligible for P setback reductions
WW flow to drainfield (Minimum Required)	gpd	300	Don't overwrite cell
WW flow to drainfield	gpd	300	per TGM
Required Setback to Surface Water	ft	200	Don't overwrite cell
Proposed Setback to Surface Water	ft	196	Assume this value
Minimum Drainfield Area (primary + replacement drainfields)	ft2	1333	Don't overwrite cell
Drainfield Area Proposed	ft2	1400	Martindale 9/2011 (AJ 20x30 -> 26x36)
For Drip Enter Zero in Cell D21	ft2	0	Adjacent area required for Cap and Fill
Width of Entire Drainfield Perpendicular to GW flow	ft	70	Site map geometry
Required WW Application Rate (gpd/ft2)	gpd/ft2	0.45	
Modeled WW Application Rate to Trench	gpd/ft2	0.21	
Flow Criteria Check gpd per ft2 trench ->	Meets gpd/ft2 Criterion		
Drainfield Area	ft2	1400	
Ground Water Setback Calculations			
Ground Water Velocity (mean Kh)	ft/d	2.4	
Grnd Water Time of Travel to Setback distance (yr)	yr	0.22	
Grnd Water Time of Travel to Setback distance (d)	d	80	
Ground Water [P] Selection: Max [P] gw or Depth Weighted	none	Max Conc	
Surface Water Type	none	stream/river	
Depth / Distance Weighted [P]	mg/L	0.070	
GW [P] Max Conc Disch to Surface Water -	mg/L	0.150	Use Mean Kh value
Selected $[P]_{gw}$ value	mg/L	0.150	
Ground Water [P] Acceptibility	Acceptible: [P] less than limit		

Figure 4-1. Drainfield data input sheet.

4.1.1 Drainfield Sheet Inputs

The following describes the input parameters for the Drainfield sheet. As with the other sheets, cells used for inputs are colored yellow with red font.

1. **Soil Class:** The soil class is entered from a drop-down list of choices that are limited to those soil classes defined and listed in the TGM, section 2.1.2, Table 2-4.
2. **Residential/Commercial:** Select the residence's number of bedrooms from the drop-down list, from 1 to 6 bedrooms. If the facility is a commercial operation, or a Large Soil Absorption System (LSAS), select 86.

3. **Select Drip/Cap and Fill/Gravity:** As discussed in section 4.1, only pressurized systems (drip or cap and fill) are considered for setback variances based on P loading. The *gravity* option is retained as a selection only for the evaluation of existing systems (i.e., for case-study purposes or other site-specific analyses). A *drip* selection directs one to insert a value of zero for recommended adjacent area. A *cap and fill* selection directs one to insert a value for required adjacent area. The minimum dispersal area for trenches includes only the trench bottom infiltrative area. Since trenches must be placed no closer than 6 feet apart, this additional area must be accounted for when a cap and fill drainfield configuration is selected. This adjacent area is typically two times the minimum dispersal area requirement.
4. **Wastewater Flow to Drainfield (Minimum Required) (gpd):** The value appearing in this cell is not entered but is retrieved from a lookup table based upon the number of bedrooms entered in section 4.1.1(2) (IDAPA 58.01.03.007.08). If commercial, numerical value 86, is chosen, a TBD appears in this cell. Commercial should also be selected if the system is a LSAS.
5. **Wastewater Flow to Drainfield (Proposed) (gpd):** Enter the proposed flow rate for the scenario being modeled. The recommended rate appearing in the cell above should be consulted when making this choice. Flow rates that deviate from IDAPA 58.01.03.007.07 specified minimums appearing in the cell above must be justified. All commercial and LSAS flows should be arrived at using the flows listed in IDAPA 58.01.03.007.08, unless justification is provided from flows that are significantly different. All flows differing from IDAPA 58.01.03.007 will be reviewed and approved/rejected by DEQ during the assessment of the model's results.
6. **Required Setback Distance to Surface Water (feet):** The value appearing in this cell is not entered but is retrieved from a lookup table based upon the soil class (TGM, section 2.2.2, Table 2-8) entered in section 4.1.1(1).
7. **Proposed Setback Distance to Surface Water (feet):** Enter the proposed setback distance for the scenario being modeled. The recommended distance appearing in the cell above (section 4.1.1(6)) should be consulted when making this choice. The distance entered should represent the shortest horizontal distance from the adjacent surface water to the distribution field's perimeter. In no instance shall the separation distance between the drainfield and the surface water be less than 100 feet.
8. **Minimum Drainfield Area (primary + replacement drainfields) (ft^2):** The value appearing in this cell is not entered but is calculated by dividing the proposed wastewater flow entered in 4.1.1(5) by the Long-Term Application Rate (LTAR) affiliated with the soil class entered in 4.1.1(1) and then doubling the area due to the requirement that both pressurized distribution fields are installed during initial construction. Both drainfields must be utilized upon placing the system into service. This use will allow the undosed areas within the drainfield a longer drying time between doses, which will assist with phosphorus adsorption.
9. **Drainfield Area Proposed (ft^2):** Enter the proposed trench area for the scenario being modeled. The recommended area appearing in the cell above (section 4.1.1(8)) is IDAPA 58.01.03.007 required minimum area to be designated for drainfield use. The proposed drainfield area must equal or exceed the recommended drainfield area in order to properly assess a suitable surface water setback reduction. Current IDAPA 58.01.03.007 requirements are minimum values. Increasing the drainfield size to

obtain more phosphorus adsorbing soil in order to obtain a setback reduction is acceptable. Additional drainfield area, once designated for surface water setback distance reduction, cannot be utilized to accommodate increases in future wastewater flow from the structure.

10. **Width of Entire Drainfield Perpendicular to Ground Water Flow (feet):** Enter the total width of the pressurized drainfield area perpendicular to ground water flow. A representative pressurized drainfield configuration designed for installation in a type A soil is provided in Figure 4-2. This input in part determines the cross-sectional area of ground water discharge and thus the flow of ground water (Q_{gw}) that is used in mixing and contaminant transport calculations. The lower this input is, generally the higher the calculated mixed ground water concentration (C_{mix}) is; so, if either the ground water flow direction or installation orientation is not known, the conservative assumption would be to input the lesser of length or width of the installation.

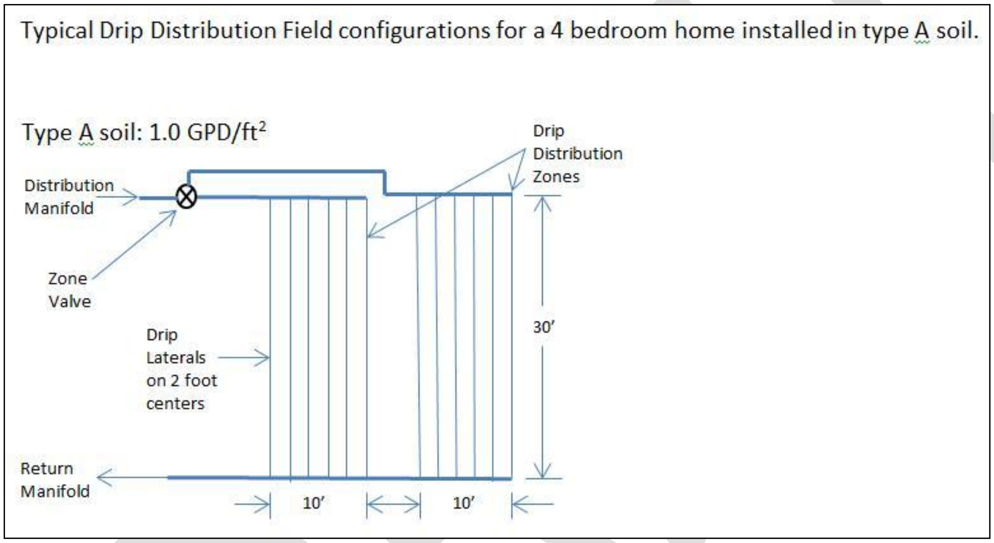


Figure 4-2. Typical drip distribution field geometry.

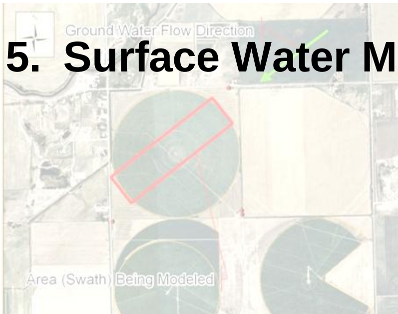
4.1.2 Drainfield Sheet Calculated Outputs

1. **Required Application Rate to Field (gpd/ft^2):** The value appearing in this cell is retrieved from a lookup table based upon the soil class (TGM, section 2.3, Table 2-9) entered in section 4.1.1(1).
2. **Modeled Application Rate to Field (gpd/ft^2):** This is a calculation based upon the entered effluent flow (section 4.1.1(5)) divided by the entered drainfield area (section 4.1.1(9)).
3. **Flow Criterion Check:** This output compares the required application rate (section 4.1.2(1)) to the calculated rate (section 4.1.2(2)) for the proposed scenario. If the calculated rate is equal to or less than the required rate, the adjacent cell format becomes green and the cell indicates that an acceptable rate is proposed. If the calculated rate is above the required rate, the adjacent cell format becomes red and the cell indicates that an unacceptable rate is proposed.
4. **Drainfield Area (ft^2):** This value is the sum of the Drainfield Area Proposed and the Adjacent Area Proposed. This area is used in the Ground Water Transport sheet

(section 6.1) to derive a length of the site along the ground water flow path that is in turn used in the calculation of the mixing zone depth.

5. **Ground Water Velocity (mean K_h) (ft/d):** This output is calculated using the mean K_h value of the range of K_h input in the GW Transport sheet (section 6.2.1.1(8)). This velocity is utilized to calculate aquifer travel times (in both years and days) to the proposed setback distance. The calculated time is used as one of the options in the selection of time elapsed from the commencement of drainfield operation. The other options, calculated in the GW Transport sheet (section 6.2.1.2(6)) include designated site life, infinite time, or *other* specified time span.
6. **Ground Water Time of Travel to Setback Distance (years):** This calculation is made by dividing the setback distance entered in section 4.1.1(7) by the ground water velocity calculated in section 4.1.2(5), and expressed in years.
7. **Ground Water Time of Travel to Setback Distance (days):** This calculation is made by dividing the setback distance entered in section 4.1.1(7) by the aquifer velocity calculated in section 4.1.2(5), and expressed in days.
8. **Ground Water P Concentration Selection—Maximum or Weighted:** This cell shows which ground water concentration was selected in the Surface Water Mixing sheet to be utilized in mixing calculations. See section 5.2.1(9) for further discussion.
9. **Select Surface Water Type:** This cell shows which surface water type was selected in the Surface Water Mixing sheet between one of the two choices: streams and rivers, or lakes and reservoirs. For further discussion, see section 5.2.1(9) and section 5.3.1(13).
10. **Depth/Distance Weighted [P]:** See explanation of this depth and distance weighting of the ground water P concentration in the cross-sectional area of discharge in section 5.2.1(9). The calculated value of the depth and distance-weighted P concentration appears here.
11. **Ground Water [P] Maximum Concentration Discharge to Surface Water (mg/L):** This calculation is made using Domenico equations. The calculation yields the value at the top of the water table at the point of concern specified in the GW Transp sheet (section 6.2.1.2(1)). The point of concern is (generally) set at x = setback distance, y = 0 (the plume centerline), and z = 0 (the top of the water table).
12. **Selected $[P]_{gw}$ Value:** The value of either the depth and distance weighted $[P]_{gw}$ or the maximum $[P]_{gw}$ appears here depending on what option was selected in the input described in section 5.2.1(9) or section 5.3.1(13)
13. **Ground Water [P] Acceptability:** This output compares the maximum ground water P concentration allowed (input in the GW Transport sheet, section 6.2.1.1(7)) to the modeled concentration at the setback distance for the proposed scenario. If the calculated concentration is equal to or less than the allowable concentration, the cell format becomes green and the cell indicates that an acceptable modeled concentration can be achieved at the setback distance. If the calculated concentration is above the allowable concentration, the cell format becomes red and the cell indicates that an acceptable modeled concentration cannot be achieved at the setback distance and the cell indicates that an unacceptable concentration is predicted.

