POSSIBLE MOTION

I move to approve an award of a Professional Services Contract to Pacific Groundwater Group for Sitka Groundwater Supply Development Phase 1 - not to exceed $107,370; and authorize an expenditure not to exceed $700,000 for the purpose of exploring potable water source alternatives.

MEMORANDUM

To: Mayor Westover and Assembly Members
Jim Dinley, Municipal Administrator

From: Michael Harmon, Public Works Director MH
Dan Tadic, P.E., Senior Engineer DMT

Cc: Jay Sweeney, Finance Director
Stephen Weatherman, P.E., Municipal Engineer
Chris Brewton, Electric Utility Director
Mark Buggins, Environmental Superintendant

Date: April 4, 2012

Subject: **Sitka Groundwater Supply Development Phase 1 - Exploration Approval to Award Professional Services Contract**

Background

Construction of the Blue Lake Dam Expansion will necessitate an approximate 90 day window during Fall 2014 in which the penstock from Blue Lake will be out of commission. Since Sitka receives its drinking water from Blue Lake, an alternate drinking water source is required during this outage. In years past, CBS has drawn surface water from Indian River via an infiltration gallery at the Indian River water plant. However, due to new regulations, the Alaska Department of Environmental Conservation (ADEC) has gone on the record as stating that CBS Water Department will be required to issue a boil water notice to the entire community should we ever draw surface water from Indian River. This would pose a major concern for restaurants, hospitals, and schools should this occur.

CBS Public Works (PW) hired a consultant in Fall 2011 to assist with a preliminary evaluation of groundwater well potential in Sitka. The goal would be to construct a wellfield that could provide potable water to Sitka during the outage and also provide the added benefit of a long-term backup system. This consultant identified Indian River Valley and Starrigavan Valley as areas worthy of further investigation into groundwater well potential.

A surface-based geophysical investigation is the next step required to help identify the potential for groundwater wells in either Indian River Valley or Starrigavan Valley. Geophysical surveying is a specialized service that most consulting firms in Alaska do not provide. This work includes electrical resistivity imaging and seismic refraction to help discover buried stream channels and the depth to bedrock. Identification of the subsurface features is critical to developing a test drilling program. Depending on the results of the geophysical investigation, subsequent tasks may include water-right permitting, selection of test drilling sites, and eventually a test drilling program.

Analysis

Pacific Groundwater Group (PGG) is a water resource and environmental consulting firm that specializes in groundwater supply development and water resource management among other services. A team led by PGG has been selected by Public Works for this project given their strong expertise in this field and their track record of successfully completing similar projects throughout the Pacific Northwest. PGG understands the critical nature of this project and has put together a project schedule that will accommodate future phases to include test well drilling, wellfield facility engineering, and wellfield facility construction in advance of the 2014 outage.

The PGG proposal and fee includes geophysical investigations, water-right permitting, selection of test drilling sites, selection of drilling contractor, and a summary report. The summary report will include the test drilling (Phase 2) scope and fees. The total fee for this scope of work is $107,370. A preliminary cost estimate for Phase 2 is estimated at $300,000 to $400,000.

CBS has requested $5,000,000 in FY 2013 State funds to develop an approved alternate/emergency potable water source as a part of the CBS Legislative Priorities for Fiscal Year 2013. However, no outside funding has been secured for this project to date.

Fiscal Note

This project is critical to the City and Borough of Sitka and the Blue Lake Dam Expansion Project. However, a funding source has not been identified. CBS Public Works recommends that a Capital Fund Account be set up with authorization to spend up to $700,000 to investigate any and all possible potable water source alternatives to include groundwater wells, filtration, etc.

Recommendation:

- Approve award of a Professional Services Contract to Pacific Groundwater Group for the Sitka Groundwater Supply Development Phase 1 - Exploration for a not to exceed amount of $107,370.
- Authorize the expenditure amount not to exceed $700,000 for the purpose of exploring potable water source alternatives.

PACIFIC groundwater GROUP

JM1204

April 3, 2012

City and Borough of Sitka
Department of Public Works
100 Lincoln Street
Sitka, AK 99835

Attn: Dan Tadic, P.E., Senior Engineer

Re: Scope of Consulting Services – Sitka Groundwater Supply Development
Phase 1 - Exploration

Dear Dan:

At your request, Pacific Groundwater Group (PGG) and Zonge International, Inc., (formerly Northwest Geophysical Associates) have prepared this scope of work and cost estimate for professional services to assist the City and Borough of Sitka (CBS) with the development of a backup groundwater supply source. Given the over-all project needs, PGG would serve as the prime contractor, while Zonge would provide subcontractor services.

We are very excited to be considered for participation in this interesting and highly challenging project. We believe that we can readily meet all the deadlines on the schedule that we have proposed and believe that we would provide the responsiveness that you are seeking. PGG has a long and successful history of working with municipalities, from our formation in the late 1980s to today. Our clients return to us with new projects, because our work is high in quality and scientifically sound. We have enclosed our Statement of Qualifications that provides references and hopefully displays the great depth and breadth of our experience in groundwater-supply development.

