TG 8: Groundwater Investigation and Characterization

Date: July 9, 2010

Document Section(s)	Issue	Comments	Stakeholder Recommendation	Ministry Response
General Comment		We believe we are correct in understanding that MOE undertook to prepare groundwater investigation guidance in part because of a desire by the members of the CSAP Society to have greater certainty on acceptable groundwater investigation scope. We suspect that TG8 reinforces the adage "Be careful what you wish for". Overall, TG8 implemented "as is" would reduce the (probably already low) incidence of false negatives, and in some areas improve the science. Implementing TG8 as presently written will also result in a substantial increase in the cost and duration of most site investigations, with more effect on sites that are suspect but uncontaminated, or only modestly contaminated. Is the benefit commensurate with the cost? The affordability of site assessment and instruments was already an issue before the current economic squeeze, particularly outside the Lower Mainland. In a context where existing costs are unsustainable and an active impediment to site remediation, the effect of TG8 is only to make it less sustainable. We question the wisdom of implementing any part of TG8.	Do not implement TG8	The ministry's opinion is that guidance on groundwater investigation and characterization for sites in BC is both necessary and widely requested. The ministry's objective is for TG8 to provide an adequate amount of guidance to ensure that data collected during contaminated sites investigations are consistent, representative, and scientifically defensible. Several changes have been made to the draft document that may alleviate many of your concerns.
General Comment		"Guidance to qualified professionals" – It has been our experience that within the existing CSAP/Roster framework, what happens in practice is that "Guidance equals Policy". The parent document (http://www.env.gov.bc.ca/epd/remediation/reports/pdf/tech-guide-gw.pdf) opens with phraseology "*The guidelines and procedures outlined here are not applicable at every site; others may also be used"*. Insertion of these words into TGD-8 document would be extremely useful. In theory this would help in a perfect world; however, that seldom exists and the Ministry should make the assumption that practitioners will be encouraged/forced, whatever the case may be, to implement these Guidelines carte blanche as quite simply, it's safer to do that. Based on that and to permit professional judgement, the Guideline should omit the use of "absolute" triggers (e.g., % of standards, etc.)	Insertion of the following words into TGD-8 document "*The guidelines and procedures outlined here are not applicable at every site; others may also be used".* Omit the use of "absolute" triggers (e.g., % of standards, etc.) and implement the rationale that was relied upon during development of these triggers. Provide rationale for use of percentages, distances, etc. used throughout	The suggested wording from the parent document has been added to the guidance document. Several of the "absolute" triggers have been removed from the document and several requirements have been altered.

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		and implement the rationale that was relied upon during development of these triggers. Guidance documents that emphasize the tools and criteria used to assess risk have a better chance of succeeding as opposed to those that establish rules. The rationales for use of percentages, distances, etc. should be provided such that the practitioner can assess if these conditions and assumptions exist at the Site. This document appears laden with hard-and-fast rules when qualitative rationale might prove more useful.	document.	
General Comment	Phase-in period for past investigations	We would like the Ministry of Environment to provide clarity if past or ongoing investigations need to meet the new draft guidance methods and approaches. If so, we suggest there be consideration to have a significant (i.e. a 3 to 5 year) phase-in period for past investigations. Alternatively, it appears that methods and approaches used for past investigations (that do not adhere to the guidance document) may be deemed acceptable (as noted on Page 1, i.e. "deviations from this guidance or use of alternative methods are acceptable if they are accompanied by documented, defensible rationale").	Apply a phase-in period for past investigations	A grandfathering process has been incorporated in the revised document.
General Comment	Current version is over-prescriptive	Instead of outlining prescriptive approaches for monitoring frequencies and well spacing, we suggest the Ministry allow Qualified Environmental Professionals to decide the best procedures and approaches to design monitoring frequencies and well spacing to meet the desired end results. These approaches could be based on site specific conditions and circumstances.	Do not implement TG8	See response to first comment.
		The current draft version of Technical Guidance 8 (TG8) is very prescriptive, extremely conservative, and overly protective. The respondent does not believe that this is the MOE's intent. The requirements of the guidance will result in poor utilization of resources for little or no technical value. For complex sites, proponents and environmental professionals should be allowed the flexibility to develop a site specific groundwater investigation and monitoring program that		As discussed previously, the ministry's opinion is that guidance on groundwater investigation and characterization for sites in BC is both necessary and widely requested. Several changes have been made to the draft document that may alleviate many of your concerns.

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		is technically defensible. Any of a number of site conditions may make complying with all the delineation criteria currently set out in TG8 very impractical in real life situations (e.g. multiple plumes both onsite and off-site, complex hydrogeology, buildings and utilities, etc.). There are several proposed criteria in the document (e.g. maximum screen length, maximum distance between well screens in nested wells, delineation criteria for NAPL plumes) that make work impractical and not resource effective for minimal incremental technical value. There are other criteria (e.g. delineate any groundwater concentrations in excess of 10% of the applicable standard and the need for groundwater to be <50% of the applicable standard for all parameters before groundwater at the site can be considered compliant to the applicable standard) that are overly protective considering that numerical standards already have degrees of conservatism built-in. The combined effect of very conservative assumptions and prescriptive requirements will result in a marked increase in the resources expended at a typical site which will put in jeopardy the MOE's stated goal to have contaminated sites put back into productive use in British Columbia.		
General Comment	Important issues not addressed in draft document	To help make this a practical tool, the respondent recommends adding guidance on a number of other important issues not included in the draft document: a) In many areas of the province, including northeastern BC, the soils are very low permeability and it is difficult to obtain groundwater samples. It would be helpful to have guidance on how to proceed in these situations. b) At many sites in the province, groundwater samples exceed numerical guidelines for certain combinations of chemical parameters and pathways (e.g. some metals for the Freshwater Aquatic Life pathway). In many cases, these exceedances are representative of naturally occurring background conditions in the area. TG8 does not provide guidance to professionals on how to eliminate naturally occurring contaminants. The	See comment section	Responses to the comments are as follows: a) Guidance on sampling groundwater from monitoring wells installed in low-permeability formations is included on page A-3 (Appendix A) of the parent document. b) A procedure for determining local background concentrations in groundwater is provided in the ministry's Protocol 9: Determining Background Groundwater Quality, which is available on our website. c) A discussion of the no-flow purging and sampling technique is included on page A-5 (Appendix A) of the parent document.

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		respondent recommends that the option to scientifically demonstrate that the observed concentrations are due to elevated natural background levels be recognized. c) There is now a large database of scientific literature that has demonstrated that no-purge groundwater sampling is just as effective as traditional purge methods for a wide range of contaminant parameters. The advantages of no-purge sampling are that it takes less time (providing data of equivalent quality at a lower cost) and generates no purge water requiring disposal (reducing waste generation). This is particularly advantageous for long-term monitoring sites, and also low permeability sites, where two separate trips are often required for purging and sampling. It is disappointing that no-purge sampling option has not been included in TG8.		
General Comment	Overstepping the bounds of the Intent of the Guidance	The guidance document in places extends beyond providing technical guidance on groundwater characterization and includes discussion on; the responsibilities of the responsible persons, reasons and requirements for conducting a Stage 1, statistical evaluation of data, and reporting requirements. Discussion of these issues bogs down the document and is better (if required) provided as amendments to existing guidance on those specific topics. The information in the section “What are B.C.’s groundwater quality classes?” is best not provided in this guidance as it appears in greater detail in a guidance document specific to this topic.	Duplication of information in TG8 which is provide in other guidance or in the regulations should be avoided as the duplication introduces the potential for errors in duplication and the requirement for changes to the TG8 documentation if changes to the documents containing the duplicated material are amended in the future.	The ministry appreciates the comment, but feels that the information provided in the guidance document is relevant to the topic being presented.
General Comment	Absence of Peer Review	During the latest MoE seminar, the contract author noted that some of the limits that are identified in this guidance document were sourced “from my head”. The use of non-peer reviewed quantitative limits, even in draft form, is inappropriate for use in a scientific guidance document.	Recommend that all non-peer reviewed concepts and quantitative limits be removed from this document.	The ministry generally concurs that we should not be using guidance that is not scientifically based. Several changes have been made to the draft document that may alleviate your concerns.
General Comment	Ostentatious/Preachy Text	There are sections through the guidance that discuss concepts that are obvious not only to the intended audience of this	See comments.	The ministry feels that the information provided in the guidance document is relevant to the topic being presented.

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		guidance but likely also to a layperson, and thus come off as ostentatious or preachy; including, but not limited to: • Section “How should a field program be designed?”. The information provided here is obvious. • b. Section “Range of options for identifying contamination” This section provides methods of investigation but does not comment on their use, applicability and acceptance by the MoE. Accordingly, the information provided in this section is of extremely limited value and as such is better left out of the document. • c. Section “Obtaining hydrogeologic information”. Again, this section provides methods of investigation but does not comment on their use, applicability and acceptance by the MoE. Accordingly, the information provided in this section is of extremely limited value and as such is better left out of the document. • d. Section “Stage 2 PSI” - Starting with “A well-developed CSM….” The text states the obvious. • e. Section “Stage 2 PSI “ – Indicating that 3 well points are required to provide a groundwater gradient followed by cautioning that there are a myriad of other hydrogeological condition which may cause data from 3 points to be insufficient to characterize the groundwater regime is both obvious and completely devoid of guidance which would aid a practitioner in obtaining a solution to anything but the simplest of groundwater gradient determinations. The text goes on to repeat the goal of the Stage 2 PSI and to indicate that if contamination is found you should proceed to a DSI. This concept is well presented in other more relevant documentation. Recommend removing this entire discussion. • f. Section “Chemical Spatial Characterization” – “The DSI should include the chemical analysis of		

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		representative samples for appropriate substances and parameters at the appropriate detection limits". Should add "at the appropriate locations and using appropriate methods". Just kidding, but you get the picture.		
General Comment	Socio-Economic Responsibility	Whenever new regulation is implemented, regulatory bodies should consider the socio-economic impacts that the regulation will have on the public. It can be argued that this burden extends to the regulatory bodies in their guidance on the application of the regulation. The intent of TG8 is to aid in the collection of groundwater data which is ultimately used to protect human and ecological health to a specific effects level.	In the application of TG8 I would encourage regulators to consistently consider the "bigger picture" when evaluating and balancing the impacts (both health and socio-economic) that this guidance will have on the public which it is working to protect.	The ministry believes that the health and socio-economic impacts to society have been considered and balanced appropriately in the development of this guidance piece.
General Comment		If you remove from this document, concepts that are already presented in other Ministry guidance and instructional documents, sections which provide concepts that are overly simplistic and obvious even to a lay person, and excessive/repetitive text, you end up with a relatively short document with few "new" concepts. The new concepts provided however trend towards being "rules" rather than "tools" for practitioners to increase the quality of groundwater assessments. The rules provided are calibrated to extreme cases which are overkill or simply not relevant at 95% of the contaminated sites which are investigated and remediated in BC. At the latest MoE information session, the contract author of this document indicated that the majority of the "new" limits provided in this document originated "from my head". This is inappropriate for a technical document of this nature which will carry the weight of provincial regulators. In all, this document as it stands is unlikely to provide any needed improvement the quality of groundwater assessments, but will almost certainly increase the cost in time and money to the proponent to complete site investigations.	Recommend that the new concepts provided within, be re-assessed by a group of practitioners with demonstrable experience and technical training in the area of groundwater assessment, and that the document be substantially amended to suit its intended purpose.	Several changes have been made to the draft document that may alleviate your concerns.