5. Surface Water Mixing Sheet



5.1 Description

The Surface Water Mixing sheet calculates both mass discharge of P from ground water into a surface water body as well as *instream* mixed concentration of P from ground water discharging into a surface water body. A limit for either a mass discharge or instream mixed concentration is set and the modeled output is compared to the set limit to determine acceptability of the modeled scenario. There are two areas on the sheet, one for rivers and streams, and another for reservoirs and lakes. This is due to the two types of water bodies each requiring different approaches and assumptions associated with discharge and mixing calculations.

5.2 Surface Water Mixing Sheet—Streams and Rivers

The following describes the input parameters for the Surface Water Mixing sheet—Streams and Rivers, which is shown in Figure 5-1. As with the other sheets, cells used for inputs are colored yellow with red font.

Project Description -------------------------->	General Model Development Copy
Date --->	2/15/2012 14:14
Select Surface Water Type ->	stream/river

Surface Water Mixing - Stream /River			
Parameter	Abbreviation	Value	Comments/Notes
Surface Water Inputs - Stream / River		Spkn R.	USGS 12419000 SPOKANE RIVER NR POST FALLS ID
Depth of Stream (ft)	d	15	
Flow - [30Q5] or [M30D5Y] cfs	30Q5	844	
Optional Custom Flow (if needed)	--	345	
Upstream [P] (mg/L)	C(sw)	0.0090000	http://nwis.waterdata.usgs.gov/id/nwis/qwdata/?site_no=12419000&agency_cd=USGS&inventory_output=0&r
Allowable limit [P] to sw from this source	C(sw-allowed)	0.0090050	
Allowable mass flux from this source lb/yr	m(sw-allowed)	3	mjc value arbitrary
Mixing Zone Calculation			
GW Discharge Width (ft)	w	90	From inspection of plume width plot - calculated
GW Discharge Area (ft^2)	A	1350	
GW Flow (ft^3/d)	Qgw	4455	
GW Flow (cfs)	Qgw	0.0516	
Select Either the Max [P]gw or Depth Weighted	Selection	Weighted Conc	By selecting 'Weighted Conc', a [P]gw is calculated that is weighted by depth (see vertical profile plot) and by plume width profile at Setback
Depth / Distance Weighted [P]gw		0.208	
Selected [P]gw value	[P]gw	0.2082	
Mixing [P] - Flow [30Q5]	Cmix - 30Q5	0.0090122	Does not Meet [P] Limit
Mixing [P] - Optional Custom Flow	--	0.0090298	Does not Meet [P] Limit
Mass Loading (lb/yr)	M(sw)	0.83	Meets P Loading Limit

Figure 5-1. Surface water mixing data input sheet—streams and rivers.

5.2.1 Streams and Rivers Inputs

1. **Select Surface Water Type:** Select from the drop-down list in the top center of the sheet (Figure 5-1) one of the two choices: streams and rivers, or lakes and reservoirs. Enter streams and rivers. The top area of this sheet will prompt the user to enter data and observe outputs from the Streams and Rivers portion of the sheet and ignore those in the Lakes and Reservoirs portion of the sheet.
2. **Surface Water Inputs—Stream/River:** Enter the name, or segment, of the stream or river being modeled. In the Comments cell to the right, enter documentation for the parameter selection, such as particular stream identification numbers, website locations of information obtained, etc. At the outset, it should be determined whether this water body is a gaining or losing stream (i.e., whether ground water is discharging into the stream, or whether the stream is discharging to ground water). Keep in mind this property of a stream may be seasonal. If the stream is a losing stream, there will be no mixing of ground water with surface water at any time of the year, and completion of the Surface Water Mixing Sheet is not necessary.
3. **Depth of Stream (feet):** Enter the maximum depth of the stream at low flow (30Q5) conditions (section 5.2.1(4)). The depth of the stream defines the depth dimension of the portion of the discharging ground water plume to be used in mixing calculations. For example, if the ground water contaminant plume is 22 feet deep at the surface water boundary, but the stream is only 15 feet deep, only the upper 15 feet of the discharging ground water plume will be used in mixing calculations. The remainder of the plume is assumed to bypass the surface water body and is not used in mixing calculations. It must be noted that ground water flow to a stream described here is greatly simplified and is likely much more complicated and beyond the scope of this document to discuss. A site visit during low flow conditions may be required to determine the appropriate depth.
4. **30 Q5 Flow cubic feet per second (cfs):** Enter the low annual stream flow rate for the period of record that is representative of the scenario being modeled. The 30Q5 flow rate represents the 30-day average low flow based upon a 5-year recurrence period. This flow rate will be used in calculating the instream ground water/surface water mixing P concentration and will (most likely) yield more conservative (higher) mixed concentration values than average flows. Generally, but not always, 30Q5 conditions occur in the late summer or fall. Values for 30Q5 flows may be found by utilizing the United States Geological Survey (USGS) StreamStats utility (Hortness 2006) found at the following website: http://water.usgs.gov/osw/streamstats/

   The United States Environmental Protection Agency (EPA) program DFlow will generate other flows such as 30Q10 (which may be close enough for modeling purposes) at a stream gage site but does not generate 30Q5 flow statistics. See the following website: http://water.epa.gov/scitech/datait/models/dflow/index.cfm

5. **Optional Custom Flow (cfs):** If another flow scenario besides the 30Q5 scenario is desired, this flow can be entered here. Provide justification and information source in the Comments/Notes cell.
6. **Upstream P concentration (mg/L):** Enter an estimate of the upstream P concentration for low (30Q5) flow conditions and for the period of record that represents the scenario being modeled. Sources of these data include EPA Storet

Database at http://www.epa.gov/storet/dbtop.html, USGS National Water Information System (NWIS) at http://waterdata.usgs.gov/nwis, and local data that may not be in a database or accessible online, including discharge monitoring reports and consultant reports. Document the source of this information in the Comments/Notes cell.

7. **Allowable Instream Mixed [P] (mg/L):** Enter the instream P concentration limit that is allowed during the time period of the low-flow conditions specified in section 5.2.1(4) (e.g., late summer or fall, growing season, etc.). This value will be compared to the mixed concentrations modeled to determine whether the limit would be met in the modeled scenario. For narrative criteria for excess nutrients and oxygen-bearing materials, see IDAPA 58.01.02.200.06 and 07.
8. **Allowable Mass Flux (Mass Loading) of P into Stream (lb/year):** Enter the allowable mass flux (mass loading) of P that is allowed during the time period of the low-flow conditions specified in section 5.2.1(4) (e.g., late summer or fall, growing season, etc.). This value will be compared to the mass loading values modeled (section 5.2.2(9)) to determine whether the limit would be met in the modeled scenario. The basis for this limit may be derived from a total maximum daily load (TMDL) completed for the water body, or other basis.
9. **Ground Water P Concentration Selection—Maximum or Weighted:** This drop-down list allows the user to specify which ground water concentration to be utilized in mixing calculations. By selecting Maximum Conc, the maximum ground water concentration at the point of discharge to surface water is used. This concentration is that at the top of the water table and on the plume centerline. By selecting Weighted Conc, a concentration is calculated that attenuates the maximum concentration in two ways. First, the concentration is *depth-weighted,* meaning an *average* concentration (rather, an attenuation factor) is calculated for the entire vertical gradient from the top of the water table to the depth of the stream. Second, since the ground water concentration decreases as a function of the distance away from the plume centerline, an attenuation factor is calculated for this also. The maximum concentration is modified by these factors in order to arrive at an estimate of the concentration in the entire cross-sectional area of the ground water plume that is discharging to surface water.

5.2.2 Streams and Rivers Outputs

1. **Ground Water Plume Discharge Width (feet):** The width of the P plume at the ground water discharge point to surface water is calculated and the value appears here. This width can be visually determined by inspecting Plot #3 in the All Plots sheet (Figure 5-2). This plot shows the ground water P concentration from the plume centerline laterally until it reaches background levels. The lateral distance calculated is doubled since the plume is on both sides of the plume centerline.

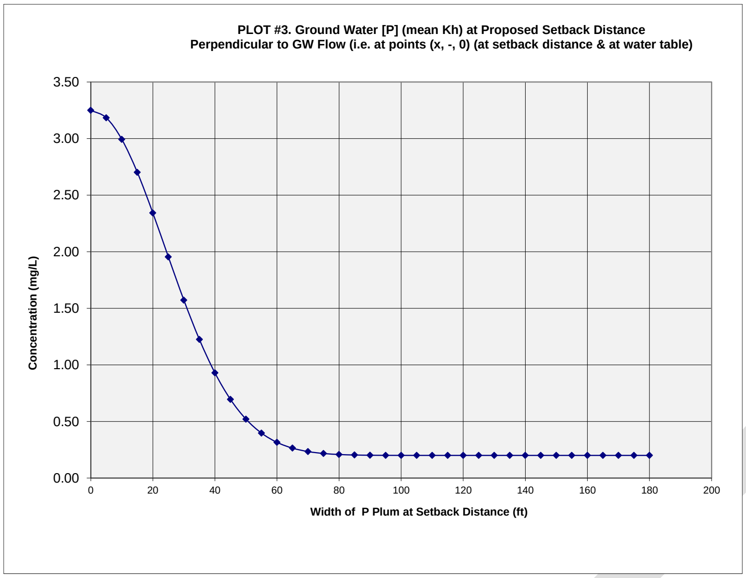


Figure 5-2. Ground water plume discharge width at setback distance.

2. **Ground Water Discharge Area (ft^2):** The value appearing in this cell is the product of the ground water plume width (section 5.2.2(1)) and the stream depth (section 5.2.1(3)). This is the cross-sectional area of ground water discharging into the stream.
3. **Ground Water Flow (Q_{gw}) into Surface Water (ft^3/day):** This calculation is the product of the mean hydraulic conductivity (K_h), the hydraulic gradient (i), and the cross-sectional area (A), or, $Q_{gw} = K_h iA$.
4. **Ground Water Flow (Q_{gw}) into Surface Water (cfs):** This is the same as section 5.2.2(3) except expressed in cubic feet per second.
5. **Depth/Distance Weighted Ground Water P Concentration (mg/L):** See explanation of this depth and distance weighting of the ground water P concentration in the cross-sectional area of discharge in section 5.2.1(9). The calculated value of the depth and distance weighted P concentration appears here.
6. **Selected Ground Water P Concentration (mg/L):** Depending on whether Maximum or Weighted was selected in section 5.2.1(9), the maximum ground water P concentration value, or the weighted value (section 5.2.2(5)) appears here and is used for further mixing and mass discharge calculations.
7. **Instream Mixing P Concentration—Low Annual [30Q5] Flow (mg/L):** Appearing here is the calculated mixed concentration of the low annual stream flow and concentration with the discharging ground water flow and concentration. The cell to the immediate right shows the result of the comparison with the P concentration limit set in section 5.2.1(7). If the calculated value is less than or equal to the limit, the cell format turns green and the statement, Meets [P] Limit, appears. If the calculated value exceeds the limit, the cell format turns red and the statement, Does not Meet [P] Limit, appears.
8. **Instream Mixing P Concentration—Custom Flow Conditions (mg/L):** Appearing here is the calculated fully mixed concentration of the high annual stream flow and concentration with the discharging ground water flow and concentration. The cell to the immediate right shows the result of the comparison with the P concentration limit set in section 5.2.1(7). If the calculated value is less than or equal to the limit, the cell

format turns green and the statement, Meets [P] Limit, appears. If the calculated value exceeds the limit, the cell format turns red and the statement, Does not Meet [P] Limit, appears.

9. **Mass Loading of P to Stream (lb/year):** This value is the mass of P discharging into the stream from ground water through the cross-sectional area previously determined (section 5.2.2(6) and section 5.2.2(2)). The cell to the immediate right shows the results of the comparison with the P mass loading limit set in section 5.2.1(8). If the calculated value is less than or equal to the limit, the cell format turns green and the statement, Meets [P] Loading Limit, appears. If the calculated value exceeds the limit, the cell format turns red and the statement, Does not Meet [P] Loading Limit, appears.

5.3 Surface Water Mixing Sheet—Lakes and Reservoirs

The following describes the input parameters for the Surface Water Mixing sheet—Lakes and Reservoirs, which is shown in Figure 5-3. As with the other sheets, cells used for inputs are colored yellow with red font.