Dan Matlock, who will act as project manager and lead hydrogeologist, has worked for over 30 years in this field and has successfully completed dozens of municipal-scale production-well projects. Linton Wildrick, who will act as assistant project manager and senior hydrogeologist, has worked for 35 years in this field and has completed many water well projects and water-right transactions. Other PGG staff who will work on this project include Wayne Rennick, our senior GIS analyst, Jill Van Hulle, senior water-right specialist, who spent 15 years as a water-right permit writer at the Washington Dept. of Ecology, and Dr. Glen Wallace, staff hydrogeologist.

PROJECT UNDERSTANDING

We understand that Sitka wishes to develop a groundwater supply of 4,000 gallons per minute (gpm) to serve both as a replacement supply during construction to raise the Blue Lake Dam height in 2013, when the surface water supply from Blue Lake will unavailable, and as a long-term backup water source during potential future interruptions to the Blue Lake diversion. Although CBS could potentially use their Indian River backup surface-water supply system during the interim construction period, the State Department of Environmental Conservation would require costly upgrades to meet current water quality regulations.

PRINCIPAL PROJECT STEPS AND SEQUENCE

The timeline for completing this development is relatively short, given all that the steps need to be accomplished by fall 2013 and given the considerable uncertainty about the availability of large groundwater yields in the area. Based on our review of the project schedule and background information, we envision that five phases of the work will be needed to bring a groundwater supply online before the autumn 2013 dam-construction season. These phases and their approximate timing are:

- Phase 1 - Geophysical exploration and permitting (spring 2012)
- Phase 2 - Test drilling (late summer to fall 2012),
- Phase 3 - Production-well construction (spring through summer, 2013),
- Phase 4 - Engineering design for wellfield facilities (winter, 2012), and
- Phase 5 - Wellfield facility construction (spring through summer, 2013).

Our consulting team would be involved in the first three phases. Phases 4 and Phase 5 would be completed by CBS and a water-system engineering group.

The following proposal sections describe a schedule and approaches to various principal tasks of Phase 1. The "approach" sections are followed by descriptions of specific tasks and a cost proposal.

SCHEDULE

Our proposed schedule for the overall project is presented in Table 1.

We envision that the Phase 1 geophysical exploration should be completed as early during 2012 as the weather and ground conditions will allow access for geophysical surveying equipment and crews. The results of this survey would be assessed quickly, so that a test-drilling plan can be developed and initiated by August or September 2012 (perhaps earlier), with completion of the testing work by mid-to-late October 2012.

We have assumed that the test drilling would lead to the selection of several sites for construction of production wells during spring 2013, as early as the weather permits and access to the sites for drilling equipment can be arranged.

Water-right permitting work would be initiated immediately, so that temporary or final groundwater permits are in place by summer 2013.

Wellfield engineering could commence in late 2012 and would be completed by spring 2013.

Finally, wellfield facility infrastructure would be installed in spring and summer 2013, so that the wellfield would be available for use in fall 2013.

POTENTIAL CONTROLS ON GROUNDWATER DEVELOPMENT

Groundwater development along the Indian River will need to avoid the 100-year floodplain and avoid falling within the criteria of the Federal rule for groundwater under the potential influence of surface water (GWI). Under the GWI rule, wells located less than 200 feet from surface water and constructed with the intake screen less than 50 feet deep may be subject to meeting the requirements of the surface-water rule for drinking-water treatment, which the City wishes to avoid. From a practical standpoint, the availability of firm access roads will determine where the required heavy well-drilling rigs and support vehicles can operate. Property ownership will also impose limitations on where water supply can be developed.

Information from geologic and topographic maps, published geologic reports, and limited borehole drilling along Sawmill Creek Boulevard, suggest that groundwater occurrence in the Indian River valley is controlled by the relatively limited distribution of sand and gravel units that are contained within one or more buried stream channels. The channels were cut into bedrock by the combined action of glacial ice and stream erosion, followed by infilling of the channels by deposition of the stream sediments. These buried channels also appear to be much narrower than the main valley and may be only a few hundred feet wide and less than one hundred feet deep. The sand-and-gravel units were later buried under glacial till, volcanic ash, and a thin veneer of recent stream alluvium, muskeg, and slope colluvium. The fine-grained, sparsely fractured, and tectonically tilted bedrock that constrains the buried channels typically contains very little groundwater and would add little to well yields. Therefore, we propose that locating the buried stream channels and their coarse-grained sediments will be the key exploration goal for Phase 1 of this project.

The likely limited depth and width of the buried channels will limit the available drawdown (depth from the water table down to the top of the pump) in wells and will limit the aquifer volume from which groundwater can flow toward a given well. Although it is premature to draw a definitive conclusion, it appears that City may need to install four to eight 12- to 16-inch diameter wells, yielding approximately 500 to 1,000 gpm each, to obtain the desired 4,000 gpm. The wells will need to spaced sufficiently far apart to avoid interference drawdown effects that would decrease the available drawdown and thereby limit individual well yields.