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Introduction	Lack of definitions, mentioning responsible parties	The first paragraph refers to a “qualified professional” for which no definition is provided. Further the document states it is specifically for the use of such qualified professionals. The document goes on to say that “while it is not required, it is the responsibility of the site owner….”, a statement which is in and of itself contradictory. As this document relates to groundwater investigation, the responsibilities of any responsible parties do not need to be identified.	Define “qualified professional”. Remove statements regarding responsible parties.	A definition for “qualified professional” has been added to the parent document. The ministry’s intent in including comments regarding responsible parties is simply to emphasize that the responsible party should ensure appropriate professionals have been hired to conduct an investigation. Contradicting portions of the sentence have been deleted from the document.
Introduction		The statements in the Introduction are significant. This document is directed at qualified professionals and deviations from this document are acceptable if defensible rationale is provided. Therefore, the guidance document is allowing for professional judgement from the qualified professional.		The ministry agrees with this statement. Professional judgement may be relied upon, provided that sound rationale in support of the decisions made by the professional is provided.
Investigation Triggers	Lack of definitions	Investigation Triggers – The document indicates investigation is required for determining suitability for “direct use or…. adjacent uses”.	Definitions for “direct” and “adjacent” should be provided or accurate wording used to allow practitioners to effectively determine the areas the document advises to be investigated.	Wording in the revised document has been altered to reflect that the direct use of groundwater is based on groundwater uses at the site. Determination of applicable groundwater uses for the site and neighbouring sites is included in other ministry guidance documents specific to the subject.
The Conceptual Site Model	Discussion of CSM	The CSM should not be limited to “a hydrogeological context” and the Ministry should select a more generic document (e.g., TGD-11) to implement requesting a CSM. Also, given that vapour assessment requires a conceptual site model, why would we not incorporate everything into one CSM?	TG8 document not the appropriate place to discuss CSM.	The ministry agrees that the CSM should consider media other than groundwater. The ministry looks forward to the possibility of consolidating CSM guidance into one guidance document in the future.
The Conceptual Site Model	Guidance in this section may not always be required.	"*At the completion of investigations, the CSM should as a minimum, include key hydrogeologic features and properties such as...*": The respondent recommends changing the word "should" to "could", If a risk assessment approach is not used and remediation is to numerical guidelines, the guidance information in this section is not always required.	Change word “should” to “could”	It is not a requirement that the CSM include all of the bulleted items. The ministry believes that the current wording of the documents reflects this fact (i.e. “should” does not imply “must”).
The Conceptual Site Model	The respondent would like other processes referred to	*“...contaminants of concern at a site (e.g. advection, dispersion retardation, ion exchange, precipitation, dissolution, diffusion) should be identified and*	Add words “volatilization and biodegradation” to portion of sentence in	The words “volatilization and biodegradation” have been added to the text.

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	in the document.	*described where available data make such assessments possible ...* ". The respondent recommends that the processes of volatilization and biodegradation be added. Biodegradation is important as a fundamental process in the fate of Potential Contaminants of Concern (PCOC).	brackets.	
The Conceptual Site Model	Discussion of CSM	In discussing the CSM, the document should be specific that groundwater is but one component of the site and the sites as a whole must be considered in the development of the CSM (including Site and regional geology and hydrology).	Accordingly the 5th point should include surficial geology as a component.	The ministry agrees that the CSM should consider the site as a whole. Surficial geology is referenced in the first bullet of this section. Note the above comment regarding a possible future guidance document for development of CSMs.
The Conceptual Site Model	Discussion of CSM	Clarification is needed in this section. The level of detail of a CSM is unclear in relation to the stage of investigation that has been completed. Presumably the key and minimum hydrogeologic features and properties that are listed in the bullets within this section are not to be expected in whole from a Stage 1 Preliminary Site Investigation. Perhaps the hydrogeologic features that are listed are implied to be known upon completion of a Detailed Site Investigation?	Provide detail as indicated in the comment.	The ministry believes that there is adequate language with respect to this comment in the first paragraph of this section. Specifically, "*The CSM should be developed at the outset of the investigative process and refined throughout the course of the investigations to strengthen and clarify the site understanding".*
What methods and approaches are acceptable? (Conventional monitoring wells – note box.)	Restricting the use of drill cuttings for backfill above annular seal.	It is not clear whether the issue is the seal, the placement of potentially impacted material back into the hole, or both. This would be a cost issue for investigations with deep boreholes/wells. The Ground Water Protection Regulation, which recommends the use of layered seals, could perhaps be referenced here. If backfill is the issue, then backfilling of test pits at contaminated sites could be indirectly affected by this guidance, where dealing with backfill materials could add significant expense and perhaps even trigger soil relocation agreements.		The issue is both emplacement of potentially contaminated material and the potential for preferential migrations through annular backfill materials. The guidance document indicates that professional judgement may be exercised provided that supporting rationale is provided in the documentation. Please note that the Ground Water Protection Regulation was developed with a focus on drinking water wells; the guidance provided in TG8 focuses on wells that are being installed in potentially contaminated areas. The concept of restricting drill cuttings for use as backfill is specific to monitoring wells and does not apply to backfilling of test pits.
		The direction that backfilling above the annular seal with drill cuttings is to be avoided (where a seal is not required) is not technically required for the functionality/reliability of the well. It also places a	It is recommended this recommendation be removed.	The ministry is of the opinion that drill cuttings should not be used for backfill. This approach is consistent with guidance from other jurisdictions (e.g. EPA). As indicated in the guidance document, any deviation from the

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		mistaken trust that backfilling with bentonite will eliminate preferential vertical groundwater transport along the borehole annulus. Insufficiently hydrated bentonite solids are just as liable to be leaky and subject to settling as poorly placed drill cuttings. So while this recommendation does not provide substantial improvement in well function, it can substantially increase the cost of well construction, potentially doubling the cost for wells with more than 5 m of unscreened depth.		requirements of using bentonite grouts or solids should be identified in site investigation reports, along with supporting rationale. Therefore, other appropriate materials may be considered for use as backfill, but the documentation must support their use.
Section 5.2.2 of Parent Document – Considerations for Immiscible Fluids	Estimation of dissolved concentrations of NAPL	The bold and italicized text in section 5.2.2 (where NAPL thickness in a well is significant (i.e. greater than 2 mm), then dissolved concentrations equivalent to the effective solubility of the constituents in the NAPL should be estimated and used to compare against applicable groundwater standards) does not appear to be consistent with the generic standards in Schedule 6, which indicates that non-aqueous phase liquids must not be present. Also, the calculation (inference) of effective solubility requires analysis of the NAPL mixture, which is not always done or even justified. The comparison of a worst-case inferred concentration, assuming complete equilibrium, to actual measured values and regulatory standards is difficult to justify. Once the inferred piece of "data" is reported, it will likely be treated the same as a measured exceedance and will be hard to disprove using the results of later measured DSI data.		The inconsistency is not apparent to the ministry. The text discussion is consistent with the Director's advice regarding nonaqueous phase liquids not present provided in Protocol 13. The objective of estimating dissolved concentrations is to provide a qualitative assessment of the potential degree of dissolved groundwater contamination based on the inherent difficulty in sampling groundwater in monitoring wells with immiscible fluids.
What methods and approaches are acceptable? (Acceptable length of monitoring well screens)	Length of screened interval being restricted to 1.6 m	Relevant information on well design (e.g. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, published by the National Water Well Association) suggests that due to the strong sorption capacity of bentonite (and hence it's potential to alter groundwater chemistry) that the bottom of the bentonite seal should be at least 1 foot (30cm) above the top of the well screen. This suggests that a well screen, in order to meet the TG8 guidelines, would be no longer than 1.3 metres. This is quite a small interval and also requires that all standard well	Increase acceptable length of monitoring well screens (i.e. screened interval – including all of sand pack) so that length of screen does not have to be cut in the field.	The ministry agrees with this comment. The acceptable length of monitoring well screens has been changed to 1.8 m so that the length of screen does not have to be cut in the field.

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		screen pipe (which comes in lengths of 1.5m) must be cut.		
		We believe that the document should indicate a maximum wetted screen length of 1.6m. Longer screens can be a practical necessity when water table depth is uncertain. With respect to well tests, if the well screen were restricted to the recommended length there would be insufficient room in the well to accommodate the necessary equipment and conduct the test. The author of the underlying report recognized this at the MOE workshop in February, stating that specific well installations would be required for that purpose. Is there commensurate benefit?	Do not restrict length of screen to 1.6 m.	The document has been changed to indicate that the maximum screen length is referring to the maximum saturated screen length. Supporting rationale should be provided in the documentation if the professional feels that a longer well screen length is required to conduct well tests. See also the ministry's response to the above comment.
		The respondent is not aware of any technical justification for 1.6 m as the absolute length for well screen intervals and this is not consistent with the common industry practice of using a 3.2 m (10 foot) well screen interval. This is especially important when groundwater wells are designed to capture groundwater at the water table which is often the case at petroleum sites. A 3.2 m screen is used to straddle the groundwater table, in order to take into account groundwater fluctuations and to ensure the screen is not totally submerged beneath the water table as this will impede the movement of mobile LNAPL into the well. The use of screens half this length would increase the difficulty of ensuring that the groundwater well was straddling the water table. The result of restricting screen lengths to 1.6 m would be that an increased number of monitoring wells will be needed at a site to ensure the same amount and quality of data. The USA Resource Conservation and Recovery Act (rcra_gw.pdf)1992 document gives three examples where longer screen wells (>I0 feet) are useful: • Water table fluctuations slightly exceed 10 ft (they use an example of 12 ft) • A thick homogenous aquifer • Low permeability aquifers where long screens may be needed to have the well recharge.		As per the above comments and responses, the ministry has changed the wording in the document to indicate that the **maximum saturated screen length** is **1.8 m**. With respect to the situations where longer well screen lengths are useful, the introductory section of the guidance document indicates that "*Deviations from this guidance or use of alternative methods are acceptable if they are accompanied by documented, defensible rationale*". The ministry also notes that shorter well screen lengths may be advantageous in some site conditions and situations.