Surface Water Mixing - Lake / Reservoir			
Parameter	Abbreviation	Value	Comments/Notes
Surface Water Inputs - Lake/Reservoir		Lakewood Cove	Martindale 9/2011
Shoreline Gradient into Lake/Reseroir	degrees	12	mjc - assumed
Depth of Lake/Res - Recommended	ft	23.4	<----Recommended Value. Do not overwrite.
Depth of Lake/Res in Mixing Area (ft)	d	1.6	http://www.fyinorthidaho.com/lake_river_facts
Area of Lake/Reservoir (acres)	A(L/R)	150	assume S. half of Windy Bay is 700' x 9,300' = 6,510,000 = 150 acres
Fraction of Lake/Res Area for Mixing	A(f)	0.10	0.10 required value by DEQ rule
Approx # of Onsite Systems near Lake	Syst(os)	33	Martindale map shows ~20 systems on 1,500' shoreline; 124 systems along 9,300 ft
Lake/Res Annual Turnover Rate	R(t)	1	i.e. number of lake volumes displaced per year
Lake/Res Mixing Volume (ft3)	Q(sw)	31680	
Lake/Res [P] (mg/L)		0.0155	DEQ, Nov 22, 2000, p. 42 (for Lower Twin Lk; need to locate source for Lake CDA data)
Allowable limit [P] to sw from this source	C(sw-allowed)	0.020	mjc arbitrary
Allowable mass flux from this source lb/yr	m(sw-allowed)	2	mjc arbitrary
Mixing Zone Dimensions in Lake / Res (areal)			
Distance into Lake / Res (ft)	L	220	
Mixing Zone Calculation			
GW Discharge Width (ft)	w	90	Also assumed to be the Shoreling Width (ft)
GW Discharge Area (ft^2)	A	144	
GW Flow (ft^3/d)	Qgw	4455	
GW Flow (ft3/yr)	Qgw	1626075	
Select Either the Max [P]gw or Depth Weighted	Selection	Weighted Conc	By selecting 'Weighted Conc', a [P]gw is calculated that is weighted by depth (see vertical profile plot) and by plume width profile at Setback
Depth / Distance Weighted]P]	[P]gw	0.222	
Selected [P]gw value	[P]gw	0.222	
Mixing [P]	Cmix	0.21792	Does not Meet [P] Limit
Mass Loading to Lake / Res (lb/yr)	M(sw)	2.22	Does not Meet P Loading Limit

Figure 5-3. Surface water mixing data input sheet—lakes and reservoirs.

5.3.1 Lakes and Reservoirs Inputs

1. **Select Surface Water Type:** Enter from the drop-down list in the top center of the sheet (section 5.2.1(1) and Figure 5-1) one of the two choices: streams and rivers, or lakes and reservoirs. Enter lakes and reservoirs. The top area of this sheet will prompt the user to enter data and observe outputs from the Streams and Rivers portion of the sheet and ignore those in the Streams and Rivers portion of the sheet.
2. **Lake or Reservoir:** Enter the name, or subarea such as a bay, of the lake or reservoir being modeled. In the Comments cell to the right, enter any other documentation for the parameter selection, such as particular identification numbers, website locations etc. At the outset, it should be determined whether this water body (hereafter referred to as *lake* for convenience) is a gaining or losing water body (i.e., whether ground water is discharging into the lake, or whether the lake is discharging to ground water). If the lake is a losing body, there will be no mixing of ground water with surface

water and the basic assumption of the Surface Water Mixing Sheet is not satisfied, and no ground water/surface water mixing or mass loading can be calculated. Do not use this sheet.

3. **Shoreline Gradient into the Lake/Reservoir (degrees):** Enter the angle (θ, slope) at which the lake bottom makes with the water surface in degrees (Figure 5-4). The depth of the lake/reservoir mixing zone is determined by the formula
$d = (L/2)*\tan\theta$,
where:
   a. d is depth of the lake along the shoreline where mixing will be calculated
   b. L is the length of the surface area of the mixing zone obtained by calculation from the ground water plume discharge width (sections 5.2.2(1) and section 5.3.2(3)). Dividing L by 2 yields an average depth of the mixing zone. If the lake bottom is steep and abrupt, this calculation may not be appropriate. Both this calculation and the recommendation in section 5.3.1(4) may be ignored and a custom depth entered in section 5.3.1(5).

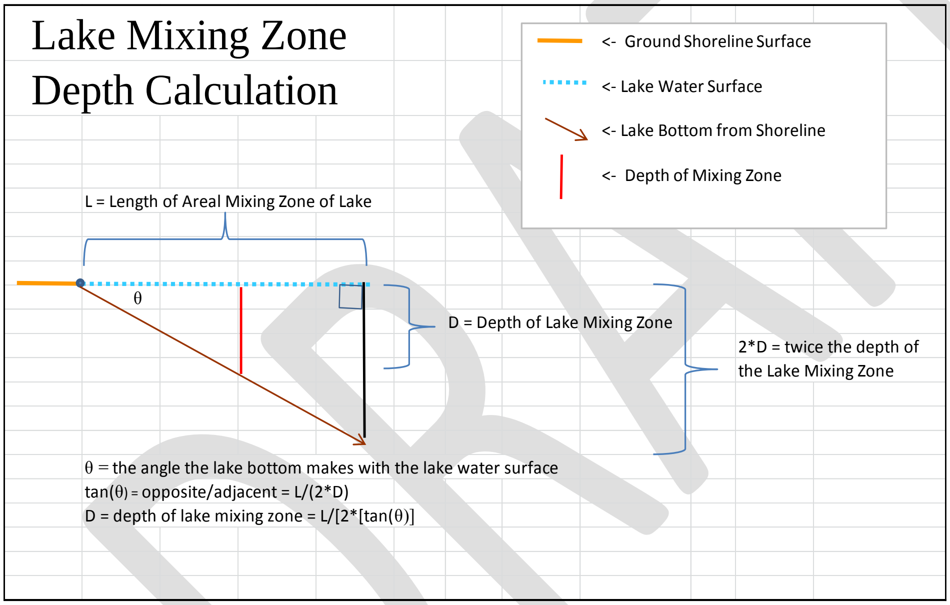


Figure 5-4. Method for calculating lake mixing zone depth.

4. **Depth of Lake/Reservoir—Recommended (feet):** The result of the calculation $d = (L/2)*\tan\theta$, appears here as a recommended value to enter into section 5.3.1(5) input described below.
5. **Depth of the Lake/Reservoir in the Mixing Area (feet):** Enter the depth of the lake calculated in section 5.3.1(4) or other estimate as appropriate (Figure 5-4). The manner in which this area is determined is discussed in section 5.3.1(6), (7) and (8) below. The depth of the lake defines the depth dimension of the portion of the discharging ground water plume to be used in mixing calculations. For example, if the ground water contaminant plume is 22 feet deep at the point of surface water discharge and if the lake is 5 feet deep, only the upper 5 feet of the discharging ground water plume will be used in mixing calculations. The remainder of the plume is assumed to bypass the surface water body and is not used in mixing calculations. It must be noted that ground water flow to a lake described here is greatly simplified

and is likely much more complicated and beyond the scope of this document to discuss.

Note: Stratification of the water column in lakes often takes place, and such stratification may change seasonally. This seasonal stratification may result in restricted mixing of the water column. No attempt has been made to incorporate this phenomenon into mixing calculations.

6. **Area of the Lake/Reservoir (acres):** Enter the acreage of the lake here. If a subarea (such as a bay) of a larger lake like Lake Coeur d'Alene is being modeled, enter the bay's acreage.
7. **Fraction of the Lake/Reservoir (Surface) Allowed for Mixing:** Enter the fraction of the surface area of the lake that is allowed for mixing. A value less than or equal to 0.10 is required (IDAPA 58.01.02.060.01.f(i)).
8. **Approximate Number of On-Site Systems on the Lake:** Enter an estimate of the number of on-site systems that are near the lake's shore, or are planned to be installed along the shoreline of the lake. The reason for this input is to mathematically split the lake up into several smaller parts so that each on-site system is associated with its own *virtual lake,* not comprising the entire lake, but rather comprising its *share* of the lake.
9. **Lake/Reservoir Annual Displacement Rate (number):** Enter an estimate of the number of lake volumes displaced per year for the period of record of interest. This is calculated by dividing lake volume by annual discharge rate: V_{lake}/Q_{disch}. A rough estimate of the volume of a lake can be made by taking the area of the lake, assuming a circular shape and deriving the radius. Then assume an hemispherical three-dimensional shape and, using a maximum depth, find the volume of the hemisphere. A value for the discharge from a lake may be obtained in many cases from stream gaging stations. An example of a lake displacement calculation is as follows: given a lake volume of 200 million gallons (MG) and its annual discharge of 100 MG/year, the displacement rate is 200 MG/100 MG/year = 2 years. As a rough rule of thumb, displacement rate of most lakes is less than 1 year, larger lakes (such as Lake Coeur d'Alene) are greater than 1 year. It must be noted that the displacement rate of a reservoir can be highly variable, depending upon how they are managed from year to year. DEQ has a database containing certain information on several lakes in Idaho that is only available internally. Larger lakes will have USGS gages to measure discharge but most other lakes will not.
10. **Lake/Reservoir P Concentration ([P]) (mg/L):** Enter an estimate of the lake P concentration for the period of record and season (if applicable) that represents the scenario being modeled. If the lake is thermally stratified, one may want to restrict this mixing analysis to the upper mixed layer (epilimnion).
11. **Allowable Lake/Reservoir Mixed P Concentration ([P]) (mg/L) from this Source:** Enter the lake P concentration limit that is allowed. This value will be compared to the mixed concentrations modeled to determine whether the limit would be met in the modeled scenario. This might be a seasonal (i.e., summer) limit when septic usage is high and temperatures are warmer.

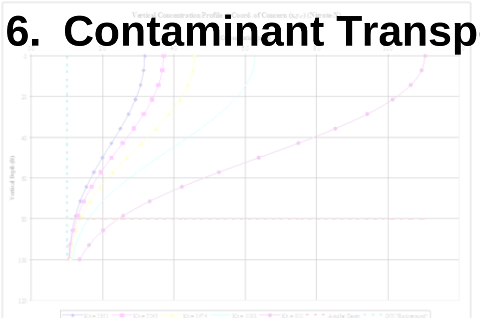
12. **Allowable Mass Flux (Mass Loading) of P into Lake (lb/year):** Enter the mass flux (mass loading) of P that is allowed. This value will be compared to the mass loading values modeled to determine whether the limit would be met in the modeled scenario.
13. **Ground Water P Concentration Selection—Maximum or Weighted:** This drop-down list allows the user to specify which ground water concentration to be utilized in mixing calculations. By selecting Maximum Conc, the maximum ground water concentration at the point of discharge to surface water is used. This concentration is that at the top of the water table and on the plume centerline. By selecting Weighted Conc, a concentration is calculated that attenuates the maximum concentration in two ways. First, the concentration is *depth-weighted*, meaning an *average* concentration (rather, an attenuation factor) is calculated for the entire vertical gradient from the top of the water table to the depth of the lake. Second, since the ground water concentration decreases as a function of the distance away from the plume centerline, an attenuation factor is calculated for this also. The maximum concentration is modified by these factors in order to arrive at an estimate of the concentration in the entire cross-sectional area of the ground water plume that is discharging to surface water.

5.3.2 Lakes and Reservoirs Outputs

1. **Lake/Reservoir Mixing Volume (cubic feet per year [ft^3/year]):** This volume is calculated by dividing the lake acreage (section 5.3.1(6)) by the number of on-site systems on the lake (section 5.3.1(8)), then multiplying this value by the fraction of the lake surface allowed for mixing (section 5.3.1(7)). Then, this value is multiplied by the depth of the mixing zone area (section 5.3.1(5)) to obtain a preliminary mixing volume. Lastly, the value is multiplied by the lake turnover (displacement) rate calculated in section 5.3.1(9) to obtain the mixing volume.
2. **Mixing Zone Dimensions (Shoreline)—Width (Ground Water Discharge Width) (feet):** The width of the P plume at the ground water discharge point to the lake is calculated and the value appears here. As discussed for streams, this width can be visually determined by inspecting Plot #3 in the All Plots sheet (Figure 5-2). This plot shows the ground water P concentration from the plume centerline laterally until it reaches background levels. The lateral distance calculated is doubled since the plume is on both sides of the plume centerline.
3. **Mixing Zone Dimensions (Distance into Lake) (feet):** This cell is calculated by first dividing the lake area (section 5.3.1(6)) by the number of other on-site systems on the lake (section 5.3.1(8)). This value is multiplied by the fraction of the lake allowed for mixing (section 5.3.1(7)). The resulting value is multiplied by 43,560 to convert acres to ft^2. Then the value is divided by the shoreline width (ground water discharge width) (section 5.3.2(2) to yield length.
4. **Ground Water Discharge Area (ft^2):** The value appearing in this cell is the product of the ground water plume width (section 5.3.2(2)) and the lake mixing zone depth (section 5.3.1(5)). This is the cross-sectional area of ground water discharging into the lake.
5. **Ground Water Flow (Q_{gw}) into Surface Water (cubic feet per day [ft^3/d]):** This calculation is the product of the mean hydraulic conductivity (K_h), the hydraulic gradient (i), and the cross-sectional area (A), or, $Q_{gw} = K_h iA$.