EXPLORATION APPROACH

We recommend that the City initially focus all its groundwater-exploration efforts along the lower Indian River valley, extending upstream to slightly above the surface-water diversion, because it appears to be the most promising and accessible area for development. Conditions above the Indian River diversion, or in the Starrigavan Creek valley, are less promising, so Phase 2 test drilling would not be conducted unless the groundwater capacity in the lower Indian River valley is found to be insufficient. Geophysical studies will cover both project areas, but with greater emphasis on the Indian River area.

Only a few boreholes have been drilled in one small area near the Indian River channel, so little is known about the distribution of buried stream channels. We have found some indirect clues to the distribution, but will need to use surface-based geophysical methods to remotely sense the presence of the channels and to distinguish between finer-grained (clay and silt) and coarser-grained (sand and gravel) sedimentary units. We have used the geologic and topographic information to choose promising area where exploration should be concentrated in the lower valley.

Zonge International (Zonge) will use electrical resistivity imaging (ERI) and seismic refraction methods to conduct geophysical surveys in both the Indian River and Starrigavan valleys. Zonge's proposal is attached, together with brochures describing the two methods. Ground Penetrating Radar (GPR) methods are not recommended[1] for the survey.

WATER-USE PERMITTING APPROACH

Because the construction of new production wells will require groundwater permits, pursuant to Alaska Water Use Act (AS 46.15), PGG will assist CBS through the permitting process. A water right allows a specific amount of water from a specific water source to be diverted, impounded, or withdrawn for a specific use, and although Sitka appears to hold a surface-water right for 2.5 mgd (equivalent to 1,736 gpm) from Indian Creek (ADL 43672), it may also need to acquire specific new authorizations for the wellfield. The State does not allow direct substitution of groundwater rights for surface-water rights; however, retiring the surface-water right on the Indian River or agreeing to not use it when a new groundwater right is in use, or some related arrangement may prove useful in obtaining both a temporary and permanent permit.

Because the processing time for obtaining new water rights can be significant, we recommend a two-step permitting process. First, CBS should immediately request a Temporary Permit to allow for well construction and use, and then at the same time request a permanent Ground Water Permit for long-term needs. Temporary permits could likely be obtained within a few months, whereas a permanent permit may take about a year to obtain.

[1] The Ground Penetrating Radar (GPR) method proposed in CBS's initial Well Siting Consultation report would only be capable of mapping peat thickness in this setting, which would not be particularly useful for locating the buried channel aquifer.

TEST DRILLING APPROACH

Productive wellfield areas will be identified though test well drilling (Phase 2). The test well drilling program will involve drilling and casing of boreholes, installation and development of well screens, and pumping tests from which to estimate production-well yields, aquifer hydraulic properties, and any boundary influences that might affect the long-term performance of the wells or wellfield.

Test drilling in the Indian River valley to date, has been limited to the use hollow-stem auger rigs that are suitable for penetrating and sampling clay, silt, sand, and finer gravel units, but cannot penetrate through cobbles and boulders that might be encountered in the target aquifer and cannot penetrate the local hard bedrock. Unfortunately, the method often cannot distinguish bedrock from cobbles or boulders. Thus, the test borings completed at the Indian River bridge and Public Safety Academy that encountered refusal at various depths did not necessarily encounter bedrock. In addition, hollow-stem auger drilling does not allow installation of large enough casing to allow testing of water-bearing zones.

To enable penetration of large rocks, distinguish bedrock, and afford the opportunity to complete aquifer tests, we propose to use air-rotary drilling rigs for the test-drilling program. Air-rotary rigs can penetrate relatively quickly to depths of hundreds of feet, while providing adequate sample quality for characterizing soil stratigraphy. These rigs also can be used to install, expose, and develop screens as part of the well construction process,

Well screens and temporary pumps will be installed in each well in order to conduct aquifer tests that will be analyzed to estimate aquifer properties such as transmissivity, storativity, leakance, and boundary effects from bedrock and the river leakage. The tests would last for approximately one day each in order to significantly stress the aquifer. The estimated aquifer properties will be used to estimate production-well performance and required spacing, as well as the long-term effects of pumping, including streamflow effects.

PGG has already contacted a number of drillers as to their capability and availability for test-drilling in Sitka and found four contractors that appear to be suitable, including two from Anchorage and two from Seattle. Rig transportation from either City will require barging or possibly use of the Alaskan Marine Highway (AMH) system. The AMH system would likely be far cheaper than using a barge; however, reservations would likely need to be secured several months in advance of departures. For this reason, during the early stages of Phase 1, we will prequalify a preferred driller based on their pricing structure, equipment capability, and availability, so that the logistics for mobilization can be worked out several months ahead of time.