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		In addition, a fourth example is for areas where the hydraulic head is falling steadily through time (e.g. areas with over pumping). If discreet interval sampling is an objective, there are methods for long screen wells, for example, no purge sampling tools, or nested wells can be installed.		
		The MOE should consider revising the wording about specifying a "maximum well screen interval of 1.6m" as the ability to collect a representative sample is a function of the "wetted screen length", and not the actual screen length.	Consider revising wording.	The ministry concurs. See responses to previous comments.
		The industry production standard well screen length is provided in 10 foot (3.05m) and 5 foot (1.52m) sections. Typical well construction as identified in the BC Field Sampling Manual identifies that the filter pack should extend above the screened length of the well by 20% of the total screen length. Using the TG8 guidance for maximum screen and filter pack length of 1.6m, this would mean that maximum screen length would be an unconventional 4.4 feet.	It is recommended that the maximum standard screen and filter pack length be changed to 1.8m to accommodate the standard length of well supplies and to meet the recommendations for standard well construction as outlined in the Field Sampling Manual. It is unlikely that groundwater data will suffer significant degradation in quality though this change.	The ministry concurs. See responses to previous comments.
		Screen length as it applies to the collection of a representative sample can be defined as the "wetted screen length", thereby not negating the acceptability of groundwater samples collected from a 3m well screen where 1.5m or less of the screened length is below the groundwater surface. Similarly, where wetted screen lengths exceed 1.5m and where aquifer soil types and contamination zones are well defined, dilution factors can be applied to the resulting chemical data to "normalize" the sample results to the standard screen length.	It is recommended that the document be amended to identify where and how longer screen lengths could be used to obtain MoE approved reliable data.	As indicated in the above responses, the ministry has changed the wording in the document to indicate that the **maximum saturated screen length** is **1.8 m**. The application of dilution factors to chemical data from wells with wetted screen lengths exceeding the maximum recommended saturated interval is not common practice or recommended by the ministry. Wells with longer saturated screen lengths may be considered acceptable based on site-specific conditions. Where the investigative methods have deviated from the guidance, the practitioner should provide defensible rationale.
		Disagree for water table wells, but agree for wells screened below the water table. The investigator should	Allow longer well screens for water table wells.	The ministry concurs. See responses to previous comments.

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		be allowed to use a 3 m long screen to straddle the water table and account for seasonal fluctuations in the water table. If the water table well has 1.5 to 1.6 m of water, there is no difference than using a 1.5 m long screen. A 1.5 m long screen may not effectively capture an LNAPL if present, where there is a 1.5 m or more column of water in the well. A 1.5 metre screen to investigate water table aquifers is not practical or possible due to typical seasonal fluctuations of 1 or more metre. Two 1.5 m well screens would be required for this purpose, which again, doesn't make a lot of sense.		
Acceptable Screen Lengths	Communication between groundwater zones	Multiple portions of the text identify scenarios where well construction or investigational drilling may provide opportunity for communication between groundwater zones.	It should be presented clearly (and preferably only once) within this document that boreholes/monitoring well completion should protect against any potential for communication between separate and distinct groundwater zones.	The ministry notes this redundancy in the document and appreciate your comment. However, we feel that the information has been presented adequately.
What methods and approaches are acceptable? (Acceptable length of monitoring well screens)	*"...the screen length should not extend beyond a depth of one metre below the greatest depth to the water table as defined by the seasonal minimum and/or minimum groundwater elevation during low tide*."	This requirement will certainly add time, cost and complexity to a groundwater assessment for no technical justification. It is difficult to determine elevations in advance without installing groundwater monitoring wells and then monitoring elevations in these wells. As water tables change through time and seasonally, a long well screen is suitable for measuring head as long as it is not screened through two discreet intervals with different heads (to create vertical flow).	Do not restrict length of well screen for water table wells.	See previous responses regarding wording changes in the document with respect to saturated well screen intervals. Where fluctuations of the water table are expected to be large, the qualified professional may decide to install longer well screens provided that the decision can be accompanied by sound rationale. Note that more accurate head measurements are provided by monitoring wells completed with shorter screened intervals; longer saturated intervals result in more generalized/averaged head measurements.
		This guidance is not practical to achieve in the field. In most of the Lower Mainland where most investigations are completed, there are glacial till soils. Initially locating the water table in these soils is often uncertain,		See response to above comment.

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		therefore, minimizing screen penetration below the water table to 1 m is almost impossible. Also, most water tables, particularly that are tidally influenced, show up to 1 m or more seasonal variation, which again makes this impractical and virtually impossible.		
What methods and approaches are acceptable? (Acceptable length of monitoring well screens)	Maximum well screen interval for water table wells.	Due to seasonal fluctuations, the potential that the water table would be above of the top of screen or that the well would be dry during part of the year is high. Additional issues may arise due to difficulties associated with sampling wells that have only 20 or 30cm of water (particularly if deep), and with sample quality due to potential sediment at the well bottom, etc. It could double the cost of most investigations to require nested wells to capture seasonal variations at water table locations. Perhaps it would be better to base the guidance on the saturated interval and not the screen length. If a 10-foot screen is installed at the water table and only 5 feet of the soil is saturated, the data should still be acceptable if it is the same soil unit. If during the wet season the saturated screen length increases to say 2.0m (in the same soil unit) but the chemical concentrations are low (or non-detect) this data should also be acceptable at the DSI stage. However, if the saturated thickness is excessive and the concentration marginally below the standard, more discrete sampling would be warranted. At sites where significant LNAPL thicknesses occur, a screen interval this small may also be impractical.	At the water table, it is recommended that the 1.6 m requirement be relaxed.	See responses to previous comments. The examples provided show situations where professional judgement can be exercised, and deviations from the guidance may be appropriate provided the rationale is documented in the report.
What methods and approaches are acceptable? (Acceptable length of monitoring well screens)	Restricting comparison of chemical data to standards for wells with screens greater than 1.6 m in length.	The respondent does not understand the basis of this guidance. There is no technical justification for stating that groundwater data from wells with screens greater than 1.6 m long cannot be compared to groundwater quality standards. This is especially true when the screen straddles the groundwater table and (on average) 1.6 m of the screen is submerged in the water table. This criterion is inconsistent with documentation from the US EPA and common industry practice. However, if dilution is anticipated, the sentence should state that "However, where saturated well screen	If dilution is anticipated, the sentence should state that "However, where saturated well screen intervals exceed 1.6 m .....".	The text has been changed in the document to reflect that the **saturated well screen interval** should not exceed 1.8 m.

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		intervals exceed 1.6 m .....", since there are many cases where the entire 1.6 m well screen may not be saturated.		
		While the intent is understood, providing such specific guidance for a maximum screen length and comparison directly to regulatory standards is not recommended. Other than to be consistent with previous guidance presented within this document, what is the rationale to support that 1.6 m is the maximum acceptable screen length for direct regulatory standard comparison? Why 1.6 m? This guidance may not be relevant in the case of water table wells in which there is 1.6 m or less water. Even if more than 1.6 m, but (for example) less than say 2 m, direct comparison of the analytical results to standards would likely be acceptable. One could question in these cases that the sampling methodology could introduce similar bias or uncertainty e.g. low flow sampling with the intake in less or more contaminated soil zones, but within a 1.5 m long screen.		The ministry's intent is to minimize well screen lengths. Dilution in wells with long well screens is a recognized occurrence; contaminant concentrations in samples collected from monitoring wells represent averaged conditions over the entire well screen length. The length selected for the maximum well screen interval was chosen for its practicality. Five-foot screen lengths are readily available and do not require cutting in the field. Regarding the comparison of analytical results to standards, the ministry again emphasizes that professional judgement may be exercised, and deviations from the guidance may be appropriate based on site-specific conditions.
What methods and approaches are acceptable? (Acceptable length of monitoring well screens)	Requirement for prompt decommissioning of wells with long screened intervals.	The Ground Water Protection Regulation indicates that a well does not need to be decommissioned until it has not been used for 10 years.	Consider rewording this [paragraph] to say that wells that are no longer being used or that screen across more than one aquifer should be decommissioned promptly – i.e. not based on screen length >1.6m.	The ministry concurs with this recommendation. The wording in the document has been changed as suggested.
		The respondent believes it is not prudent to abandon wells with screens longer than 1.6 m since considerable resource has been put in place for these wells and good data is derived from these wells. Vertical contamination will not occur in the absence of vertical gradients if the screen lies in one hydrogeologic unit.	The respondent recommends the following wording: "Wells suspected of cross contamination, should be decommissioned promptly, regardless of screen length to avoid risk of future cross contamination."	See above comment. Wording in the document has been changed.
		Disagree for water table wells between 1.5 to 3 m in		See previous comments.

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		length, but this could apply to wells greater than 3 m in length.		
What methods and approaches are acceptable? (Vertical Groundwater Profiling)	Use of nested wells/other vertical profiling methods in place of conventional wells	As noted above, there are methods for discrete interval sampling in long screen wells (some no purge sampling tools for example), or installation of nested wells. Furthermore, the statement that "vertical profiling provides a superior approach to conventional wells to determine zones of highest groundwater concentration within the aquifer of interest" is a matter of opinion that not all practitioners would agree. Many find these types of approaches more costly and less reliable than the installation of nested groundwater wells.	This statement should be removed and it should be stated that both methods of vertical groundwater profiling are acceptable.	In our opinion, the statement stands true if installation is completed correctly. Well screens always allow for dilution; vertical profiling provides a better picture of zones of highest contamination.
What methods and approaches are acceptable? (Vertical Groundwater Profiling)	Use of one to two metre thickness target	When “contamination” is discussed at the beginning of this paragraph it is unclear if “contamination” refers to soil or water or both. Also placing a do not exceed recommendation (investigation of thick contaminant zones) on a variable target (“one to two metres”) leaves room for argument as to which value is appropriate as a maximum and hints that these values were arrived at in an un-scientific manner. This concept is not relevant to more than 5% of the sites within BC. Where groundwater contamination extends to depths longer than the acceptable screen length for the site (default 1.5m) and the depth of highest concentration is not reasonably inferred based on contaminant type and site geology/hydrogeology, then vertical profiling will likely be required to vertically delineate the groundwater plume.	Recommend specifying the concept behind contamination thickness and removing the “one to two metres” recommended numerical target. Recommend removing the requirement for vertical profiling as a default, but highlighting situations where the application of vertical profiling should be considered.	Wording in the document was clarified (the section is referring to groundwater contamination). The one to two metres thickness was based on the maximum wetted screened interval specified in the guidance document. Note that the guidance is not requiring that vertical profiling be conducted at all sites. At all sites, the vertical extent of groundwater contamination must be delineated, as required under the CSR. The guidance document indicates that this may be conducted using nests of wells completed at different depths or by vertical groundwater profiling. The ministry maintains that vertical groundwater profiling is generally a superior approach to conventional monitoring wells, but that the project goals and the site conditions will dictate the best method to use.
		It can be understood how the guidance provided in this statement coincides with the preferred screen intervals specified in this document. However, similar to themes of previous comments, the thickness limitations provided in this statement are very conservative. There may be instances where nesting of wells within this small an aquifer thickness is required, however, this should not be considered to be the norm.		See the above response.
		Providing a range of (groundwater?) contamination thickness of one to two metres leaves room for		See the above response.