6. **Ground Water Flow (Q_{gw}) into Surface Water (ft^3/year):** This is the same as section 5.3.2(5) except expressed in cubic feet per year.
7. **Depth- and Distance-Weighted Ground Water P Concentration (mg/L):** See explanation of this depth and distance weighting of the ground water P concentration in the cross-sectional area of discharge in section 5.3.1(13). The calculated value of the depth- and distance-weighted P concentration appears here.
8. **Selected Ground Water P Concentration (mg/L):** Depending on whether Maximum or Weighted was selected in section 5.3.1(13), the maximum ground water P concentration value, or the weighted value (section 5.3.2(7)) appears here and is used for further mixing and mass discharge calculations. Repeat the selection made on the Drainfield Sheet here.
9. **Lake Mixing P Concentration ([P]) (mg/L):** Appearing here is the calculated mixed concentration of the lake mixing volume (section 5.3.2(1)) and concentration (section 5.3.1(10)) with the discharging ground water flow (section 5.3.2(5) and (6)) and concentration (section 5.3.2(8)). In the cell to the immediate right, compare the cell value with the P concentration limit set in section 5.3.1(11) above. If the calculated value is less than or equal to the limit, the cell format turns green and the statement, Meets [P] Limit, appears. If the calculated value exceeds the limit, the cell format turns red and the statement, Does not Meet [P] Limit, appears.
10. **P Mass Loading to Lake/Reservoir (lb/yr):** The value appearing is the mass of P discharging into the lake carried by ground water (section 5.3.2(4) and section 5.3.2(8)). The cell to the immediate right compares the cell value with the P mass loading limit set in section 5.3.1(12). If the calculated value is less than or equal to the limit, the cell format turns green and the statement, Meets [P] Loading Limit, appears. If the calculated value exceeds the limit, the cell format turns red and the statement, Does not Meet [P] Loading Limit, appears.

6. Contaminant Transport Module



6.1 Description

This spreadsheet module is an adaptation of the *Nutrient-Pathogen Evaluation Program for On-Site Wastewater Treatment Systems* (DEQ 2002), which in turn is an adaptation of the Pennsylvania Department of Environmental Protection (2002) *Quick Domenico.xls* implementation of the Domenico (1987) analytical solution for multidimensional transport of a decaying contaminant species. Adaptations include the following:

1. Inclusion of a procedure to estimate the mixing zone depth in ground water of contaminants beneath the wastewater land treatment source area. This procedure is taken from Equation 38 in the EPA Soil Screening Guidance, Technical Background Document (EPA 1996). This mixing zone depth, along with the estimated width of the source perpendicular to ground water flow, provides the dimensions of the rectangular patch source used in the Domenico solution.
2. Inclusion of a mass-balance mixing calculation to estimate the source zone chemical concentration in ground water resulting from the mixing of site percolate and upgradient ground water. The chemical concentration of the upgradient ground water is assumed to be zero. This provides a relative increase over the site-specific background value for the constituent of concern.
3. Inclusion of the Xu and Eckstein (1995) empirical equations for estimation of longitudinal dispersivity, as corrected by Al-Suwaiyan (1996).
4. Inclusion of charts plotting the vertical concentration profile at a specified distance downgradient from the source and the centerline concentration profile. The charts show the absolute concentration change with background chemical concentrations added in, and show five scenarios for K_h between the upper and lower ranges specified by the user.

The following describes the input parameters for the Ground Water Transport sheet, which is shown in Figure 6-1. As with the other sheets, cells used for inputs are colored yellow with red font.

INPUTS: GW Contaminant Transport Model: ADVECTIVE TRANSPORT				
WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION <Rev 8/11/2010>				
Note: All Inputs are in Rows 6 - 54 and are in Cells with Red Font.				
Project Description:	Windy Bay Case Study; Pmt 92-28-77004			
Date:	5/15/2012			
Prepared by:	M. Cook			
Contaminant:	Phosphorus			
Mixing Zone Depth Calculation Inputs	**Symbol**	**Units**	**Input**	**Data Sources and Comments**
Onsite Installation Length Parallel to GW Flow	L	feet	51.00	From Drainfield Inputs Sheet
Onsite Installation Width Perpendicular to GW Flow	W	feet	36.00	From Drainfield Inputs Sheet
Percolate Volume	Qp	inches/ac	47.8	Calculated from Drainfield Sheet
Percolate Constituent Concentration:	Cp	mg/L	1.2	
Upgradient GW Concentration:	Cgw	mg/L	0.05	estimated
Allowable INCREASE above Bkgrd at Setback Distance	delta-Cgw	mg/L	0.1	mjc: arbitrary
Ground Water [P] Limit at Setback Distance	C(lim)	mg/L	0.15	
Aquifer Hydraulic Conductivity: Upper Range	K	feet/day	5	Stevens April 2011, p. 8, Tbl 6.
Aquifer Hydraulic Conductivity: Lower Range	K	feet/day	1	Stevens April 2011, p. 8, Tbl 6.
Aquifer Hydraulic Gradient	i	unitless	0.006	Stevens April 2011, p. 10
Aquifer Material	Driscoll, 1987 - Sand			
Aquifer Porosity (Suggested values, range in percent)	ne	unitless	25 – 40%	Suggested value. Don't overwrite
Aquifer Effective Porosity (enter suggested or other value as a perc	ne	unitless	43%	Stevens April 2011, p.9, Tbl 6.
Aquifer Thickness	da	feet	15	Stevens April 2011, p. 7, Tbl 4.
Model Domain & Other Spatial Inputs				
Spatial Coordinates of Concern (Origin is plume centerline at DG discharge boundary				
X (longitudinal)	x	feet	100	X coord at required distance from surface water.
Y (latitudinal/transverse)	y	feet	0	
Z (depth)	z	feet	0	
Depth of Vertical Profile to Calculate and Observe	z	feet	25	Stevens April 2011, p. 7, Tbl 4.
Time that the Source is Discharging	d	days	Infinite	worse case
			15728	<------- Ignore This Entry
Selected Time that the Source is Discharging	d	days	1000000	Do not Overwrite Cell
AREAL Model Calculation Domain			2739.7	
(dimensions of area modeled)				
Length (ft)	L	feet	500	assumed mjc
Width (ft)	W	feet	200	assumed mjc
Alert: Significant Vertical Dispersion Below Actual Aquifer Depth in One or More P Scena				

Figure 6-1. Ground water contaminant transport data input sheet.

6.2 Contaminant Transport Module—Instructions for Use

6.2.1 Contaminant Transport Module Inputs

This section provides descriptions of the following:

- The required aquifer parameters
- Ground water quality
- Ground water impact analysis inputs

General instructions for inserting these parameters into the model are also provided.

1. **Data Sources and Comments:** The column titled, Data Sources and Comments, is a space where the user should document sources and rationale for input parameters chosen.
2. **Project Description:** The Project info appearing here is carried over from the Isotherm sheet (section 2.2.1(1)). This label should include a description of the scenario that is being run, and how a particular scenario may differ from other scenarios.
3. **Run Date:** The time/date stamp is automatically calculated for the particular model run.
4. **Prepared By:** Enter users name.
5. **Contaminant:** Enter contaminant being modeled.

6.2.1.1 Mixing Zone Depth Calculated Inputs and Selected Outputs

1. **On-Site Installation Length Parallel to GW Flow (feet)—Calculated Cell:** The length of the on-site installation parallel to ground water flow is calculated by dividing the total drainfield area (section 4.1.2(4)) by the width of the on-site installation perpendicular to ground water flow (section 4.1.1(10)).
2. **On-Site Installation Width Perpendicular to GW Flow (feet)—Calculated Cell:** The value of this cell appearing here is brought from the Drainfield sheet (section 4.1.1(10)).
3. **Percolate Volume (Q_p) Calculated Cell (inches/acre-year):** The value of this cell is calculated using the daily flow to the drainfield (section 4.1.1(5)) and the total drainfield area (section 4.1.1(9)) entered in the Drainfield sheet, to calculate flow in inches/acre-year.
4. **Percolate Constituent (P) Concentration (C_p or C_{eq}) (mg/L):** The value of this cell is brought from the P equilibrium concentration assigned to the system in the Phase II analysis in the Sorption sheet (section 3.4.1(2)).
5. **Upgradient Ground Water Phosphorus Concentration (C_{gw}) (mg/L):** Enter a value for the upgradient ground water phosphorus concentration. The upgradient (background) concentration is shown on centerline and vertical plots for reference.
6. **Allowable Increase in Ground Water Phosphorus Concentration (mg/L):** Enter a value for the allowable increase above upgradient (background) ground water phosphorus concentration.
7. **Ground Water [P] Model Threshold Value at Setback Distance (mg/L)—Calculated Cell:** The value appearing here is the sum of the upgradient concentration plus the allowable increase (section 6.2.1.1(5) and (6)), thus yielding the model threshold value. The concentration limit is shown on centerline and vertical plots for reference.
8. **Aquifer Hydraulic Conductivity (K_h) (upper and lower range):** Enter these values in the next two cells in ft/d. Uncertainty exists when estimating this parameter. See the Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater (DEQ 2007) sections 2.5.3 through 2.5.8 and DEQ 2007 section 2.1.4.2.2 for further information on K_h values. See the DEQ 2007 section 7.7.5.2.2 for a detailed discussion of how aquifer parameters are used in mixing zone calculations. This model generates five different K_h scenarios, including those of the upper and lower range, as well as three intermediate values, and plots the results.
9. **Aquifer Hydraulic Gradient (i) (unitless):** Enter the aquifer gradient here. The gradient is derived from potentiometric maps or other sources. Document the source of the gradient value used in the Data Sources and Comments column.
10. **Aquifer Material:** From the drop-down list, select the aquifer material. A suggested porosity will appear below.
11. A**quifer Porosity (suggested values) (n)—Calculated Cell:** A suggested aquifer porosity value appears in this cell, which is based upon the aquifer material chosen in section 6.2.1.1(10). Values are based upon those found in Freeze and Cherry (1979), Driscoll (1987) and Domenico and Schwartz (1998).
12. **Aquifer Effective Porosity (n_e):** Enter an aquifer effective porosity here. See DEQ 2007, Sections 2.1.4.2.2 and 2.5.9 for further information on n_e values. Note that standard tables for aquifer parameters list porosities, not effective porosities. The

modeler should use best professional judgment when using porosity values, or modifying them as needed to reflect effective porosity.

13. **Aquifer Thickness (b):** This is the thickness of the aquifer, *not* the mixing zone depth (which is calculated from various aquifer parameters and site geometry). Geological studies and/or well logs should be consulted for aquifer thickness information. Aquifer thickness is plotted on vertical profile plots (section **Error! Reference source not found.**(2)) for reference. If *aquifer thickness* is greater than the *depth of vertical profile to be observed* (section 6.2.1.2(2)), then aquifer thickness will set the scale of the vertical plots. If *aquifer thickness* is less than the *depth of vertical profile to be observed*, then depth of vertical profile to be observed will set the scale of the vertical plots.

    Note that at the bottom left of the Inputs area in this sheet there are two cells that alert the user if significant dispersion of the constituent of concern is occurring below the specified depth of the aquifer (which would represent an unrealistic scenario). In this model, depth of vertical dispersion cannot be limited so it must be *manually* checked. If the constituent dispersion exceeds aquifer thickness these cells will be displayed in red, and if the aquifer thickness exceeds the constituent dispersion, these cells will be displayed in green.