Access considerations for test-well drilling include location of the 100-yr floodplain, ownership, roads with substantial load-bearing capacity, and drilling-pad preparation. Although at least one drilling contractor can provide a track-mounted rig for rough terrain access, all of the rigs are heavy and on the order of 40-feet long. Space for one support truck carrying casing, drill rod, and tools also will be needed at the drilling pads. We estimate that if may take 1 to 2 months to address rig-access issues. This work would be completed by CBS, with input from PGG, after sites have been selected based on the geophysical surveys.

We anticipate the need for about four to six test wells at promising locations. Following construction and testing, the wells will be used for monitoring purposes during production well testing. The test wells might be abandoned in the future if not needed for long-term purposes.

PROPOSED PHASE 1 TASKS

In the following text, we explain the details of our proposed work tasks and present a cost estimate for the tasks. A proposal and cost for Phase 2 work cannot be developed until Phase 1 field work is completed and water-right efforts have been initiated, but will be developed quickly thereafter.

TASK 1 – GEOPHYSICAL SURVEY

Zonge's geophysical surveys would be conducted along the Indian River valley at the approximate locations of the three cross-valley lines shown on **Figure 1,** and along the Starrigavan Valley at the approximate locations of the two cross-valley lines shown in **Figure 2.** These locations will likely be adjusted in the field based on field observations of bedrock geometry and accessibility issues.

The survey line locations are based on our preliminary interpretation that the depth to bedrock and related thickness of the buried channel aquifers are likely to be greater in the lower sections of the valleys. For Indian River, this extends from slightly upstream of the surface-water intake down to around Sawmill Creek Road. The uppermost line will need to be accessed with an all-terrain vehicle and by foot during the geophysical studies. The other two lines will be accessed in part using existing roads on the north side of the river. The specific location of the exploration lines also are based on topographic indicators. Even though there is no current road access to the south side of the river, we believe that it is important to explore in this area for buried channels because the historical river channel likely would have meandered as much as the modern river and may not follow the existing river course. The same strategy was used to identify the survey-line locations in the Starrigavan valley. The survey equipment is relatively small and can be transported by an all-terrain vehicle. The vehicle will be able to cross the river during low flow. The crew will need CBS's assistance to clear lines through underbrush and downed trees.

One PGG staff hydrogeologist will join Zonge's crew on approximately the third day of the field survey in order to observe field conditions, review the preliminary survey findings, and confer on potential modifications to the survey program. Zonge's field geophysicists, together with PGG's hydrogeologist, will monitor data quality and effectiveness of each technique and adjust the field program accordingly.

PGG and Zonge have provided our best informed estimate about now many exploration lines and lengths are needed to broadly understand subsurface conditions in the two valleys. In general, the survey costs will be much less than the costs of test or production well drilling, so potential changes to the survey program that lead to better well-site selection would likely be cost-effective.

Assumptions:

Zonge's will cover costs for a three person crew to clear brush for the geophysical lines. Zone will send a project coordinator to work with the bushing crews two days in advance of starting the geophysical surveys.

The cost estimate assumes that the geophysical work will be completed over a 7-day work period

Earth resistivity measurements require an area free of conductive utilities (above ground and underground), fences, and other linear conductive objects (a distance of 1.5 times the desired depth-of-exploration).

CBS will arrange for site access for the duration of the site investigations.

If the need for changes to the survey program become apparent in the field, we will discuss them and associated costs with CBS managers before proceeding.

Deliverable: Preliminary interpretations within 2-4 weeks and draft report of field-survey findings within 4-7 weeks following field-survey completion..

TASK 2 – WATER-RIGHT PERMITTING

PGG will file an application for an expedited Temporary Permit and an application for a new Groundwater Permit. Our application package will include relevant information needed to facilitate an early permit decision on the Temporary Permit request, such as maps, diagrams, and work plans. Once the wells are constructed and additional information is acquired, PGG will provide the reports of hydrogeological findings and other environmental information as supporting documentation.

PGG will confer with Department of Natural Resources' (DNR) Water Resource Program staff regarding the nature of supporting information that is needed to support a groundwater-right application. It is expected that a hydrogeologic assessment will be required. This assessment would likely include the Phase 1 geophysical survey results and the Phase 2 test well drilling results of this project, so it will not be possible to submit all the required information during Phase 1.

Alaska's DNR has limited resources, so the expedited and successful processing of CBS's applications will depend on our submittals of high-quality, relevant technical information regarding how the proposed wells will affect river flow. PGG will work directly with DNR staff to communicate CBS's need for a timely decision and supply requested information, as needed.

Assumptions: Not all of the work required to obtain permits can be anticipated at present. Therefore, our cost estimate assumes only that applications will be filed, together with preliminary hydrogeologic information.

Deliverables: Water-right application for signature by a CBS authority; preliminary supporting information.

TASK 3 – SELECT TEST DRILLING SITES

The results of the geophysical survey and other field observations by PGG staff will be used to choose several sites for test wells. The potential locations also will be based on the access considerations discussed in the *Test Drilling Approach* section, above.