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		argument so more rationale for selecting this range would be useful. It may not be the actual thickness that is important as opposed to the rationale that is actually important.		
What methods and approaches are acceptable? (Vertical Groundwater Profiling)	Diving Plumes	The concept of "diving plumes" was highlighted at the recent MoE Seminar in 2009, and was presented as a key reason for the requirement of vertical delineation. It should be noted that there are specific geologic, hydrogeologic and hydrologic conditions which will create a diving plume, conditions which can be assessed without additional well installation (conditions which exist at a small percentage of BC sites). Even where these conditions exist (a small sub-population of the above), plume dive occurs over significant horizontal distance from the contaminant source. Significant empirical data is available that indicates the size of the site required to produce a degree of plume dive which would in turn produce measurable impacts in monitored groundwater quality, is larger than the average BC contaminated Site.	If vertical profiling is to be a requirement or recommended under this guidance, it is recommended that a minimum delineated plume area be provided under which limits vertical groundwater profiling would not be considered required as impacts to the investigation reliability would not be substantial.	The ministry does not agree with this approach. As per the CSR, vertical delineation of groundwater contamination is a requirement in BC.
Level of investigation in Stage 1 PSI	Not included in this Guidance but should be.	It should be noted in this section that it is essential that the assumptions of groundwater transport as they pertain to contamination migration (on and offsite) which were used to include and exclude potential APECs, should be confirmed during the Stage 2 PSI. Where the conclusions of groundwater transport as determined in the Stage 2 PSI differ from those inferred in the Stage 1 PSI, the conclusions of the Stage 1 PSI should be re-examined. In my role as a CSAP reviewer, I have noted that this step is rarely taken in the investigation process, with 10% to 20% of sites having a local groundwater regime which differs significantly from that initially inferred in the Stage 1 PSI.	See comments	The ministry agrees with this recommendation. Text has been added to the document indicating such.
Level of investigation in Stage 1 PSI	Use of CSM term.	The use of the CSM term seems to be too broad and is perhaps inappropriate in the context of the level of hydrogeologic information acquired in a Stage 1 Preliminary Site Investigation. The use of the CSM term in this guidance extends beyond how this term is		The ministry agrees that the development of a CSM is an iterative process. The concept may continuously change as new information is acquired in subsequent levels of investigation. A CSM formed at the Stage 1 PSI is common practice, and forms a basis for planning the next

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		defined in the “Groundwater Investigation in Site Assessment” document that this guidance is based upon.		stages of investigation.
What level of groundwater investigation is required for a preliminary site investigation? (Stage 2 PSI)	Suggestion to drill and log a stratigraphic borehole.	The suggestion to drill and log a single "stratigraphic borehole" at the site is not technically defensible. Stratigraphy across the site can vary significantly from borehole to borehole, and cannot reliably be determined by a borehole in a single location. The respondent is not clear what information this borehole would provide that is not already provided by several other boreholes being drilled and logged across the site (providing much better area coverage) as part of the Stage 2 PSI.	Delete this discussion from the guidance document.	The wording in the document has been changed from “should” to “could”, i.e. leaving the completion of a stratigraphic borehole as optional.
		The drilling and logging of a “stratigraphic” borehole outside of the Site area provides limited benefit to the investigation process. This recommendation assumes an areal homogeneity which does not exist in the overwhelming majority of “real life” situations. In refining the CSM, the area of primary concern is the geology at the (hydrogeological and in some cases physical) downgradient area of the plume as it will determine the projected plume movement.	As there is no strong technically supportable reasoning for this requirement, it is recommended that the default requirement be removed from the document.	See above response.
		A borehole completed solely for “stratigraphic” purposes would seem redundant in the majority of site investigations. Stratigraphic information is obtained from the boreholes and monitoring wells that are completed to investigate APECs at a site. A borehole completed solely for “stratigraphic” purposes may be needed in the fewer cases where investigation of APECs is unable to determine stratigraphic conditions in the area (e.g., properties that are predominantly comprised of fill or where fill is encountered to depths below the water table).		See previous responses.
What level of groundwater investigation is required for a preliminary site		Recommend adding in addition to “local site conditions” that the media to be sampled will be dependent on PCOC characteristics. Where the text indicates “where site-specific	Recommend adding text “....and on PCOC characteristics”. Recommend identification	The recommended text was added to the document. The type of information would be highly site-specific. Professional judgement would dictate whether a

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investigation? (Stage 2 PSI)		information may be lacking…" the exact type of information referred to is not noted, nor can be reliably inferred.	of type of information being referred to.	stratigraphic borehole, as discussed in this section, would be necessary at the site in question.
What level of groundwater investigation is required for a preliminary site investigation? (Stage 2 PSI)	Installation of a background well upgradient of each APEC.	The absence of contamination in an APEC would be the primary reason not to drill upgradient. Otherwise, you are delineating in which case this seems more appropriate as DSI guidance.	Move this paragraph to DSI section and re-phrase.	The portion of this paragraph requiring an upgradient well at each APEC has been deleted from the document.
		Delineation is specified in the CSR as a component of a DSI, and so why is bounding "the contamination and provid[ing] certainty as to the lateral extent of contamination" being pushed back into Stage 2? We have always understood that the purpose of Stage 2 investigation is assessing presence/absence of contamination. The principal function of a background well is allowing identification of confounding sources outside the APEC/AEC (and secondarily delineation).	Because it is unnecessary and redundant, we advocate against a background well specification as a default, even for DSIs.	See above response.
		The requirement to have a single upgradient well for each suspected on-site or off-site APEC is impractical. It ignores access issues for off-site plumes. It ignores the complexity of commingled plumes (on and off site).	This requirement should be changed to have at least one up gradient monitoring well for the site being investigated, if technically feasible and access is not an issue.	See above response.
		The discussion of placing wells "within each onsite or offsite APEC", should be amended to read "within each onsite APEC and at the property boundary as close as practical to offsite APECs" to reflect the true goals of the Stage 2 PSI. The default requirement for a background well for each APEC is unfounded. The rationale provided "to bound the contamination and to provide certainty as to the lateral extent.." is not a purpose of a background well, rather it is the purpose of delineation sampling points which are provided for as needed in the DSI stage of an investigation, not the PSI.	In the absence of technically supportable reasoning for this requirement, it is recommended that the default requirement be removed from the document.	Wording in the document regarding off-site APECs was changed as suggested. As indicated above, the portion of the paragraph requiring an upgradient well at each APEC has been deleted from the document.
		The purpose of a Stage 2 Preliminary Site Investigation is to confirm/refute the presence of contamination associated with an APEC. Completing a background well to bound contamination and provide certainty to the	Remove this requirement.	See above response.

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		lateral extent of contamination are requirements that are more suited for a Detailed Site Investigation. Also, there is the chance that groundwater collected from wells installed specifically to investigate the individual APEC come back clean. In which case the additional background well installation was done unnecessarily. The installation of one well would also not "bound" the contamination nor provide lateral delineation.		
What level of groundwater investigation is required for a preliminary site investigation? (Stage 2 PSI)	Required use of three well locations to determine groundwater flow direction.	Estimating groundwater flow direction from monitoring wells can usually be completed at sites with multiple APECs (= multiple monitoring wells). However, a site with only one APEC and a notable surface slope or close to a significant surface water body may only warrant one monitoring well. In this situation why should three wells be installed to define the groundwater flow pattern at a Stage 2 PSI?		It is common industry practice to use water level measurements from at least three wells to establish hydraulic gradient.
What level of groundwater investigation is required for a preliminary site investigation? (Conditions requiring further investigation)	Further assessment required where PCOC concentration exceeds one-tenth the applicable standard.	The main issue here is appropriately locating the well. If the location is defensible, applying a one-tenth rule will become an item of dispute and may not be legally defensible. This guidance would almost certainly cause grief for substances such as iron and manganese, or any contaminant that is barely detected but has a detection limit >10% of the standard (e.g. LEPH).	Remove the one-tenth rule from the guidance piece. Ensure wells are appropriately placed in each APEC (which hopefully will be assisted through the use of this guidance).	The one-tenth rule has been removed from the guidance document. The original intent of this rule, to ensure that the well is properly located, is adequately considered in the second bullet of the section entitled "Conditions requiring further investigation".
		Most APECs are investigated with only one monitoring well in a typical Stage 2, so this has very broad effect. Firstly, no science or engineering analysis produced one-tenth. During the MOE workshop on February 17, 2009, the author of the report underlying the draft guidance said that one tenth was set based on his own professional judgment. By comparison, analytical uncertainty factors less than five apply even in the worst case, and are mostly a factor of two to three. Because MOE specifically says that groundwater results can't be averaged, the de facto effect of having two samples will be that an investigation will use the higher result, which will in nearly all cases be higher than the actual concentration (on the assumption that all results vary around the actual result without bias,	The guidance needs to indicate how this is to be addressed.	See above response.