6.2.1.2 Ground Water Transport Calculated Inputs

On the Inputs worksheet, input parameters related to ground water contaminant transport modeling include the following:

1. **Spatial Coordinates (x,y,z) of Concern:** The user specifies a point in space (i.e., in the contaminant plume) by entering coordinates (x, y, z). Figure 6-2 shows the coordinate system of a contaminant plume. The coordinate system consists of the following:

    The x Axis—Calculated Cell: This cell has a value brought in from the Drainfield sheet (section 4.1.1(7)) and is the proposed setback distance from the on-site installation to a surface water body. The x axis is parallel to the direction of ground water flow through the center of the site, passing through the origin and is positive downgradient along the plume centerline (i.e., the x value specified refers to the distance downgradient from the source discharge boundary).

    The y Axis: This axis is perpendicular to ground water flow along the downgradient boundary of the wastewater land treatment site (i.e., the y value specified refers to the distance from the center of the source area in a horizontal direction perpendicular to the direction of ground water flow). Zero is located at the midpoint (center) of the site at the downgradient boundary.

    The z Axis: This axis is depth below the water table surface. The water table surface is at z = 0. Positive numbers represent depth below the water table.

A constituent concentration at the selected (x, y, z) coordinate of concern is calculated in Domenico Outputs sheet (section 6.2.2.1). This may be a point of compliance or a location where ground water criteria should be met.

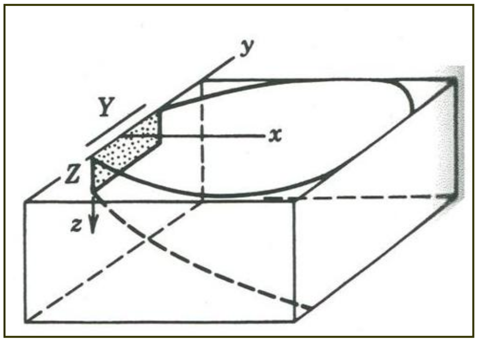


Figure 6-2. Coordinate system for a contaminant plume.

2. **Depth of Vertical Profile to Calculate and Observe:** This entry determines over what thickness of the aquifer, starting at the water table, the chemical concentrations will be calculated by the model. If *depth of vertical profile to be observed* is greater than *aquifer thickness* (section 6.2.1.1(13)), depth of vertical profile to be observed will set the scale of the vertical plots. If *depth of vertical profile to be observed* is less than *aquifer thickness,* then aquifer thickness will set the scale of the vertical plots. Initially, set the *depth of vertical profile to observe* slightly greater than the *aquifer depth.*
3. **Location and Time Information:** The location and time information inputs are used to calculate the predicted chemical concentration at a specific location away from the source at a specific time after source release begins. The time is specified in days from the start of chemical release. If steady-state conditions are to be simulated, the value for time should be set at an appropriately large value. Steady state conditions are reached when concentration profiles no longer change with increasing time. Other values of time should be input if certain time frames need to be considered.
4. **Time that the Source is Discharging:** The drop-down list allows many options for the user to select the length of time the source is discharging. All values except Other are automatically calculated from data already entered in other sheets. The options are as follows:
   a. Infinite, as discussed above, is reckoned as 1 million days and will yield the worst case scenario of the system achieving steady state conditions. Other options include the following:
   b. Setting the time to the regulatory site life allowed by the agency (Phase I plus Phase II operational lives)
   c. The installation site life as determined by the maximum (Phase I) P sorption capacity (section 3.2) determined in the Isotherm sheet (section 2) utilizing the Langmuir isotherm
   d. The time until P breakthrough where $C_p = C_{ww}$ under Phase II conditions (see section 3.4)
   e. The ground water travel time from the installation to the setback distance
   f. An Other time frame selected by the user.

5. **Field for Other Time Frame Entry:** If the Other drop-down list selection is chosen, in the cell below the list, a place to enter (in days) the time that the source is discharging appears. Enter the time where designated.
6. **Selected Time that the Source is Discharging—Calculated Cell:** The value for the menu option chosen appears in this cell.
7. **AREAL Model Calculation Domain:** The planar (length and width) dimensions of the area to be modeled are input in these two cells. They are selected in relation to the center of the source and extend in both the x and y directions, as shown in Figure 6-2, delineating one-half of the symmetrical plume. The model performs contaminant transport calculates within this area. The length input determines the x scale dimension on the plume centerline profile plot. See Figure 6-3 and the discussion in section **Error! Reference source not found.**(1).

6.2.2 Contaminant Transport Module Graphical Outputs

All graphical outputs discussed in this section are found in the All Plots sheet. Data used to make the plots drawn from the various locations where they are generated and are shown in the Plot Data sheet.

1. **Centerline Profile Graph:** Provides graphical representations of the horizontal (x) distribution of the constituent of concerns' chemical concentration, including background ground water concentrations, for five K_h scenarios. See Figure 6-3 for an example of the Centerline Profile output. It shows concentration distributions for the centerline of the plume (y = 0) downgradient from the source to a distance determined by the length value input for the model domain. This concentration profile will be calculated at the z value chosen in the coordinate of concern; if z = 0, the concentrations will be calculated for the top of the water table. See Coordinate of Concern inputs in section 6.2.1.2(1). Notice in the plot the following *marker* lines:
   a. The green vertical dashed line representing the setback distance
   b. The red horizontal long-dashed line representing the ground water constituent limit
   c. The blue horizontal short-dashed line represents upgradient or background ground water quality.

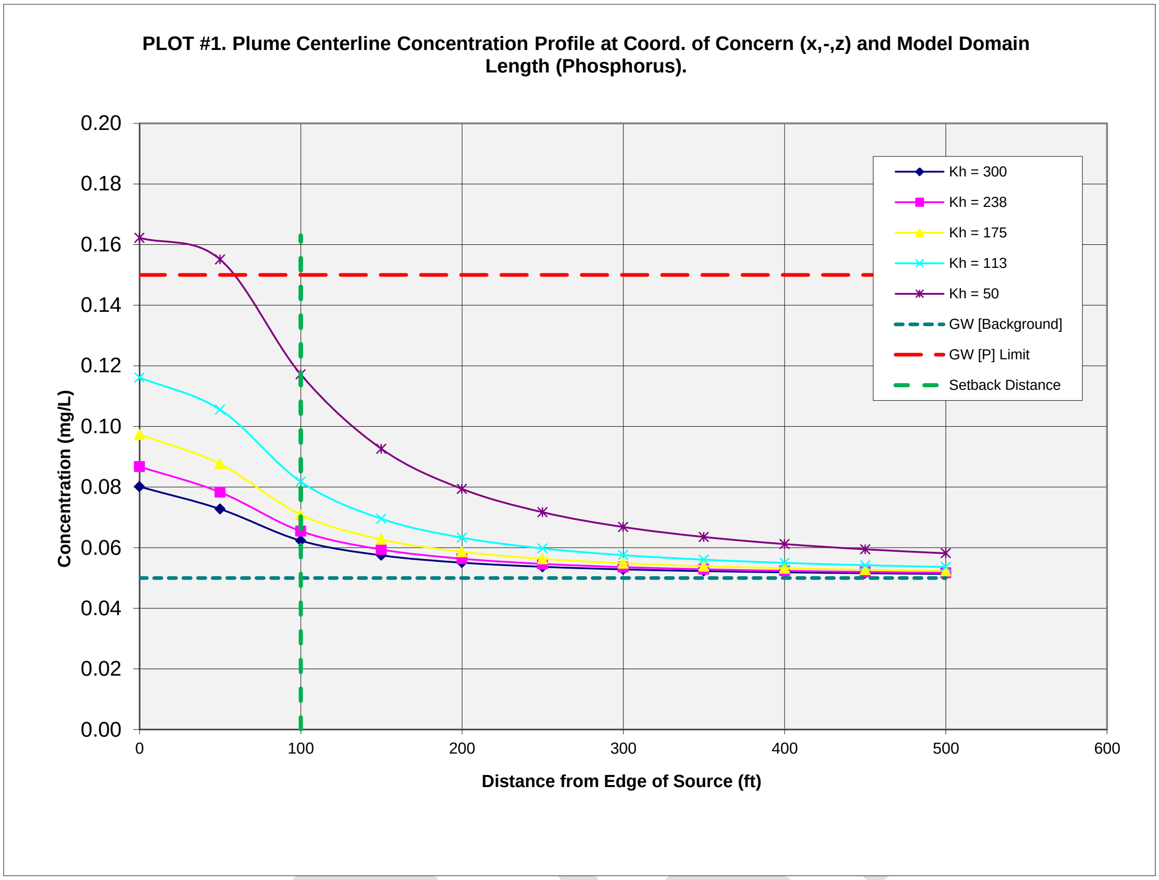


Figure 6-3. Plume centerline P concentrations downgradient of the source.

2. **Vertical Profile graph:** Provides graphical representation of the vertical distribution of the constituent of concern's chemical concentration, including background ground water concentration, for five K_h scenarios. See Figure 6-4 for an example of the vertical profile output. The vertical plot shows the concentration distribution from the water table (z = 0) to a specified depth at a (x, y) coordinate down-gradient of the source, specified in the Coordinate of Concern inputs in Section 6.2.1.2(1). Notice in the plot the following 'marker' lines:
   a. The brown horizontal dashed line represents the aquifer depth.
   b. The red vertical long-dashed line represents the ground water constituent limit.
   c. The blue vertical short-dashed line represents the up-gradient or background ground water quality.

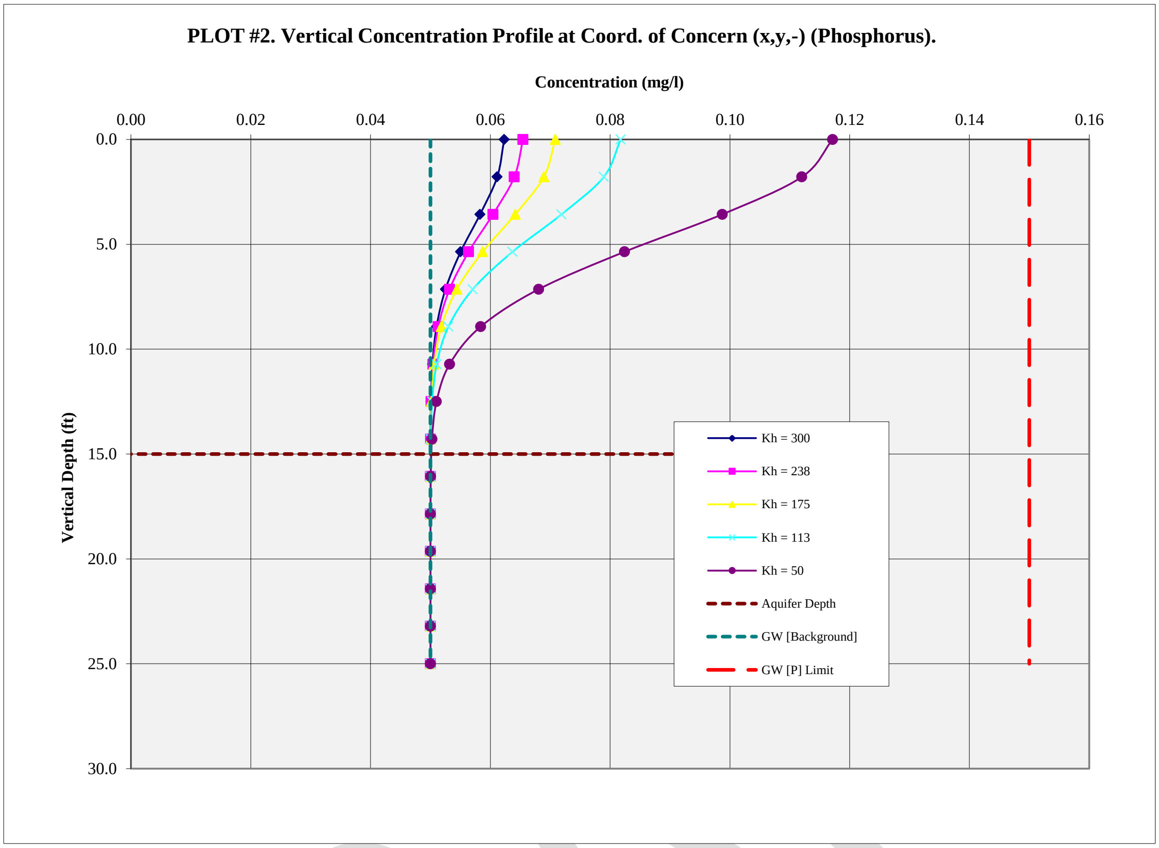


Figure 6-4. Vertical P concentration gradients at the setback distance.