PGG will develop a standard design for the test wells. Test wells would likely be either 6-inch and/or 8-inch designs. Although six-inch wells would be likely somewhat less expensive to construct, their capacities would be generally less than about 275 gpm. An 8-inch well design would allow installation of a sand pack, if needed to hold back thin fine-grained layers, and would afford testing capacities of 500 gpm or more.

CBS and PGG will need to work together to select final drilling sites based on property ownership, potential of final production wells, and costs of road construction.

Assumptions: CBS staff will confer with PGG staff regarding potential site limitations.

Deliverables: Map with proposed test-well locations; test-well design drawing

TASK 4 – SELECT DRILLING CONTRACTOR

PGG will prepare construction specifications and prepare a bid sheet, send the documents to three or four pre-qualified drilling and temporary pump contractors for bids, review the bids, and recommend a contractor. We will solicit bids for a generic test-well drilling program during the initial stages of the project. This will allow us to select a preferred contractor and to make arrangements very early in the project for scheduling the mobilization of equipment via the Alaskan Marine Highway system. This could provide for substantial cost savings relative to using a barging contractor. Once the geophysical studies have been completed, we will have a more refined definition of drilling depths from which to assess a final bid with the drilling contractor and Phase 2 budget.

Deliverables: Bid documents; recommendation of preferred contractor, initial and final contractor bids.

TASK 5 – PHASE 1 SUMMARY REPORT

PGG will prepare a description of findings that included the report by Zonge, together with recommendations for test-well locations and design, and a scope of work and estimated costs for Phase 2 costs.

Deliverable: Report of findings and recommendations

TASK 6 - PROJECT MANAGEMENT

PGG's Project Manager will prepare and document invoices, manage staff resources and the project schedule, and communicate with CBS staff regarding project logistics, schedule, and technical issues as the project progresses.

COST ESTIMATE

Project costs for Phase 1 work are summarized in Table 2. The budget will be largely dependent on the required length of field time needed to complete the geophysical investigations. Our proposed budget assumes that a representative form Zonge will arrive on-site 2 days ahead of the geophysical surveys to work with local crews in clearing brush along the proposed geophysical alignments. Furthermore, the budget assumes that the geophysical surveys will require up to 7 additional days to complete. Total estimated costs for Phase 1 are estimated at **$107,370**

Our costs will be invoiced monthly on a time-and-materials basis. In the event that unexpected information is encountered that appears to require additional work, PGG will bring it to your attention and seek your approval for any added expenditures. The attached *Terms and Conditions* are incorporated into our agreement with you, and by your authorization to proceed, you are accepting them.

Our professional services will be performed, our findings obtained, and our reports prepared in accordance with generally accepted hydrogeologic practices. This warranty is in lieu of all other warranties, either express or implied.

We appreciate the opportunity to submit this proposal and are ready to start the project. We look forward to hearing from you. Please call me at (206) 329-0141, if you have any questions.

Sincerely,
Pacific Groundwater Group

Daniel T. Matlock, LHG
Principal Hydrogeologist

Attachments: Figures 1 and 2
Table1 Project Schedule
Table 2 Cost Estimate Spreadsheet
Terms and Conditions
Zonge International subcontractor proposal
Geophysical methods brochures
PGG Statement of Qualifications

Table 1 - Schedule for Groundwater Supply Development Studies
City and Borough of Sitka Alaska
JM1204
April 3, 2012

Task	Description	2012										2013										
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
PHASE 1 - EXPLORATION																						
1-0	Prepare Phase 1 Contract																					
1-1	Plan and Conduct Geophysical Investigations																					
1-2	Water-Right Permitting																					
1-3	Select Test Drilling Sites																					
1-4	Select Drilling Contractor																					
1-5	Prepare Phase 1 Summary Report and Phase 2 Scope																					
1-6	Project Management																					
PHASE 2 - TEST WELL DRILLING																						
PHASE 3 - PRODUCTION WELL DRILLING																						
PHASE 4 - WELLFIELD FACILITY ENGINEERING																						
PHASE 5 - WELLFIELD FACILITY CONSTRUCTION																						

Table 2 - PGG Cost Estimate for Phase 1 Groundwater Supply Development Studies
City and Borough of Sitka Alaska
JM1204
April 3, 2012