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		statistically the odds are good that the higher measurement of two is higher than the actual concentration). This guidance would have the effect of creating de facto standards for further investigation of PCOCs that are one-tenth the standards that have been derived based on toxicological data. The effect is to make site classification more protective, when there is no evidence that they are not sufficiently protective. There are a number of cases where the detection limit reported by a laboratory is greater than one tenth the applicable standard. Two examples of this are: o the reported detection limits for LEPHw can range from 80µg/L to 250µg/L while the CSR AW standard is 500µg/L o the typically reported detection limit for benzo(a)pyrene in water is 0.01µg/L, which is equivalent to the CSR DW standard.		
		The respondent does not understand this extremely conservative guidance and has several concerns: • a) Numerical guidelines or standards are established to be protective of receptors (e.g. drinking water wells and aquatic water bodies). The respondent is concerned that this guidance will require the installation of unnecessary wells and the collection of large amounts of unnecessary data. • b) One tenth appears to be completely arbitrary level. Hydrocarbons at 1/10th the standards do not present a concern for the environment. • c) There may be existing historical groundwater data or recent soil data that would allow placement of a single groundwater well within an APEC that would have a very high probability of being representative of "worst case" groundwater conditions for the APEC. • d) Some numerical standards are less than 10 times the laboratory detection limit for the parameter. Precious resources could be wasted	The respondent recommends that this requirement be removed.	See above response.

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		chasing false positives, or results at or just above the laboratory detection limit, when the detected values are actually analytical artifacts.		
		The Stage 2 Preliminary Site Investigation section indicates that "during the Stage 2 PSI, monitoring well locations should be selected to intercept highest concentrations of potential contaminants in groundwater associated with each suspected source zone within each onsite or offsite APEC." Further, in the Section "Conditions Requiring Further Investigation", it's noted that in conditions where only 1 well was installed in an APEC, and in the absence of a supporting rationale, further assessment should be conducted where analytical results indicated any of the PCOC concentrations exceed 1/10th the applicable standard. This 1/10th recommendation sounds arbitrary and punitive. The absence of a well as stipulated in the Stage 2 PSI section should be enough to warrant some kind of rationale OR be enough to require further investigation.	We recommend deleting this 1/10th recommendation as it seems unscientific.	See above response.
		The default requirement for assessment of APECs where PCOCs have been identified at >10% of the applicable standard is unfounded at a general level. There are conditions where additional sampling may be prudent when concentrations of PCOCs are identified albeit below the applicable standard, however these situations would be in the minority. The conditions which are common in most sampling cases would not technically support the requirement for additional sampling. Specifically, where the sampling is targeting the source or "worst case" location based on field screening or actual knowledge of the source location, additional sampling would not be technically defensible and would be irresponsible.	It is recommended that this guidance be removed and replaced with examples of specific site and PCOC conditions where data from one sampling point may not be able to identify conclusively the presence/absence of contamination.	See above response. Conditions where data from one sampling point might not conclusively identify the presence/absence of contamination would be site-specific, and therefore have not been included in the discussion.
		This needs clarification on what "further assessment" means, i.e. more groundwater monitoring, or more well installation? What is the supporting rationale behind the selection of a one-tenth criteria to determine that further assessment is required? This should not apply if		See above response.

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		the single well for the APEC is situated directly on top of the APEC. Providing guidance to this level of detail will lead to interpretive complications that may make the guidance document impractical.		
What level of groundwater investigation is required for a detailed site investigation?	"....*The sampling program must be sufficiently detailed to satisfy data requirements for a risk assessment, if applicable, and for developing a remediation plan*."	The sampling program required of a DSI is to delineate contamination to the physical limitations provided by TG1, or that prescribed and technically supported by a practitioner if the limitations provide by TG1 are inappropriate to the site conditions in consideration of the characteristics of the site and PCOCs being investigated. If deemed to be required by a risk assessor or a practitioner planning remediation, additional sampling can be prescribed to obtain any additional data required to characterize the Site to meet their needs.	Recommend removing the text requiring that the DSI fully support a RA or RAP.	Wording in the document is consistent with wording in the CSR – see section 59 (2) of the CSR: "A detailed site investigation must provide information necessary for conducting a risk assessment, if applicable, and for developing a remediation plan..."
		The guidance for the sampling program should be sufficiently detailed for a risk assessment, if applicable, **or** for developing a remediation plan. Generally, a risk assessment only requires that delineation is achieved and that the highest concentration of the contaminant is known. However, for remediation (i.e., to numerical standards), the level of investigation is expected to be more significant to ensure that numerical standards have been achieved.	Change underlined text in document.	See above response.
What level of groundwater investigation is required for a detailed site investigation? (Well Spacing and Spatial Characterization)		Figure 1 shows a recommended 12 monitoring wells strategy, for an idealized plume. At a typical service station site, there may be groundwater plumes emanating from two or three different APEC's (e.g. pump island, tank nest and fanner furnace oil tank). Following this guidance would imply an unreasonable requirement for 36 monitoring wells at a service station with three APEC's. The number of groundwater wells needed to characterize a site should be left to the judgment of a professional and not be a prescriptive requirement, based on an idealized model. The guidance for less that 10m at the leading edge and less than 5 m lateral delineation rule for plume definition may be acceptable for small plumes on an idealized modeled site. For most investigations this will result in a	Resolution required for plume delineation should be left to the judgement of the professional. Figure 1 should be qualified as being "best case under ideal conditions".	Professional judgement may be exercised in determining the resolution required for plume delineation, provided that supporting rationale is adequately documented. The figure caption has not been changed as it currently indicates that the number of wells may vary from site to site, which inherently implies "best case under ideal conditions".

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		larger number of wells being installed with little additional technical value. There is no technical justification for having a resolution this fine for a dissolved plume in the vast majority of cases. The resolution required should be left to the judgment of the professional. Significantly greater spacing may be required to account for large plumes, third party access restrictions, presence of buildings, etc. These conditions and restrictions are recognized for LNAPL, as outlined in the second paragraph of the LNAPL Monitoring section on page 8 (" ... depending on proximity ... to property boundaries, structures and other sensitive features "). The respondent recommends the same consideration be applied for dissolved concentrations. Figure 1 should be qualified as being “best case under ideal conditions”.		
		The indication that groundwater sampling point spacing is required a level which is denser than that required for a soil investigation is not technically supported and would indicate that delineation requirements for soil investigation as identified in TG1 are inappropriately large. The resolution of a groundwater plume through chemical characterization is not necessary to the degree identified in this document if there is a comprehensive understanding of the groundwater regime in the immediate area of the plume which can be used to target areas to be investigated/delineated. Recommend reassessing the guidance for minimum delineation point spacing, either increasing the spacing to a technically defensible limit or providing a series of steps for the practitioner to consider in determining what the adequate spacing will be at the site. This section of the document requires the practitioner to “take into account the effects of well screen length and dilution” yet provides no guidance as to what would be deemed an appropriate level of accounting.	Recommend that clarifying text be added or this text be removed.	As discussed in previous response, refer to qualifier added to the note to Figure 1.
		At many sites where risk assessment is applied, the spacing requirement that is specified would not be		See previous response.

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		required.		
What level of groundwater investigation is required for a detailed site investigation? (Chemical Spatial Characterization)	The respondent would like biodegradation referred to in the sentence.	"*geochemical and chemical information that will assist in assessing contaminant transport and fate in the subsurface (e.g., redox conditions, soil and dissolved organic carbon content, dissolved oxygen and pH, nutrients, hardness, etc.) during migration through the aquifer to a receptor.* " The respondent recommends the addition of biodegradation to the wording.... transport, fate, and biodegradation...	See comment	Biodegradation is one of the many processes that affect the transport and fate of contaminants in the subsurface. Other processes that can influence contaminant fate and transport include mass transport processes (advection, diffusion and dispersion) and mass transfer processes (dissolution, sorption, and volatilization).
What level of groundwater investigation is required for a detailed site investigation? (Temporal Characterization)	Requirement for quarterly sampling (minimum) for one year where there are significant seasonal effects or where concentrations likely vary and are within 50% of a standard.	This is another criterion that may cause dispute and may not be legally defensible. This guidance would cause some sites that are not contaminated to be held up in the system for almost a year. The guidance is good but perhaps without the 50% criterion.	Remove the 50% criterion from the guidance piece. Quarterly sampling required for one year simply where significant seasonal effects are likely, or where concentrations are likely to vary for other reasons.	The wording in the text referring to concentrations that are within 50% of the standard has been removed from the guidance piece. Wording in this paragraph was changed to include "....or where concentrations are likely to vary significantly for other reasons....".
		• Understanding temporal variation is really only relevant where the thesis is that the location is not contaminated • Groundwater quality at contaminated sites is inherently variable. Acceptable analytical variation between duplicates can be over 40%. But this variability has always been the case, it is hardly emerging science. As such, the test in the draft guidance has the effect of changing the meaning of "standard" as a lay person would understand it, because it creates a safety margin that has never before been suggested. The practical effect is to essentially mandate quarterly sampling over one year for all sites that where groundwater quality is within 50% of the standard. Is this necessary? • TG8 needs to provide guidance which indicates how we would decide "where seasonal effects be may be significant". We cannot say that we have noticed predictable seasonality in groundwater results as much as we have noticed variability. We suspect the reason we have not observed		Temporal concentration variations are indicative of the degree/magnitude of contamination, and in the ministry's opinion, are important to establish during the site investigation process. The wording referring to 50% of the standard has been removed from the guidance document. One might expect seasonal effects to be significant in areas where precipitation patterns change relatively consistently with the seasons. This is indicated in the first paragraph of the section where it is stated that "*Several factors may account for observed changes in substance concentrations over time, including changing water levels caused, for example, by changes in seasonal infiltration rates*....". Seasonal changes in groundwater levels may not necessarily result in a corresponding change in substance concentrations; however, where the seasonal effects have *the potential* to influence substance concentrations, this potential should be explored during the

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		predictable seasonal effect on groundwater quality is that seasonal variability is small and/or site specific, and so cannot be generalized because other sources of variability mask it.		site investigation phase.
		This is reasonable when conditions are expected to vary greatly (e.g. tidally influenced sites). Under more stable conditions, less frequent sampling should be required where concentrations are at 50% of standard. There are degrees of conservatism already built in to the numerical standards. If the plume is stable, the remedial program should be considered complete when the groundwater concentration is below the standard.	Require less frequent sampling in some cases even if concentrations are at 50% of standard.	See previous responses.
		TGD 8 states that if contamination is identified or suspected during a PSI then a DSI must be undertaken. Assuming the work was completed correctly, this means that if PSI samples meet the applicable (100%) numerical standard, no further investigation is required. Conversely, the DSI guidance establishes a “50% of standard” guideline for sites with seasonal effects. This is inconsistent as wouldn’t the seasonal effects qualifier apply to all investigations?		As indicated in previous responses, the wording in the text referring to concentrations that are within 50% of the standard has been removed from the guidance document.
		Although we understand the intent that “where concentrations are likely to vary and are within 50% of a standard, then at least quarterly sampling should be performed over at least one year”, there remain strong concerns regarding its wording. Given that even lab duplicates (as per BCELQAAC recommendation) can vary by upwards of 30%, what does the Ministry constitute as acceptable variance when applying this 50% rule? Also, the real issue is that seasonal effects are a concern and that should be the trigger; not implementing what appears to be an arbitrary (50%) rule of thumb. Our concern is the 50% rule has the potential to become a “defacto” policy and miss the overall intent.		See previous response.
		There needs to be an allowance for professional judgement. Does this guidance take into account variations that can occur at the laboratory?		See previous response.