6.2.2.1 Utility Sheets

There are 10 sheets to the right of the Utility Sheets tab. Five of them are labeled IP_N(1) through IP_N(5). These five sheets perform the ground water contaminant transport calculations. One sheet is utilized for each of the five K_h (hydraulic conductivity) values being evaluated. For our purposes the constituent is phosphorus.

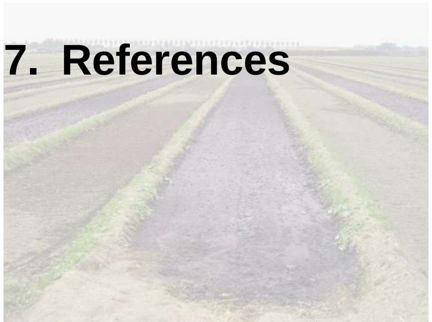
The second set of five sheets are labeled IP_TDS(1) through IP_TDS(5). These five sheets also perform ground water contaminant transport calculations. One sheet is utilized for each of the five K_h values being evaluated.

Each of these nine sheets has an identical format (the sheet, IP_N(1), is arranged differently). Examining sheet IP_N(2) for example, there are several calculation areas that are delimited by black borders. These areas are discussed as they appear from the top to the bottom of the sheet.

1. The first area summarizes Mixing Zone Depth Calculation Inputs and Ground Water Transport Calculation Inputs. (Begin at cell B2.)
2. The second area shows various aquifer modeling calculation outputs. (Begin at cell B51.)
3. The third area shows Domenico dispersion calculation outputs for both the plume centerline and vertical profile (these are in the yellow shaded cells). (Begin at cell B74.)
4. The fourth area shows Mixing Zone Model Output Calculations. (Begin at cell B102.)

5. The fifth area has the Domenico Calculations (i.e., the advection/dispersion calculations). (Begin at cell B141.)
6. The sixth and last area contains Miscellaneous Calculations and Lists. These are the lookup tables from which drop-down list choices derive. (Begin at cell 205.)

7. References



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Appendix A—Soil Sampling for P Sorption Characterization

Surface site characterization and subsurface site characterization of test pits for on-site septic systems will generally conform to the following American Society for Testing and Materials (ASTM) designations, except where rule or guidance indicate otherwise:

- Designation: D5879 – 95. Standard Practice for Surface Site Characterization for On-Site Septic Systems
- Designation: D5921 – 96. Standard Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems

Sampling of soils for P sorption analysis should follow an approved quality assurance project plan to ensure adequate accuracy, precision, and representativeness of the samples. Contact The Idaho Department of Environmental Quality for further guidance.

Appendix B—Phosphorus Sorption Isotherm Methods

B.1 Graetz and Nair (2000) P Sorption Isotherm Method

From: Graetz, D.A. and V.D. Nair. 2000. Phosphorus Sorption Isotherm Determination. *In* Pierzynski, G.M. ed. 2000. *Methods of Phosphorus Analysis for Soils, Sediments, Residuals, and Waters*. Southern Cooperative Series Bulletin No. 396. http://www.soil.ncsu.edu/sera17/publications/sera17-2/pm_cover.htm
URL http://www.sera17.ext.vt.edu/Documents/P_Methods2ndEdition2009.pdf

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Phosphorus Sorption Isotherm Determination

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V.D. Nair, University of Florida

Introduction:

Phosphorus (P) retention by soils is an important parameter for understanding soil fertility problems, as well as for determining the environmental fate of P. The P adsorption capacity of a soil or sediment is generally determined by batch-type experiments in which soils or sediments are equilibrated with solutions varying in initial concentrations of P. Equations such as the Langmuir, Freundlich and Tempkin models have been used to describe the relationship between the amount of P adsorbed to the P in solution at equilibrium (Berkheiser et al., 1980; Nair et al., 1984).

Advantages of the batch technique include: the soil and solution are easily separated, a large volume of solution is available for analysis, and the methodology can be easily adapted as a routine laboratory procedure. Disadvantages include difficulties in measuring the kinetics of the sorption reaction and optimizing the mixing of solution and soil without particle breakdown (Burgoa et al. 1990). Despite the disadvantages, the batch technique has been, and still is, widely used to describe P sorption in soils and sediments.

Nair et al. (1984) noted that P sorption varies with soil/solution ratio, ionic strength and cation species of the supporting electrolyte, time of equilibration, range of initial P concentrations, volume of soil suspension to head space volume in the equilibration tube, rate and type of shaking, and type and extent of solid/solution separation after equilibration. Although most researchers use a similar basic procedure for measuring P adsorption, there is considerable variation observed among studies with regard to the above parameters. This variation often makes comparisons of results among studies difficult. Thus, Nair et al. (1984) proposed a standard P adsorption procedure that would produce consistent results over a wide range of soils. This procedure was evaluated, revised, tested among laboratories and was eventually proposed as a standardized P adsorption procedure. This procedure as described below is proposed as the standard procedure recommended by the SERA-IEG 17 group.

Equipment:

1. Shaker: End-over-end type
2. Filter Apparatus: Vacuum filter system using 0.45 or 0.2 μm filters
3. Equilibration tubes: 50 mL or other size to provide at least 50% head space
4. Spectrophotometer: Manual or automated system capable of measuring at 880 nm

Reagents:

1. Electrolyte: 0.01 *M* $CaCl_2$, unbuffered
2. Microbial inhibitor: Chloroform
3. Inorganic P solutions: Selected concentrations as KH_2PO_4 or NaH_2PO_4 (in 0.01 *M* $CaCl_2$ containing: 20 g/L chloroform)

Procedure:

1. Air-dry soil samples and screen through a 2 mm sieve to remove roots and other debris.
2. Add 0.5 to 1.0 g air-dried soil to a 50 mL equilibration tube.
3. Add sufficient 0.01 *M* $CaCl_2$ solution containing 0, 0.2, 0.5, 1, 5, and 10 mg P/L as KH_2PO_4 or NaH_2PO_4, to produce a soil:solution ratio of 1:25. The range of P values could vary from 0 to 100 mg P/L (0, 0.01, 0.1, 5, 10, 25, 50 and 100 mg P/L) and the soil/solution ratio could be as low as 1:10 depending on the sorption capacity and the P concentrations of the soils in the study.
4. Place equilibration tubes on a mechanical shaker for 24 h at 25 ± 1 °C.
5. Allow the soil suspension to settle for an hour and filter the supernatant through a 0.45 μm membrane filter.
6. Analyze the filtrate for soluble reactive P (SRP) on a spectrophotometer at a wavelength of 880 nm.

Calculations and Recommended Presentation of Results:

Two of the often used isotherms are the Langmuir and the Freundlich isotherms; the Langmuir having an advantage over the Freundlich in that it provides valuable information on the P sorption maximum, S_{max} and a constant k, related to the P bonding energy.

The Langmuir equation

The linearized Langmuir adsorption equation is:

$$\frac{C}{S} = \frac{1}{kS_{max}} + \frac{C}{S_{max}}$$

where:
S = S' + So, the total amount of P retained, mg/kg
S' = P retained by the solid phase, mg/kg
So = P originally sorbed on the solid phase (previously adsorbed P), mg/kg
C = concentration of P after 24 h equilibration, mg/L
Smax = P sorption maximum, mg/kg, and
k = a constant related to the bonding energy, L/mg P.

The linearized form of the Langmuir equation, as presented herein, is the most commonly used procedure to determine the sorption parameters for P because of its ease of use. The Langmuir equation in its nonlinear form may provide more accurate sorption parameters but fitting this model to experimental data requires a "trial and error" approach which is relatively difficult to accomplish. However, recent development of optimization programs to solve the nonlinear equation provides an opportunity to more easily utilize the nonlinear equation in P sorption studies (Bolster and Hornberger, 2007; Schulthess, 2007).

The Freundlich equation

The linear form is:

$$\log S = \log K + n \log C$$

where:
K is the adsorption constant, expressed as mg P/kg,
n is a constant expressed as L/kg, and
C and S are as defined previously.

A plot of log S against log C will give a straight line with log K as the intercept, and n as the slope.

Previously adsorbed P (also referred to as native sorbed P)

Adsorption data should be corrected for previously adsorbed P (S_o). For the calculation of previously sorbed P, Nair et al. (1984) used isotopically exchangeable P (Holford et al., 1974) prior to calculations by the Langmuir, Freundlich and Tempkin procedures. Other procedures used to calculate the previously adsorbed P include oxalate-extractable P (Freese et al., 1992; Yuan and Lavkulich, 1994), anion-impregnated membrane (AEM) technology (Cooperband and Logan, 1994) and using the least squares fit method (Graetz and Nair, 1995; Nair et al., 1998; Reddy et al., 1998). Sallade and Sims (1997) used Mehlich 1 extractable P as a measure of previously sorbed P.

Investigations by Villapando (1997) have indicated a good agreement among native sorbed P values estimated by the least squares fit method, oxalate extractions, and the AEM technology. At this point, it appears that selection of the method for determination of native sorbed P would depend on the nature of the soils in the study and reproducibility of the results. The procedure for calculation of S_o using the least square fit method is based on the linear relationship between S' and C at low equilibrium P concentrations. The relationship can be described by:

$$S' = K'C - S_o$$

where:

K' = the linear adsorption coefficient, and all other parameters are as defined earlier.

(Note: It is recommended that the linear portion of the isotherm have an r^2 value 0.95 or better).

Equilibrium P Concentration

The "equilibrium P concentration at zero sorption" (EPC_0) represents the P concentration maintained in a solution by a solid phase (soil or sediment) when the rates of P adsorption and desorption are the same (Pierzynski et al., 1994). Values for EPC_0 can be determined graphically from isotherm plots of P sorbed *vs.* P in solution at equilibrium. From the calculations given above, EPC_0 is the value of C when S' = 0.

Comments:

The above procedure was developed to provide a standardized procedure with a fixed set of conditions that could be followed rigorously by any laboratory. The procedure uses a low and narrow range of dissolved inorganic P concentrations because these are the concentrations likely to be encountered in natural systems and because higher concentrations may result in precipitation of P solid phases. However, higher concentrations of P (up to 100 mg/L) and/or lower soil:solution ratios (1:10) have been used for isotherm determinations on soils and sediments (Mozaffari and Sims, 1994; Sallade and Sims, 1997; Nair et al., 1998; Reddy et al., 1998). A 0.01 *M* KC1 solution may be used as the background electrolyte to avoid precipitation of Ca in neutral and alkaline soils.

Toluene and chloroform have been shown to increase the dissolved P concentration in the supernatant, apparently due to lysis of microbial cells, and thus, some researchers do not try to inhibit microbial growth (Reddy et al., 1998).

Most adsorption studies are conducted under aerobic conditions. However, with certain studies it is more appropriate to use anaerobic conditions, as they more closely represent the natural environments of the soils or sediments. Reddy et al. (1998) pre-incubated sediment/soil samples in the dark at 25°C under a N_2 atmosphere, to create anaerobic conditions. Adsorption experiments were then conducted, performing all equilibrations and extractions in an O_2-free atmosphere.

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B.2 University of Idaho P Sorption Isotherm Method (University of Idaho (no date)

Abstract:

This procedure is used to determine the amount of phosphorus a soil can adsorb. Phosphate moves to plant roots by diffusion, and the concentration of phosphate in the soil solution is one factor that determines this movement. It has been found that the average plant sustains maximum growth at a solution phosphate concentration of 0.2 µg/mL. Soil tests can indicate a phosphorus deficiency, but are of limited value for predicting the actual amount of phosphorus a soil requires to maintain optimum P availability. This is due to the fact that standard soil tests do not account for P sorption by Fe, Al, and Ca soil constituents.