Task #		Subtask Description	Admin	Staff/GIS	Permit Specialist	Associate	Principal	PGG Staff Costs	Direct Costs (includes 10% markup)		Subcontr. Costs (10% markup)	Total Costs
			$ 60	$ 110	$ 120	$ 130	$ 150					
PHASE 1 - EXPLORATION												
1-1	Plan and Conduct Geophysical Investigations											$ 82,720
	a	Compile background information and maps		6		10	10	$ 3,460		$ -		
	b	Indentify geophysical alignments		2		2	2	$ 780		$ -		
	c	Geophysical field investigations					24	$ 3,600	travel expenses	$ 2,000	$ 71,720	
	d	Incoporate geophysical interpretive profiles into hydrogeologic profiles				2	2	$ 560		$ -		
	e	Communicate results to CBS					4	$ 600				
1-2	Water-Right Permitting											$ 4,240
	a	Review CBS water rights portfolio			6		2	$ 1,020		$ -		
	b	Prepare water right applications		2	8		2	$ 1,480		$ -		
	c	Provide assistance with processing of applications			12		2	$ 1,740		$ -		
1-3	Select Test Drilling Sites											$ 2,680
	a	Identify exploratory/test well locations				8	2	$ 1,340		$ -		
	b	Prepare well designs				8	2	$ 1,340		$ -		
1-4	Select Drilling Contractor											$ 5,120
	a	Prepare initial bid package and obtain/review bids				2	12	$ 2,060		$ -		
	b	Select contractor based on costs and availability					2	$ 300		$ -		
	c	Refine bids based on final test well program design				4	4	$ 1,120		$ -		
	d	Plan logistics and schedule				8	4	$ 1,640		$ -		
1-5	Prepare Phase 1 Summary Report and Phase 2 Scope			12	2	40	10	$ 8,260		$ -		$ 8,260
1-6	Project Management					10	20	$ 4,300	phone, repro.	$ 50		$ 4,350
	Totals		0	22	28	94	104	$ 33,600		$ 2,050	$ 71,720	$ 107,370