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		Similar to previous comments, providing guidance to this level of detail will lead to interpretive complications that may make the guidance document impractical.		
		On page 6, TG8 states that seasonal effects should be monitored and tested if concentrations of PCOCs are within 50% of the standard. Is the intent here to address hydrocarbons, VOCs, etc.? If so, metals and other inorganic parameters should be excluded from this requirement.		See previous response.
What level of groundwater investigation is required for a detailed site investigation? (Vertical Separation Between Wells)	Vertical separation of less than one metre between bottom of one well and top of the next.	The respondent does not understand the justification for this requirement. The requirement for nested wells that the bottom of one screen must be <I m from the top of the next screen is not technically justified. The spacing of screens in nested wells should be left to the judgment of the professional. This requirement, as it is currently written, will increase the number of wells needed to be drilled at a site without any technical value.	Spacing of screens in nested wells should be left to the judgment of the professional	The intent of maintaining a minimum vertical separation between well screens was to obtain adequate characterization of the plume. Note that the guidance document clearly allows for professional judgement where site-specific rationale may suggest that other well spacing intervals would be more appropriate.
		There needs to be an allowance for professional judgement. Similar to previous comments, providing guidance to this level of detail will lead to interpretive complications that may make the guidance document impractical.		See above response.
Not included in guidance document.	Multi-level monitoring wells – horizontal separation	My comment/question relates to the use of multi-level monitoring wells. Do you think it would be valuable to include some guidance on the minimum acceptable distance of (horizontal) separation between multi-level wells? For example, for any type of drilling method, I think it's reasonable to expect a radius of disturbance (i.e. due to auger deflection, bit deflection, slough) outside the observable annulus. If the radii of two multilevel wells overlap, it may be possible to reduce the effectiveness of the surface seal, or even make it redundant.	See comment.	Horizontal separation between monitoring wells in clusters is expected to be sufficient due to the working space required for the drill rigs. However, ensuring adequate horizontal separation between wells in clusters is best left to professional judgement based on site-specific conditions.
What level of groundwater investigation is required for a detailed site	Requirement to determine whether aquifer is confined or unconfined.	What is the purpose of determining whether an aquifer is confined or unconfined as part of a DSI? In the vast majority of sites, this information is not required, and in some cases, it will not be cost effective to acquire information of little value.	The respondent recommends that this guidance is not required.	The hydrogeological model of a site is a key component of the conceptual site model. Determining whether an aquifer is confined or unconfined is typically completed as part of determining the type and distribution of hydrostratigraphic units at the Site, and remains a

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investigation? (Defining site-specific hydrogeologic conditions)				requirement in the guidance.
What level of groundwater investigation is required for a detailed site investigation? (Defining site-specific hydrogeologic conditions)	Requirement to determine vertical and lateral hydraulic gradients, groundwater flow direction and velocities within and between the relevant, permeable geologic units	It may be important to determine the velocities in aquitards at some sites, but this should not be a standard requirement as aquitards are not typically a relevant transport pathway.		Wording in the text indicates that during the DSI the "...velocities within and between the relevant, permeable geologic units" should be determined. The intent here was to ensure that groundwater velocities were determined *between* the two permeable units, i.e. it was not intended that lateral flow within the aquitard would necessarily be determined. Flow from one aquifer to another through a confining unit can be substantial in certain cases.
What level of groundwater investigation is required for a detailed site investigation? (Defining site-specific hydrogeologic conditions)		This discussion should also indicate that event and seasonal contribution to the hydrogeologic regime should be considered as well as tidal influence (where appropriate), with the ultimate goal of identifying the conditions required for sampling to be conducted such that it is characterizing as close to the "worst case" scenario as reasonably possible.	See comments	The suggested wording has been added to the section in the document.
What level of groundwater investigation is required for a detailed site investigation? (Entry of information onto drawings)	Requirement to provide cross-sections with potentiometric surfaces.	For more complicated sites, cross-sections of stratigraphic units with potentiometric surfaces should be provided in the assessment report. However, for less complex sites (e.g. small plumes, simple hydrogeology) the preparation of such figures is not required in order to understand the CSM of the site.	Do not require cross-sections with potentiometric surfaces for all sites.	The ministry feels that the provision of a cross-section with potentiometric surfaces shown is a minimum expectation at all sites. As indicated in one of the ensuing comments, the "purpose [of the cross-section] is to place the groundwater surface in relation to inferred or observed zones/depths of contamination".
		The guidance document should provide guidance on acceptable or preferred methods to plot potentiometric surface maps, e.g., hand triangulation versus computer automated statistical methods. The document should also insert a point that when evaluating the hydraulic head distribution, and specifically plotting groundwater flow directions, care should be exercised when significant hydraulic		Professional judgement should be exercised to determine which procedures should be used to interpret data collected during an investigation, on a site-by-site basis.

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		conductivity contrasts occur within the hydrostratigraphy. These contrasts lead to anisotropy, therefore groundwater flow directions cannot simply be plotted perpendicular to equipotential lines.		
		Potentiometric surfaces should be shown for each aquifer on every stratigraphic cross section as its purpose is to place the groundwater surface in relation to inferred or observed zones/depths of contamination.	See comments	The ministry agrees with this comment. Wording in the text has been changed to reflect this.
What level of groundwater investigation is required for a detailed site investigation? (Erroneous measurements – short term changes)	72-hour period for measurement of water levels affected by the tidal cycle.	In some cases, using the methods of Serfes, 25 hours is sufficient and is perhaps a better recommended 'minimum' Note that the reference to Serfes (1998) should read Serfes (1991). Also, the guidance suggests measurement for 72 hours is required although the analysis is based on measurement for 71 hours.	Reduce to 25-hour measurement period. Fix errors in document.	The 71 hour test is typically recommended. Note that professional judgement may be exercised, and deviations from the guidance should be accompanied by supporting rationale. The errors in the document have been corrected.
		The respondent believes that an error in interpretation has been made. Serfes recommends readings once per hour for 71 hours, not every ten minutes	Fix error in document.	The error in the document has been corrected.
		The presence of LNAPL **will** lead to erroneous measurement of potentiometric elevation unless accounted for. Estimates of groundwater flow direction **may** be influenced by changes in water elevation….	See comments	The presence of a small amount of LNAPL may not necessitate a corrected groundwater elevation. The wording in the text has been changed to that suggested ("Estimates of groundwater flow direction **may** be influenced by changes in water elevation….)
What level of groundwater investigation is required for a detailed site investigation? (Erroneous measurements – short term changes)	Issue not mentioned in document.	The document should add that in situations where the tidal body is a marine environment, saltwater intrusion is very probable. Accordingly, deeper nested wells may be screened within a saltwater wedge; whereas, shallower nested wells may be screened within freshwater. Wells screened within saltwater must be corrected for density contrasts and converted to equivalent freshwater head. This is critical to properly evaluate both vertical and horizontal hydraulic gradients; and generally the flow field when constructing potentiometric surface maps.	Add to document.	The suggested wording has been added to the document.
What level of	Determining average	To reliably determine the average groundwater flow	Include discussion of this	The parent document indicates that field and laboratory

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groundwater investigation is required for a detailed site investigation? (Erroneous measurements – short term changes)	groundwater flow direction.	direction, the proponent should be encouraged to examine the concentration gradient of contaminants, as well as examining the groundwater elevations.	in the section.	chemical data should be reviewed within the context of the CSM, which would include consideration of the groundwater flow direction at the site.
What level of groundwater investigation is required for a detailed site investigation? (When Should NAPL be Investigated)	Effect of sampling groundwater from wells with NAPL	The respondent agrees that groundwater should not be sampled from wells with NAPL due to the potential entrainment of the NAPL in the water and reporting of results that are biased high. However, the respondent is not aware of potential low bias due to sample dilution. The respondent would like to discuss scientific literature that documents this phenomenon.	Discuss this issue with the respondent.	Water below the NAPL that is not in direct contact with the NAPL is unlikely to be at chemical equilibrium with the NAPL. Dissolved concentrations will be less than solubility limits where water samples are withdrawn from the water column below the NAPL. Dilution will be exacerbated by sampling, whereby cleaner water from the base of the well screen is drawn into the well and the sample.
What level of groundwater investigation is required for a detailed site investigation? (When Should NAPL be Investigated)	Time frame for monitoring at wells with NAPL.	While NAPL measurement during drilling and well installation will identify if the groundwater in the immediate area is grossly contaminated with NAPL, this measurement is of value primarily for identification of potential health & safety concerns which may require consideration by the investigation crew. More often then not, the drilling method and method of well installation displaces the NAPL from its insitu equilibrium. In order to get an accurate determination on the presence and amount of NAPL in the area of the monitoring well, NAPL monitoring should be completed at least 48hrs post well installation and development to allow for it to equilibrate. Additional time may be required depending on the conductivity of the aquifer media.	Recommend clarifying discussion on applicability of NAPL monitoring data at the timeframes indicated.	The shortest time frame indicated in the document (i.e. 24 hours) was included for practicality purposes for sites that are not within the Lower Mainland.
What level of groundwater investigation is required for a detailed site investigation? (LNAPL	Continuous monitoring over a full tidal cycle at least once to establish the influence of tides on LNAPL presence and thickness.	Pressure transducers are not usually installed in wells with NAPL.	Perhaps the guidance should just indicate that “frequent” monitoring should be conducted….	The word “continuous” (suggesting that a pressure transducer might be required) has been removed from the document.