A phosphorus sorption isotherm can be used to describe the relationship between available and adsorbed P in soils. A known amount of soil is allowed to react with a succession of P solutions over a period of 24 h. The difference between the initial and final (equilibrium) P concentrations is used to calculate the amount of sorbed P. The final solution P concentration is plotted against the sorbed P. The resulting plot, known as the sorption isotherm, can be used to determine the amount of fertilizer P required for maximum growth. Approximately 10 g of dried and ground soil are needed for this procedure. Detection limits are not applicable in this procedure.

I. Equipment and Apparatus:

- **A.** Analytical balance (Mettler PC440 or equivalent)
- **B.** 50 mL plastic centrifuge tubes
- **C.** Reciprocal shaker
- **D.** Filter funnels: Polypropylene (Nagle 4252) 65 mm (Fisher catalog # 10-348A, or equivalent)
- **E.** 125 mL Wheaton bottles
- **F.** Filter paper: 15 cm pleated, grade 542, or equivalent
- **G.** ICP-AES

II. Instrument Operating Parameters

Optima 3200RL ICP-AES (see SOP.52.045.xx for more information)

- **A.** Instrument parameters, Table 1, are subject to change; see instrument method for current operating conditions. Load desired method. Select the desired elements by the enable/disable menu option.

Table 1: ICP-AES Operating Conditions
Plasma: 15 L/min
Auxiliary: 0.5 L/min
Nebulizer: 0.80 L/min
Power: 1300 W
Flow Rate: 1.5 mL/min
Wash Time: 60 sec
Wash Rate: 2.00 mL/min

B. Start the torch and allow the system to warm up for about 60 min. Note: Do not adjust the tension on the sample introduction line unless absolutely necessary.

C. Tune the ICP-AES by calibrating the instrument and checking the position of wavelength measurement against the actual emission peak (See Table 2). Adjust the position to best measure the peak (approximately the middle of the peak). Recalibrate before beginning analysis.

Table 2: Element for Optima 3200RL:

Element	Emission Wavelength (nm)
P	213.6

NOTE: The wavelength may vary slightly day to day due to instrument conditions.

D. Interelement Corrections (IEC) and background corrections: see IEC file under Model Builder.

III. Reagents

A. Calcium chloride (Granular, $CaCl_2 \cdot 2H_2O$, Organic Residue Analysis, USP/FCC Grade, VWR Order # JT1336-01 or Fisher Order # C70-500, or equivalent).

B. 0.01 M calcium chloride solution: Weigh 2.92 g $CaCl_2 \cdot 2H_2O$ and transfer to a 2 L volumetric flask. Mix and make to volume with Type I or II water.

C. Stock phosphorus solution, 1000 µg P/mL - Dissolve 4.3943 g oven dried KH_2PO_4 (Certified ACS, Fisher Order # P288-500 or Baker Analyzed Reagent, VWR Order # JT3252-1 or equivalent) in 500 mL of 0.01 M $CaCl_2$ solution. Make to 1 L volume with 0.01M $CaCl_2$ solution.

D. Working Phosphorus solutions: prepare according to the following table.

Desired P Conc. (µg/mL)	Volume of 1000 mg/L Stock P Solution (mL)	Final Volume (L)
5	5	1
25	25	1
50	50	1
100	100	1
200	200	1

1 Adjust to final volume in a 1 L volumetric flask with 0.01 M $CaCl_2$ solution.

IV. Standards

Calibration standards:

A. Primary standard: 10,000 µg P /mL
ICP/AES grade (AESAR order #14415, or equivalent).

B. Typical calibration curve: 0, 10, and 100 µg/mL in 0.01 M $CaCl_2$.
A standard dilution worksheet is located at: P:\bench\inorgan\soil\piso.xls (tab: Dilution P) for assistance in preparing the standards.

Note: This calibration is a suggestion and is not necessarily used for the analysis. Record the actual calibration curve used on the dilution calibration worksheet.

V. Sample Preparation

A. Weigh 1.000 ± 0.003 g of dried and ground sample (see SMM.85.410.xx, Soil Drying and Grinding) into each of a set of ten 50 mL centrifuge tubes. (Five phosphorous concentrations will be run, each concentration in duplicate; therefore, a total of 10 centrifuge tubes will be needed for each sample.)

Note: Rock percentage needs to be taken into account for a drainage field sample. Calculate the decimal fraction of the soil to be weighed using the following formula (g soil / total g soil + rock). The number obtained is the amount of sample (g) to be weighed into the centrifuge tubes. A spreadsheet for calculating the amount of soil for the analysis is located at **P:\soil\spdshts\pisowt.xls**.

B. Add 25 mL of the working phosphorus solutions (5, 25, 50, 100 and 200 µg P/mL) to the centrifuge tubes.

C. Cap, wrap with Parafilm, and place the centrifuge tubes on a reciprocating shaker so that the sample is being shaken lengthwise in the tube.

D. Shake for 24 h.

E. Remove from the shaker and filter into 125 mL bottles with 15 cm filter paper.

F. Submit for analysis on the ICP.

NOTE: Samples may be kept up to one week if refrigerated.

VI. Sample Analysis

A. Determine equilibrium P concentration on the ICP.

B. Plot adsorbed P µg/g (Y) vs solution P µg/mL (X).

VII. Calculations

A. Use the Excel spreadsheet to calculate and plot the amount of phosphorus sorbed vs. the amount of phosphorus remaining in solution. The Excel spreadsheets are located at **P:\soil\spdshts\pisocalc.xls**, **pisoa.xlc**, **pisob.xlc**, **pisoc.xlc**, **pisod.xlc**, **pisoe.xlc**, **pisor.xlc**, and **pisorpt.xls**.

B. Plot X axis, amount of P remaining in solution in µg P/mL.

C. Plot Y axis, amount of P sorbed by soil in µg P/g:

$$\frac{\mu g\ P}{g\ soil} = \frac{mL\ working\ standard}{g\ soil} \times (\text{concentration of working standard} - \text{concentration of P remaining in solution})$$

VIII. Quality Control and Corrective Action

Note: at least 10% of each analytical batch will consist of QC samples. At a minimum, each batch will contain a set of reagent blanks, one check standard, and a reference material. Samples are run in duplicate (assuming there is sufficient sample quantity). Additional QC samples (i.e. matrix spikes) may be required by client request.

A. Reagent (working solution) blanks

Analyze “blank” working solutions (no soil), at each concentration used (5, 25, 50, 100, 200 µg P/mL). If a solution does not fall within 10% of the known concentration it does not pass QC.

B. Check standard

If the measured analyte concentration in a check standard differs from the known concentration by more than 10%, the check standard has not passed QC.

C. Reference material

House Reference Materials – if the measured analyte concentration falls outside the acceptance range (plus or minus 2 standard deviations of the average), the reference material has not passed QC.

D. Duplicate

If the measured analyte concentration of the duplicates differs by more than 10%, the duplicates have not passed QC.

E. Corrective Action

1. Values of all QC samples are to be recorded on the Quality Control Report. Values outside of the acceptance range will be indicated.
2. Quality control results are to be considered as a package, rather than individual results. Hence, a single failure (i.e. a single QC sample not passing) may not constitute an overall failure of the analytical batch.
3. If, in the professional judgment of the Laboratory Director or Group Leader, the overall quality control is acceptable (i.e. meets both ASL and, if applicable, client data quality objectives), the QC Report will be initialed and dated indicating the results have been reviewed and are to be reported.
4. If, in the professional judgment of the Laboratory Director or Group Leader, the overall quality control is unacceptable, the chemist will be instructed to rerun all or part of the analytical batch. Unused data will be retained in the raw data packet, with an explanation regarding any actions taken.
5. In recognition of the variety of analytical tests conducted by ASL, and the unique challenges influencing the accuracy and precision of certain tests, chemists are permitted to exercise professional judgment when evaluating QC during an analytical run. However, unusual QC results should always be discussed with the Laboratory Director or Group Leader.

IX. Documentation Requirements

A. Instrument information for phosphorous isotherms is recorded in the ICP log book, which is located next to the ICP.

B. The in-house reference material results are recorded on the phosphorus isotherm QC sheet and the ICP computer printout.

C. The sample phosphorus isotherm values are recorded onto the ICP computer printout.

D. The phosphorus isotherm bench sheet can be found at **P:\bench\inorgan\soil\piso.xls**.

E. The phosphorus isotherm QC sheets can be found at **P:\qcsheets\inorgan\soil\piso.xls**.

X. Safety and Health

Consult Material Safety Data Sheets for information on reagents.

XI. References

Nair, P.S., Logan, T.J., Sharpley, A.N., Sommers, L.E. Tabatabai, M.A. and Yuan, T.L. 1984. Intralaboratory comparison of a standardized phosphorus procedure. J. Environ. Qual., Vol. 13 No. 4:571-593.

XII. Validation

The phosphorus isotherm values have a long history of in-house reference material quality control.

Revision History

SMM.85.120.05	Two year review update. Revision History – Added. 18 MΩ•cm water replaced by Type I or II water. Removed Leeman ICP information and added Optima ICP information. Added standard dilution information.

Appendix C—Ground Water Modeling: Considerations for Tier II Applications

From: Gary Stevens, P.G., Coeur d'Alene Regional Office, Idaho Department of Environmental Quality.

Water Quality Impact Evaluation Elements

This section describes the elements of a Water Quality Impact Evaluation (WQIE), the minimum data set required and guidelines to help determine how detailed an evaluation is required for the development.

General

The general steps in completing a WQIE involve;

- Data Collection
- Development of Conceptual Model
- Fate & Transport Model Selection
- Construction, Calibration and Simulations Using Fate & Transport Model
- Model Documentation

Data Collection

In order to characterize subsurface conditions all existing available information should be collected within the development boundaries and the surrounding areas. Typical sources of data include;

Geology/Hydrogeology

1. Idaho Department of Water Resources

   The IDWR is responsible for permitting new water wells in the State of Idaho. All drillers that complete new water wells must submit a Well Driller's Report that includes well construction, depth to water and a lithologic description. These are organized by location using a PLS system and are available at the local IDWR office or on-line at; http://www.idwr.idaho.gov/water/well/search.htm

2. National Resource Conservation Service

   The NRCS performs soil surveys mapping the soil types and characteristics for a given area. The soils are given a numeric rating regarding the limitations of the soils for use in various activities including subsurface wastewater disposal. The surveys are organized by county and are available at the local NRCS offices or on-line at; http://websoilsurvey.nrcs.usda.gov/app/

3. Idaho Geological Survey

The IGS collects and interprets geologic and mineral data for areas within Idaho and publishes reports and maps using this data. The data is available at the IGS office at the University of Idaho in Moscow, Idaho or on-line at; http://www.idahogeology.org/

4. Idaho Department of Environmental Quality

   DEQ enforces various state environmental regulations and administers a number of federal environmental protection laws. As part of these activities DEQ also collects, compiles and interprets ground and surface water quality data throughout the state. These data are available to the public and can be accessed by contacting the local DEQ office or on-line at; http://www.deq.state.id.us/

5. Idaho State Department of Agriculture

   The ISDA role is to protect the public, animals, and environment through regulation and education. The Agricultural Water Quality Program implements agricultural monitoring and protection programs with public and private partners to protect ground and surface water quality. As part of these activities the ISDA collects, compiles and interprets ground water and surface water quality data as it relates to agriculture. These data are available to the public and can be accessed by contacting the ISDA office in Boise, Idaho or on-line at; http://www.agri.state.id.us/index.php

6. U.S. Geological Survey

   The USGS is a federal organization that collects, compiles and interprets geological and hydrogeological data as well as ground and surface water quality data. These data are available to the public and can be accessed by contacting the a USGS office or on-line at; http://www.usgs.gov/

7. Idaho Universities

   Idaho has a number of universities that conduct research regarding the geology and hydrogeology within the state. These data are available to the public and can be accessed by contacting the respective universities;

   a. University of Idaho – Moscow, Idaho
      http://www.uidaho.edu/
   b. Boise State University – Boise, Idaho
      http://www.boisestate.edu/
   c. Idaho State University – Pocatello, Idaho
      http://www.isu.edu/

Surface Water

1. The USGS is a federal organization that collects, compiles and interprets surface water flow and quality data. These data are available to the public and can be accessed by contacting the a USGS office or on-line at: http://waterdata.usgs.gov/id/nwis/current/?type=flow

2. DEQ also collects, compiles and interprets surface water quality data throughout the state. These data are available to the public and can be accessed by contacting the local DEQ office or on-line at;
   Data:
   http://www.deq.idaho.gov/water/data_reports/surface_water/tmdls/sba_tmdl_master_list.cfm#region

Administrative Rules
http://adm.idaho.gov/adminrules/rules/idapa58/0102.pdf

If there is limited existing available data it may be necessary for the applicant to obtain site specific information from a site exploratory program. The types of site exploration methods may include test pit excavations, completion of borehole/monitoring wells, cone penetration tests (CPT) and surface geophysics. The reader is referred to the following for further information and guidance regarding the development and methods for developing an on-site subsurface exploratory program;

- ASTM D 5921 – 96 Standard Practice for Subsurface Site Characterization of Test Pits for On-Site Septic Systems.
- ASTM D 5979-96 Standard Guide for Conceptualization and Characterization of Ground-Water Systems
- ASTM D 1586 REV A Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
- ASTM D6151 - 08 Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- ASTM STP 1101 Geophysical Applications for Geotechnical Investigations
- ASTM D6429-99 Standard Guide for Selecting Surface Geophysical Methods
- EPA, 2006. Characterization of Site Hydrogeology. State of Ohio, Environmental Protection Agency, Division of Drinking and Ground Waters. Technical Manual for Ground Water Investigations, Chapter 3.
- EPA. 1987. A Compendium of Superfund Filed Operations Methods, Volume 1.
- Michigan Department of Environmental Quality, May, 2006. RRD Operational Memorandum No. 4, Interim Final. Site Characterization and Remediation Verification – Attachment 7, Groundwater Modeling.
- USGS, 1987. A Conceptual Framework for Ground-Water Solute-Transport Studies with Emphasis on Physical Mechanisms of Solute Movement. USGS WRIR 87-4191.