Figure 1
Proposed Geophysical Alignments
for the Indian River Study Area

PgG

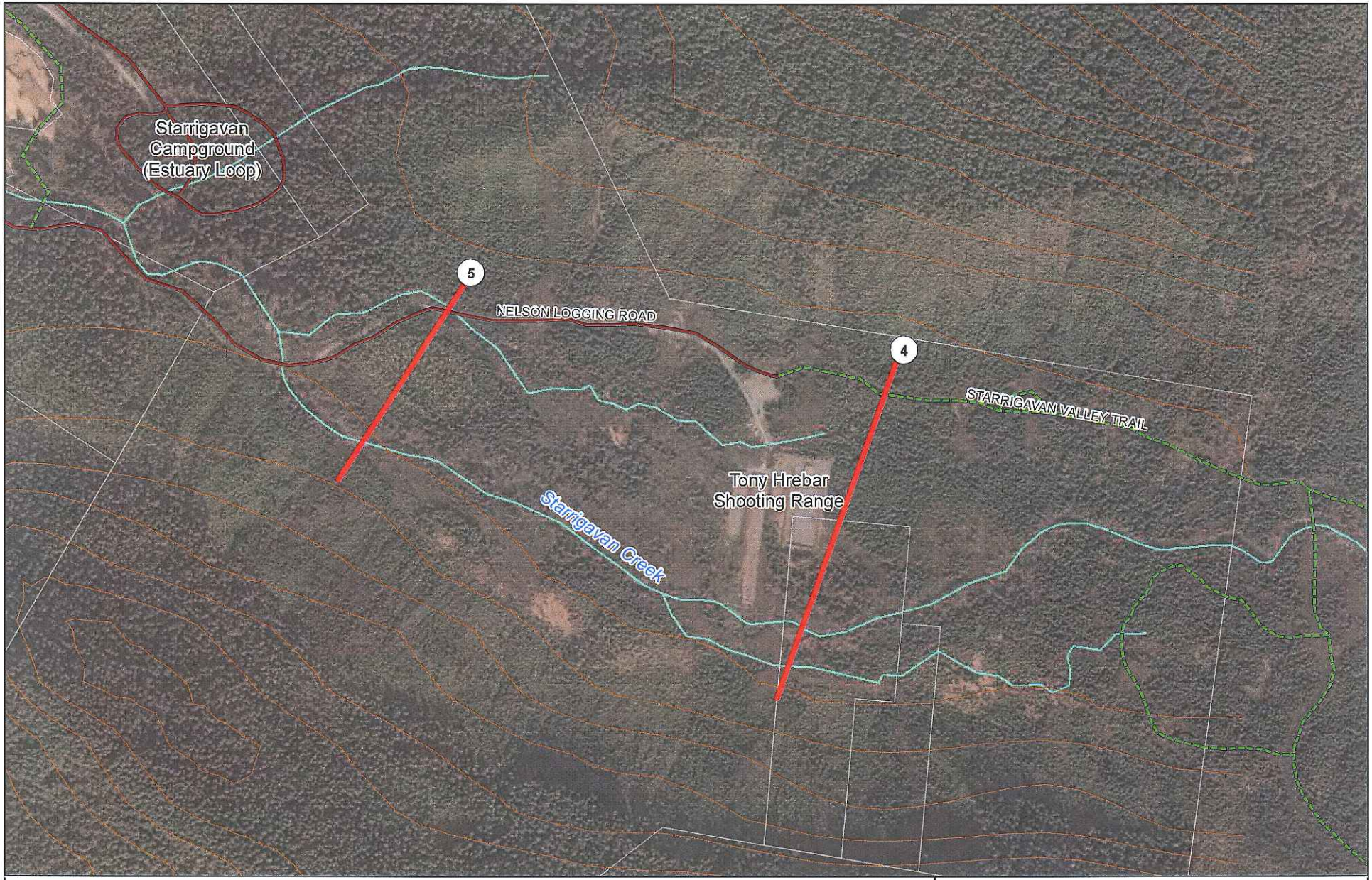

Figure 2
Proposed Geophysical Alignments
for the Starrigavan Creek Study Area

PgG

2012 PACIFIC GROUNDWATER GROUP TERMS AND CONDITIONS

SCHEDULE OF CHARGES. The schedule establishing fees for Pacific Groundwater Group's services is presented below. A new schedule is issued at the beginning of each year or when otherwise dictated by inflationary changes. Unless other arrangements have been made, charges for all work, including continuing projects initiated in the prior year, will be based on the latest SCHEDULE OF CHARGES in the latest PACIFIC GROUNDWATER GROUP TERMS and CONDITIONS.

Principal Technical Services	**$175/hr.**	**Travel & Sustenance**	**Cost plus 10%**
Senior Technical Services	**$90 to $125/hr**	**Subcontract and Direct Expense**	**Cost plus 10%**
Associate Technical Services	**$130/hr.**	**Long Distance and Cellular Phone Expenses**	**Cost plus 10%**
Staff Technical Services	**$85 to $95/hr.**	**Xerox & Oversize Copies**	**$0.15/copy & $1./sq. ft**
Technical Support Services	**$55/hr.**	**Automobile Mileage**	**Federal mileage + $0.05**
Legal Support (Preparation, Deposition, Testimony, Travel)	**$200/hr.**	**Truck Mileage**	**Federal mileage + $0.10**

PAYMENT, INTEREST, COLLECTION. Invoices will be submitted once per month for service expenses rendered during the prior month. Payment will be due within thirty (30) days of the invoice date. Interest will be added to accounts in arrears at the rate of one and one-half percent (1 - 1 1/2%) of the average for each month of delinquency not to exceed the maximum annual percentage rate allowed by law. All expenses incurred for liening or collecting any delinquent amount, including but not limited to reasonable attorney fees, witness fees, reasonable charges at current billing rates for the time devoted by the Pacific Groundwater Group's personnel, document duplication, organization and storage costs, taxable court costs, travel and subsistence, shall be paid to the Pacific Groundwater Group in addition to the delinquent amount. If at any time, present or future, the State, County, City or Municipality assesses a sales, use, or ad valorem tax upon Pacific Groundwater Group for any of the services, supplies, testing or other work performed by Pacific Groundwater Group and/or its subcontractors under this contract, the client agrees to pay such taxes in addition to, and hold Pacific Groundwater Group harmless from such, or should Pacific Groundwater Group elect to pay such taxes directly, the client agrees to reimburse and indemnify Pacific Groundwater Group in full.

TERMINATION. In the event the client requests termination of the work prior to completion, Pacific Groundwater Group will be paid for all work performed up to the notice of termination and for all expenses incurred or committed to that cannot be canceled. Pacific Groundwater Group also has the right to complete, at the client's expense, the analysis and records necessary to so order the work as to protect our professional reputation. A termination charge may also be made to cover the preparation and administrative costs related to the work. Charges will include all reasonable expenses incurred, and time for Pacific Groundwater Group's personnel, charged at the current rates.

CLIENT FURNISHED INFORMATION. The client is responsible to provide, by map or drawing, a description of the property, its location and the location of any buried structures or utilities. Pacific Groundwater Group will not be held liable for damage or injury to subterranean structures (pipes, tanks, telephone cables, etc.), nor to injury to persons arising from damage to subterranean structures, which are not called to our attention and correctly shown on the plans furnished to Pacific Groundwater Group in connection with the work performed by Pacific Groundwater Group. The client agrees to indemnify and hold harmless Pacific Groundwater Group for any and all incorrect or omitted location information to the extent and terms provided in the paragraph entitled "INDEMNIFICATION."

RIGHT OF ENTRY. Unless otherwise agreed, Pacific Groundwater Group will be furnished right-of-entry on the land to make planned borings, surveys and other explorations. Pacific Groundwater Group will take reasonable precautions to minimize damage from use of equipment, but have not included in our fee the cost of restoration of damage which may result from work as outlined in this contract. If Pacific Groundwater Group is required to restore the property to its former condition, the cost of such restoration will be estimated. The additional sum will be agreed upon in writing between Pacific Groundwater Group and the client, and added to the original fee.

SAMPLE RETENTION. Due to the expense of storage costs and limited storage life of samples, Pacific Groundwater Group will discard samples sixty (60) days after submission of the report unless arrangements are made for repackaging and storage fees. Alternatively, at the client's request, the samples will be delivered to the client at the client's expense. All samples containing hazardous materials will be returned to the client, at the client's expense , subsequent to use.