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monitoring)				
What level of groundwater investigation is required for a detailed site investigation? (LNAPL monitoring)	Wells in LNAPL area to straddle the water table.	This paragraph specifies that if LNAPL is suspected to be present, the well be installed to "straddle the water table over the anticipated seasonal high and low water table conditions". The respondent agrees with this recommendation as a good example where it will be appropriate to have well screens longer than 1.6 m.	Amend acceptable length of monitoring well screen section.	See previous responses regarding saturated well screen lengths.
What level of groundwater investigation is required for a detailed site investigation? (LNAPL monitoring)	Resolution of LNAPL zone at a scale of 5 m to 7 m or less.	Perhaps this could be recommended for ideal cases, as this scale will not be practical for many complex and larger sites. This requirement appears to be arbitrary and does into take into account site-specific conditions including plume size, property boundaries and structures. In many cases, this will result in the installation of far too many monitoring wells, with little additional technical value.	The resolution of the lateral extent of LNAPL plumes should be left to the professional.	The ministry agrees with the recommendation as is. This spacing is based on and is consistent with spacing referred to in Technical Guidance Document 1.
		Again the degree to which the LNAPL plume is required to be delineated is unnecessarily fine.	Recommend adjusting monitoring requirements to a technically defensible level.	See above comment.
What level of groundwater investigation is required for a detailed site investigation? (LNAPL monitoring)	See paragraph 2 of section.	As all sites have a potential security concern, TG8 should have a guidance that monitoring wells be locked to deter unauthorized access that would include locked monument casings for above ground installations or locked j-plugs in the riser of flush-mounted installations.	See comment.	As referenced in the guidance document, the “British Columbia Field Sampling Manual” (Ministry of Environment, January 2003) shows the recommended typical monitoring well design (see Appendix A). As shown in the figure, the recommended well configuration includes a protective cover with locking cap.
What level of groundwater investigation is required for a detailed site investigation? (LNAPL monitoring)	See paragraph 3 of section.	The discussion in this section presents a wide range in times required for LNAPL equilibration, but does not indicate what factors should be considered in determining an appropriate time.	Recommend addition of text discussing such factors.	Determining an appropriate length of time to allow LNAPL equilibration to occur has been left to the judgement of the professional.
		The frequency requirement for LNAPL monitoring is set at “one or two” months without any technical reasoning or identification of factors to consider in determination of an appropriate frequency.	Recommend adjusting monitoring requirements to a technically defensible level, or better, technical arguments to allow the practitioner to evaluate an	The sentence specifying the monitoring frequency of at least once every two months and preferably monthly is preceded by the wording “*In absence of site-specific rationale,...*”. Professional judgement is expected to be exercised in selecting an appropriate site specific monitoring frequency. As indicated throughout the

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			appropriate site specific frequency.	document, rationale should be well documented.
		The requirement for organic vapour measurements is not supported and seems unnecessary.	Recommend its removal.	Measurement of organic vapour measurements is considered standard practice for assessment of potential combustible vapour concentrations.
		The requirement for a well to be checked for integrity is unfounded and technically impossible without destruction of the well.	Recommend its removal.	The intent of this paragraph was to indicate that monitoring wells should be properly maintained. Indicators of potential tampering or poor well integrity can include damage to the protective casing, cap, and lock, cracks or other damage to the well casing and/or surface cement seal, soil collapse around the casing, etc. (see Ohio EPA Groundwater Sampling Technical Guidance and Ohio EPA Monitoring Well Design and Installation for reference). Also see section 7 of the Groundwater Protection Regulation for reference.
What level of groundwater investigation is required for a detailed site investigation? (LNAPL monitoring)	See paragraph 3 of section.	This level of monitoring appears excessive and should only be considered in cases where it is strongly suspected that mobile LNAPL is still present and expanding at the site. The Science Advisory Board (SAB) of BC has issued guidance that LNAPL should only be considered potentially mobile if the apparent LNAPL thickness in monitoring wells is greater than 10 to 30 cm thick (depending on the type of LNAPL and soil texture). The respondent recommends that the SAB guidance be incorporated in TG8. In addition, the intensity of the LNAPL monitoring program should be left to the discretion of the professional, who can take into account site specific factors (e.g. soil type, LNAPL characterization, distance to any receptors, etc) when determining an optimal monitoring program. A monitoring program with the intensity outlined here would only likely be needed and resource effective in a few percent of the "worst case" sites.	The respondent recommends that the SAB guidance be incorporated in TG8. The monitoring program should be left to the discretion of the professional.	The SAB guidance has been incorporated into Protocol 16: Determining the Presence and Mobility of Nonaqueous Phase Liquids and Odorous Substances. The ministry emphasizes that professional judgement may be exercised, and deviations from the guidance may be appropriate based on site-specific conditions. Deviations from the guidance should be supported by well-documented rationale The wording of the document already reflects that the monitoring program may be selected by the professional based on site-specific rationale.
What level of groundwater investigation is required for a	LNAPL plume – Monitoring of down/cross-gradient wells.	There should be a final bullet suggesting that the wells located down and cross gradient of the LNAPL plume or LNAPL bearing wells also be monitored to assess potential advances of the LNAPL plume. May also want	See comments – add to document.	Wording regarding the potential advancement of the LNAPL plume is included in the document (see end of third paragraph of this section).

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detailed site investigation? (LNAPL monitoring)	Alternative well construction materials.	to recommend analyzing groundwater concentrations from wells located down gradient of the LNAPL plume to evaluate potential LNAPL movement, where a temporal increase in dissolved concentrations may be indicative of LNAPL advancement. Conversely, a temporal decrease in dissolved concentrations may be indicative of LNAPL plume retreat. The document should also reference the SAB LNAPL HAT, 2006. Propose that the document mention the use of alternative well construction materials, i.e., stainless steel rather than PVC well screens/casings - for wells specifically constructed within LNAPL or DNAPL zones, if longer term monitoring is envisioned.		The SAB LNAPL HAT, 2006 is referenced in the parent document for the guidance piece (link to the parent document is provided in the second paragraph of the introduction section).
What level of groundwater investigation is required for a detailed site investigation? (DNAPL monitoring)	Resolution of DNAPL zone	The discussion above on LNAPL delineation spacing is applicable here and the MOE has recognized and acknowledged that this scale may not be practical at all sites.		The ministry concurs with this statement, and wording in the document has been clarified.
What level of groundwater investigation is required for a detailed site investigation? (DNAPL monitoring)	Direct evidence of DNAPL.	The text indicates that “direct evidence of DNAPL is rarely obtained and therefore a precautionary approach is advised” but does not identify what it considers to be “direct evidence” of DNAPL or what precautionary approaches could be considered for scenarios of concern.	Recommend provision of explanatory text, examples and a heuristic which can be used by the practitioner to evaluate site specific conditions.	Wording has been added to this paragraph to clarify the issue.
		I am unaware of how sampling of shallow soils will aid in identifying DNAPL contamination. I was unable to find published material which would support this approach. Likewise I am uncertain as to how one would go about delineating a “suspect DNAPL zone”.	Recommend this approach is removed from the document. Recommend this section is re-written to better communicate the base concepts crudely attempted here.	Collection of shallow soil samples in the source zone can potentially provide direct evidence of DNAPL presence without risking cross contamination and vertical migration of the DNAPL. Soil gas surveys can be used to identify areas with very high VOC vapour concentrations that might correspond to DNAPL release areas.

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What level of groundwater investigation is required for a detailed site investigation? (DNAPL monitoring)	Additional information required.	More guidance should be provided on how to investigate for DNAPL at the PSI-2 and DSI levels, and where to target well screens, how to install the well screens e.g., at the aquifer/aquitard interface? Should sumps be used? How long to wait before monitoring for DNAPL? Etc.	Add more information to guidance document.	A reference and link has been provided in the document to external DNAPL guidance. The reference and link included are as follows: • Pankow, J.F. and J.A. Cherry (eds.), 1996. *Dense Chlorinated Solvents and Other DNAPLs in Groundwater,* Waterloo Press, Portland, OR • USEPA, 2004. *Site Characterization Technologies for DNAPL Investigations*. EPA 542-R-04-017. Solid Waste and Emergency Response (5102G). Website URL: http://www.epa.gov/tio/download/char/542r04017.pdf, September 2004.
General comment on LNAPL and DNAPL.	NAPL samples.	The document should include that a NAPL sample be analyzed when sufficient quantity is present in the well for sampling. The sample should be analyzed for both physical and chemical properties as follows: • Physical Properties – viscosity, density, interfacial tension • Chemical Properties – at the minimum a chromatogram to identify the type i.e. EPH May also be beneficial to analyze the product sample for a full range of hydrocarbon constituents i.e. BTEX/VPH, PAH etc. such that molar fractions of individual components can be derived. This data can in turn be used to estimate effective constituent solubility's (i.e. max expected dissolved concentrations) and potential worst case constituent vapour concentrations following Raults law.	Include requirement to collect NAPL sample (see comment).	A discussion of NAPL sampling was included in Appendix A of the parent document. Additional text recommended in the comment was added to the Appendix.
What degree of groundwater investigation is required for confirmation of remediation? (Well screen lengths)	Well screen lengths should be limited to a maximum length of 1.6 m, including the screen and filter pack, or to a maximum depth of 1 m below the low water table level, to avoid dilution effects	Same as previous comment: Relevant information on well design (e.g. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, published by the National Water Well Association) suggests that due to the strong sorption capacity of bentonite (and hence it's potential to alter groundwater chemistry) that the bottom of the bentonite seal should be at least 1 foot (30cm) above the top of the well screen. This suggests that a well screen, in order to meet the TG8 guidelines, would be no longer than 1.3 metres. This is quite a small interval and also	Increase acceptable length of monitoring well screens (i.e. screened interval – including all of sand pack) so that length of screen does not have to be cut in the field.	This paragraph has been deleted from the document, and all relevant requirements for well screen lengths are discussed earlier in the document.

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		requires that all standard well screen pipe (which comes in lengths of 1.5m) must be cut.		
		The respondent recommends that this section is redundant and should be removed from the guidance. This material has been addressed on Page 4 "Acceptable lengths of monitoring well screens".	Remove this section from the guidance.	This paragraph has been deleted from the document.
Page 10 – What degree of groundwater investigation is required for confirmation of remediation? (Monitoring Frequency, Minimum Requirements)	pH, electrical conductivity, and either turbidity or dissolved oxygen should be monitored until they have stabilized	There is some literature indicating that stabilization of turbidity, while good for assessing the completion of well development, is not a good indicator that formation water is being sampled. As DO can be finicky/difficult to stabilize, a more preferable minimum subset might consist of pH, conductivity and temperature.	Change minimum subset to consist of pH, conductivity and temperature.	It is recommended to use multiple indicator parameters to assess the completion of well development. The text in this paragraph has been changed to indicate that the minimum subset of indicator parameters used should be pH, electrical conductivity plus one additional parameter.
	Amount purged prior to sampling, parameters required to be measured during purging.	The respondent recommends if purging of wells are required, then the option should also be given to purge a minimum of three well volumes from the well before sampling. This will ensure that formation water is in the well bore. However, the respondent does not agree that monitoring for all these parameters should be minimum requirements at all sites.	Provide option to purge a minimum of three well volumes before sampling. Do not require measuring all these parameters at all sites.	See above response.
Page 10 – What degree of groundwater investigation is required for confirmation of remediation? (Minimum Requirements).	Rationale for a minimum of three monitoring locations.	The respondent does not understand the rationale for specifying a minimum three monitoring locations within each affected aquifer associated with each area of groundwater contamination.	There may be some situations where this may be required and should be at the discretion of the professional.	The ministry emphasizes that professional judgement may be exercised, and deviations from the guidance may be appropriate based on site-specific conditions. Deviations from the guidance should be supported by well-documented rationale.
		The requirement that "a monitoring network should be established that includes a minimum of three monitoring locations within each affected aquifer associated with each area of groundwater contamination" seems	Rather than establishing a requirement for a minimum number of wells, the guidance should focus on	See above response.