Development of Conceptual Model

The conceptual model is a description of the relevant site-specific and regional subsurface conditions that may influence the results of the fate and transport model. The conceptual model should incorporate all the relevant site-specific information along with a description of any simplifying assumptions. The more complex the subsurface conditions or boundary conditions the more information will need to be incorporated into the conceptual model. The conceptual model will be used as the basis for deciding the type of fate and transport model that will be necessary to adequately incorporate the necessary complexities. The conceptual model may include some or all of the following;

1. Significant geologic/hydrogeologic units in the area

2. The location, along with the lateral and vertical extent of any aquifers that may be impacted by wastewater activities
3. The types of aquifers present; confined and/or unconfined.
4. The ground water flow rate and direction in each aquifer
5. Characteristics of the aquifers that include transmissivity, storativity, and porosity
6. Boundary conditions
7. Hydraulic connection to any surface water bodies

The conceptual model and all the relevant information is often shown as a geological/hydrogeological cross section(s). The reader is referred to the following for further information and guidance.

Fate and Transport Model Selection

The selection of the fate and transport model will be dependent on the conceptual model. Different fate and transport models have limitations associated with the level of complexity that each can accommodate. If the subsurface conditions exhibit complexities that need to be characterized, as shown in the conceptual model, the selected fate and transport model must have the ability to incorporate these complexities. The three types of models that will be discussed are: 1) mass balance model, 2) analytical model, and 3) numerical model.

Mass Balance Model

A mass balance model is the simplest model with the most limitations and assumptions. The mass balance model is also referred to as a single cell model or black-box model and is considered to have zero dimensions. The assumptions of a mass balance model are:

1. There is a single aquifer with constant thickness
2. The aquifer is homogeneous and isotropic
3. The boundary conditions are fixed for each stress period and independent of other model inputs and outputs.
4. Changes in water quantity and quality are distributed equally over the entire model domain for each stress period
5. Changes in water quantity and quality occur instantaneously over the entire model domain for each stress period
6. The model cannot incorporate any aquifer parameters such as hydraulic conductivity, transmissivity, flow rate, or direction.
7. The only model parameter that can be incorporated is storativity that is distributed equally over the entire model domain.

The mass balance model is useful in developing a conceptual model and identifying additional data needs. The mass balance model should not be used for determining regulatory compliance regarding proposed wastewater projects and potential down gradient water quality impacts. A mass balance model may be used to provide a general assessment on whether the proposed development may pose a threat to ground and surface water resources.

<u>Analytical Model</u>

An analytical model can be used to describe flow and transport in a homogeneous aquifer with two-dimensional flow. The analytical model provides a mathematical solution to contaminant fate and transport problems that incorporate some aquifer parameters and boundary conditions. Properly configured analytical models can provide solutions for specific locations and times over the model domain. Analytical models can incorporate more complex conditions than the mass balance model described above. The assumptions of an analytical model are:

1. There is a single aquifer with constant thickness
2. The aquifer is homogeneous
3. Flow within the model domain is horizontal and both velocity and direction are constant
4. The boundary conditions are fixed for each stress period and independent of other model inputs and outputs.

The analytical model can incorporate the following:

1. Aquifer parameters such as hydraulic conductivity, storativity, flow rate, and direction
2. The duration of a stress period can be explicitly defined
3. The contaminant concentration can be determined at specific locations within the model domain

An analytical model can successfully be used for fate and transport problems regarding proposed wastewater projects if the subsurface conditions are suitable and the complexity can be reduced or simplified to meet the assumptions and limitations described above. Analytical solutions can be categorized into approximate and exact solutions. Approximate solutions are easier to solve mathematically but may result in errors due to the approximate nature of the solution. An example of an approximate solution is the Domenico solution (Domenico, 1982). Exact solutions are more difficult to solve mathematically but provide results with minimal mathematical error. The magnitude of error introduced by using an approximate solution as compared to the exact solution will be dependent on the subsurface conditions and the type of problem posed. Examples of exact solutions are described by Wexlar (1992) and Galya (1987).

The Domenico solution is available from DEQ and has been incorporated into a spreadsheet model. The Wexlar solution has similar model geometry to the Domenico of a vertical plane source, while the Galya solution assumes a horizontal plane source. *Please refer to the referenced documents for limitations and proper use*. Other computer software is available that solves for fate and transport problems using the analytical technique, such as Stanmod which is available through the U.S. Department of Agriculture, Salinity Laboratory. Commercial software is also available that provides an analytical solution. These software include, but are not limited to Solutrans and ATD123.

A more complicated type of model that incorporates analytical solutions is the analytical element model (AEM). The AEM uses separate analytical solutions for the distinct flow and transport processes (elements). The AEM then superimposes/combines the separate analyses to arrive at a solution. A discussion of AEM models is beyond the scope of this guidance and the applicant should refer to a number of available references or consult an appropriate ground water professional for further information.

Numerical Model

A numerical model divides the model domain into a number of small cells (discretization). Each cell then is assigned flow and transport attributes. Boundary conditions are established by defining fluxes into or out of certain cells. The computer program then solves a set of algebraic equations that define ground water flow conditions. After the ground water flow direction and velocities are defined for each cell within the model domain and the fluxes into and out of the boundaries, a contaminant maybe introduced and similar computations are carried out. The entire process can be completed for discrete time steps. The ground water flow and contaminant conditions at the end of one time step are the initial conditions for the next. The entire process is repeated until the end of the simulation time period, defined by the modeler, is reached.

There are few limitations using the numerical method and thus it is ideally suited for complex subsurface conditions along with modeling flow directions, velocities, and boundary conditions that may vary over time. The construction of a numerical model may be simple and quick or complicated and timely depending on the conceptual model being represented. There are various types of numerical models based on model domain discretization, such as finite difference or finite element, and different mathematical solutions to solve the ground water flow and contaminant transport problems posed. It is beyond the scope of this guidance to describe these and the applicant should refer to a number of available references or consult an appropriate ground water professional for further information.

Construction, Calibration and Simulations Using a Fate & Transport Model

The construction of the fate and transport model is based on the conceptual model. The construction of an analytical model is facilitated by the number of underlying assumptions and resulting limited number of inputs. The construction of a numerical model is more difficult as the aquifer parameters and boundary conditions must be defined for each cell and time step across the entire model domain.

If ground water flow direction, gradient and levels are calculated over time as in a numerical model then calibration of the model should be conducted. Calibration consists of changing model parameters until the model output matches measured values. The modeled results are often displayed with measured values in a scattergram for comparison. In addition, residuals should be calculated and reported in a tabulated format.

A sensitivity analysis consists of varying selected input parameters and measuring the resulting changes in model output. The sensitivity analysis is performed to determine if the selected values of input parameters used in the model are adequate for the purpose of the model or need to be better defined and justified. The sensitivity analysis should be performed for both analytical and numerical models.

The reader is referred to the following for further information and guidance regarding the construction and use of fate and transport models;

- ASTM D 5880 Standard Guide for Subsurface Flow and Transport Modeling
- ASTM D 5447 Standard Guide for the Application of a Ground-Water Flow Model to a Site-Specific Problem
- ASTM D 5490 Standard Guide to Comparing Ground-Water Flow Model Simulations to a Site Specific Problem
- ASTM D 5609 Standard Guide for Defining Boundary Conditions in Ground-Water Flow Modeling
- ASTM D 5610 Standard Guide for Defining Initial Conditions in Ground-Water Flow Modeling
- ASTM D 5611 Standard Guide for Conducting a Sensitivity Analysis for a Ground-Water Flow Model Application
- EPA Fundamentals of Ground-Water Modeling, Ground Water Issue. EPA/540/S-92/005.
- EPA, 2007. Ground Water Flow and Fate and Transport Modeling. State of Ohio, Environmental Protection Agency, Division of Drinking and Ground Waters. Technical Manual for Ground Water Investigations, Chapter 14.
- USGS, Guidelines for Evaluating Ground-Water Flow Models. Scientific Investigations Report 2004-5038—Version 1.01
- USGS**,** User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference ground-water flow model. U.S. Geological Survey Open-File Report 96Ð485, 56 p.

Model Documentation

Because of the quantity of data used and assumptions and decisions made during the design and construction of a fate and transport model, it is imperative that the modeler document all the necessary information. The model documentation should at a minimum include:

- Introduction
- Data Collection
- Conceptual Model Description
- Model Description and Relation to Conceptual Model
- Model Construction
- Model Simulation and Results
- Summary and Conclusions

The data collection documentation should include all data used to develop the conceptual model and inputs used for the fate and transport model. If existing published data was used then the appropriate references should be included. If any information was used from water well logs to develop the conceptual model or used in calibration, then the Well Driller's Reports should be included in the report. Any data obtained as part of a subsurface exploratory program should be included along with the description of all methods, equipment and analysis.

The conceptual model and its relation to the site specific subsurface conditions as indicated by the existing data collected or obtained through site explorations should be included in the documentation. The conceptual model can be presented as a geologic/hydrogeologic cross section(s). Figures with the site and regional maps should be included with the following:

1. Development / property boundaries
2. Drain field locations
3. All water wells on the site and in the general vicinity. If pertinent the location and extent of capture zones
4. All compliance points or boundaries
5. A measured potentiometric map or maps with the direction of ground water flow indicated for each aquifer. All the monitoring and water wells that were used to generate the map should be located with the water elevation for each well shown. A justification of the model selection in relation to the conceptual model should be included. The model configuration/construction description can be short if an analytical model is used or very lengthy if a numerical model is constructed.

If a numerical model was used the following should be included:

1. A site/regional surface map with development boundary indicated along with the model grid or elements shown.
2. A site/regional surface map with all boundaries including drainfield(s).
3. A site/regional surface map containing aquifer parameters, such as hydraulic conductivity, storativity, and dispersivity. Additional plan view maps for various elevations may be necessary if these parameters vary with depth.
4. At least two cross sections orthogonal to each other showing model grid, aquifer parameters and boundary conditions.

The model simulations and results should include the model outputs, along with any calibration or sensitivity analysis, if completed. The model output documentation should include figures with the following;

1. A modeled potentiometric map(s) for each aquifer with ground water flow direction and velocity
2. A site/regional plan view map showing the contaminant plumes for each constituent of concern. The contaminant plumes should include areal extent and concentration gradients with at least five concentration divisions. The map should also include all the compliance points/boundaries that are being considered.
3. At least two cross sections orthogonal to each other showing model areal extent and concentrations gradient with at least five concentration divisions. The map should also include all the compliance points/boundaries that are being considered.

The simulation results should be discussed in relation to compliance with the WQIE. The reader is referred to ASTM D 5718 *Standard Guide for Documenting a Ground-Water Flow Model Application* for further information and guidance.