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		excessive. Better guidance and rationale for location and spacing of wells is more desirable than establishing a minimum number. In particular, a lot of AEC excavations are quite small and it seems unnecessary to install 3 wells to characterize groundwater quality.	location and spacing of wells. Sound rationale for the number/location/spacing of wells provided by the professional should be considered acceptable.	
		The number of post-remediation groundwater wells required to confirm groundwater quality will largely depend on the pre-remediated extent of the plume and the complexity of the groundwater regime. Identifying a required minimum of three wells is likely not technically supportable at the majority of sites.	Recommend its removal, and replacement with a heuristic which can be used by the practitioner to evaluate site specific requirements.	See above response.
Page 10 – What degree of groundwater investigation is required for confirmation of remediation? (Minimum Requirements).	"...at least two sets of groundwater samples should be collected on different days, at least 24 hrs apart, but preferably greater than two weeks apart....."	The respondent is not clear on the basis for this guidance and suggests this will add cost but not necessarily technical value.	The respondent recommends that this requirement be removed from the guidance.	It is not possible to determine whether concentrations are stable without at least two rounds of post-remediation sampling. The text has been left as is.
		The requirement for 2 rounds of post-remediation sampling can be eliminated if a sample is collected sufficiently later than the conclusion of the remediation activities (>2 months?).	Recommend its removal, and replacement with a heuristic which can be used by the practitioner to evaluate site specific requirements.	See above response.
Page 10 – When is Post-Remediation Groundwater Monitoring Considered Complete?	Requirement that substance concentrations are less than 50% of the applicable standards for post-remediation monitoring to be considered complete.	As discussed earlier in these comments, numerical standards are developed using very conservative assumptions and are protective of all potential receptors in virtually every circumstance. The respondent agrees that plume stability should be demonstrated, but once that is verified, there is no justification for additional levels of conservatism to be added to the process. In addition, this precautionary requirement suggests that the standards developed by the MOE are, in fact, not protective of receptors. The respondent recommends that if contaminants meet the numerical standards for two successive groundwater monitoring events (and the guidance recommends a minimum 3 monitoring wells minimum per aquifer), that post-remedial groundwater monitoring at the site can be considered complete. In addition, it is worth noting that	The respondent recommends this requirement be removed.	The requirement for post remediation groundwater samples to meet 50% of the applicable standard has been removed from the document.

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		if the source is removed, concentrations will further decrease over time through natural attenuation processes.		
		The requirement for post remediation groundwater samples to meet 50% of the applicable standard is not technically supportable and should be removed.	Remove this requirement from the document.	See above response.
		We would expect that post remediation groundwater monitoring should be considered complete when substance concentrations are less than the applicable standard, and there is no other information to suggest concentrations may increase in the future. The recommendation that "post remediation groundwater monitoring may be considered complete when substance concentrations are less than 50% of the applicable standards, and there is no other information to suggest that concentrations may increase or rebound in future" seems arbitrary and may end up being a "safe" default that our clients and their lawyers are sure to challenge us professionals on. The real issue is NOT the 50% as the recommendation appears to try and use some arbitrary trigger and misses the overall point that groundwater conditions should be stable and not increasing.	This requirement should be removed. Reconsider wording....should focus be on showing that groundwater conditions are stable and not increasing.	See above response.
What degree of groundwater investigation is required for confirmation of remediation?	Not included in this Guidance but should be.	It would be helpful for this document to identify if wells installed by placement during excavation backfill are acceptable to the Ministry, and what minimum requirements for well construction would form an acceptable well.	Include a discussion of this topic in the document.	The requested text was added to the document. On page 3 of the document, it is indicated that "A recommended design for conventional monitoring wells is provided in the "British Columbia Field Sampling Manual" (Ministry of Environment, January 2003)."
What degree of groundwater investigation is required for confirmation of remediation?	Not included in this Guidance but should be.	The guidance document should also identify that wells used for treatment of contamination (extraction of injection wells) should not be used for evaluation of post-remediation groundwater quality.	Include in guidance document.	This text was added to the section.
Page 11 – link to groundwater protection regulation	Typo		Capitalize "W" in the following: "Ground Water Protection Regulation."	The noted error has been changed in the document.

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Appendix 1 – Guidance for Data Presentation	Indication that logs should contain, at a MINIMUM the items listed in the Appendix.	Not all of this data will necessarily be available (e.g. blow counts) so these should not all be minimum requirements or the list should be edited as indicated below. • Sample condition, present percent recovery, and other field data (e.g., blow counts, moisture content o Not all of this information will be available depending upon the field methodology • Reference to USCS; ASTM D2487 o ASTM D2487 is a laboratory based practice for soil description. Most soil classification occurs in the field. ASTM D2488 may be more appropriate to reference as it is still USCS but is based on visual-manual field observations. Perhaps reference together as “ASTM D2488 and/or ASTM D2487” • Depth to water following drilling o While useful, this should not be critical (i.e. not a minimum requirement?)	Revise this section as specified, such that not all of this info is considered minimum information requirements.	• The text was left as is. If the information is not collected in the field, it would not be required on the log. • The reference to ASTM D2488 was included in the text. • Depth to water was left in the text as this information is often useful.
Appendix 1 – Page 1	First sentence includes “test pits”	Test pits are used for soil investigation only, not groundwater investigation. The collecting of water samples from test pits and/or the installation of groundwater wells in test pits should be discouraged.	Remove "test pits".	Deleted “test pits” in appendix.
Appendix 1 – Page 1, Tables section, point 2	Requirement to include field measurements in report.	Field measurements for well stability should be recorded in the field notebook and including this data in the report is not resource effective. If the wells are purged in order to obtain formation water, then the volume of water purged from each well before sampling should be recorded in the field notebook.	Include volume of water purged in this section. Remove requirement to have field measurements included in report.	This section was changed as requested. Provision of field sampling sheets has been added to the Appendix 1 section of the document.
Appendix 1 – Guidance for Data Presentation	Typo		Change present to percent	The noted error has been changed in the document.

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Appendix 1 – Page 2, Figures and Drawing section, point 3	Including stratigraphic cross-sections in each report.	Stratigraphic cross sections should only be required for more complex situations where they will provide value.	The decision whether or not to include cross sections in a report should be left to the discretion of the professional.	The ministry's opinion is that cross-sections should be provided for every site.
Not included in this Guidance but should be.	Sealing the Borehole Annulus	Currently well installation methodology allows for annulus seals to be constructed using solid bentonite material. This material only produces a working seal if properly hydrated. Sufficient hydration of the bentonite material can be difficult in the field. Accordingly, guidance on the applicability of bentonite products can provide significant improvement in well reliability where it can guide the practitioner to produce a functional well seal.	Include discussion of this topic in document.	A brief discussion has been included in the document regarding ensuring proper hydration of bentonite material.
Not included in this Guidance but should be.	Re-consideration of Stage 2 PSI results based on DSI results	Often, site investigation is conducted using "screening parameters" in lieu of analyzing for the full suite of PCOCs at all sample locations (eg. Sampling for LEPH at all locations when characterizing a diesel spill but only analyzing for xylenes at select locations where LEPH concentrations are highest). This can result in the elimination of select "non-screening" PCOCs at the Stage 2 PSI stage. That said if concentrations of screening PCOCs are identified in the DSI which exceed all concentrations identified in the Stage 2 PSI, the previously eliminated PCOCs should be re-assessed in light of the indication of potentially higher concentration.	Instruction on this subject is recommended for inclusion in the guidance document.	Use of screening methods during site investigations is supported by the ministry. However, at the end of a PSI, the investigations undertaken must be sufficient to demonstrate that all APECs have been appropriately investigated for the PCOCs. Similarly, at the end of a DSI, the investigations undertaken must be sufficient to demonstrate that all AECs have been appropriately investigated for the COCs.
Not included in this Guidance but should be.	Sample Filtration	Currently no written documentation exists to provide specific guidance on the MoE acceptable method of filtering of samples for metals parameters where required. Specifically: a. Is filtration in field preferred over filtration in the laboratory? b. For drinking water samples, is filtration of samples from monitoring wells acceptable? As filtration of tap samples is not. Is there a minimum distance from the drinking well screen where sample filtration would not be considered appropriate?	Clarifying text is recommended.	a. The ministry's preference for field filtration is discussed in Appendix A (page A-7) of the parent document. b. A Q&A regarding this topic is forthcoming on the Ministry website.
Not included in	pH Measurement	Currently no written documentation exists to provide	Clarifying text is	a. A sentence was added to Appendix A of the parent

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this Guidance but should be.	and Averaging	specific guidance on the MoE acceptable method of determining pH & hardness at a Site for the purpose of determining the applicable standard for pH/hardness specific parameters. Specifically: a. Identifying if field measured or lab measured results are preferred. b. Identifying if pH averaging across the site is appropriate and/or desirable.	recommended.	document indicating that field measurements of indicator parameters (i.e. pH, not hardness) are preferred. b. A discussion of this issue is beyond the scope of this document.
Attachment A, Page A-2	Stabilization of parameters during purging	In Appendix A, page A-2, it indicates that groundwater quality field parameters (temp, conductivity, pH, redox potential, DO and turbidity) should be monitored prior to sampling to verify static conditions. At a minimum, pH, EC and either turbidity or DO should be monitored until they stabilize. The criteria indicated in the document to represent stable conditions is for low flow sampling using a flow through cell; however, it is also common practice to purge using Waterra inertia pumps which exposes water to the atmosphere and therefore, it is impossible to meet such stated criteria.	Change criteria for stabilization of parameters during purging	Professional judgement may be exercised, and deviations from the guidance may be appropriate based on site-specific conditions. Deviations from the guidance should be supported by well-documented rationale