OWNERSHIP OF DOCUMENTS. Any documentary report or tangible item developed and furnished under this agreement is intended solely for the purpose of communicating and transferring tangible information relating to professional services. All designs, drawings, specifications, notes, data samples, materials, report reproducibles, and other works developed by Pacific Groundwater Group, are instruments of service and, as such, remain the property of Pacific Groundwater Group. The client agrees to hold harmless and indemnify Pacific Groundwater Group against all claims, demands, losses, penalties, or damages, including reasonable attorney's fees, arising use of these documents on extensions of this project or any other project without the written permission of Pacific Groundwater Group.

INSURANCE. Pacific Groundwater Group maintains Worker's Compensation for its employees as required by State law. Pacific Groundwater Group is protected by Public Liability Insurance to a maximum of $1,000,000 combined single limits, for bodily injury and property damage liability, and will furnish certificates thereof upon request. Within the limits of said insurance, Pacific Groundwater Group agrees to hold the client harmless from and against loss, damage, injury or liability arising directly from negligent acts committed by Pacific Groundwater Group, its employees, agents, subcontractors and subcontractors' employees and agents.

INDEMNIFICATION. To the fullest extent permitted by law, the client agrees to defend, indemnify and hold Pacific Groundwater Group, including but not limited to Pacific Groundwater Group's agents, employees, subcontractors and subcontractors' employees, agents and subcontractors, harmless from and against any and all claims, associated defense costs (including reasonable attorney's fees) damages and other liabilities arising out of or in any way related to Pacific Groundwater Group's work on the project. The client shall indemnify Pacific Groundwater Group against liability for damages caused by or resulting from the concurrent negligence of (a) the client, its agents, employees, subcontractors and subcontractors' employees, agents and subcontractors, and (b) Pacific Groundwater Group, and its agents, employees, subcontractors and subcontractors' employees, agents only to the extent of the client's negligence or the negligence of the clients' agents, employees, subcontractors and subcontractors' employees, agents and subcontractors.

LIMITATION OF LIABILITY. With the exception of claims covered by Pacific Groundwater Group's insurance, as provided in the paragraph entitled "INSURANCE" above, and notwithstanding any other term or condition hereof to the contrary, Pacific Groundwater Group's liability under this contract shall, under no circumstances exceed $50,000 or the total of the fees paid by the Client to Pacific Groundwater Group under the attached scope of work and contract, whichever is greater.

STANDARD OF CARE. Pacific Groundwater Group agrees to provide the client, for its sole benefit and exclusive use, the consulting services set forth in Pacific Groundwater Group's attached proposal. Pacific Groundwater Group's services shall be performed in accordance with generally accepted practices in the same or similar localities, related to the nature of the work accomplished, at the time the services are performed.

HAZARDOUS SUBSTANCES AND CONDITIONS. The client recognizes that Pacific Groundwater Group's services do not include generating, storing, transporting, or disposing of substances considered to be hazardous and requiring permits under Federal, State or local environmental laws. The client warrants that if it knows or suspects that hazardous substances may exist on the property, the client has so informed Pacific Groundwater Group.

UNFORESEEN OCCURRENCES. If any unforeseen conditions or occurrences, including but not limited to hazardous substances or pollutants, are encountered which, in Pacific Groundwater Group's sole judgment, significantly affect the recommended scope of work, Pacific Groundwater Group will promptly notify the client. After such notification, Pacific Groundwater Group will complete its original scope of work, if appropriate, or agree with the client to modify the agreement, or to terminate the work pursuant to the termination clause listed above.

SUBSURFACE RISKS AND SITE DAMAGE. The client recognizes that special risks occur and "guarantees" cannot be expected whenever professional consulting services are applied in evaluating subsurface conditions. Pacific Groundwater Group cannot eliminate these risks altogether, but can apply professional techniques to reduce the risks to a level considered tolerable and the client agrees to accept that level of risk. The client recognizes that the use of exploration and test equipment may unavoidably damage or alter the property surface or subsurface and the client agrees to assume responsibility for such unavoidable damages or alterations. Further, the client assumes responsibility for personal or property damage due to interference with subterranean structures, including but not limited to subsurface pipes, tanks and utility lines, that are not called to Pacific Groundwater Group's attention in writing or correctly as shown on plans provided by the client.

INTERPRETATIONS AND TIME BAR TO LEGAL ACTION. Interpretations and enforcement of this agreement shall be governed by the laws of the State of Washington. All legal actions by either party to this contract against the other, related to this agreement or any addendum to it, shall be barred after two years have passed from the time the claimant knew or should have known of its claim, and under no circumstances shall be initiated after four years have passed from the date by which Pacific Groundwater Group completes its services.

SEVERABILITY AND SURVIVAL. Any element of this agreement later held to violate a law shall be deemed void and all remaining provisions shall continue in force. However the client and Pacific Groundwater Group will, in good faith, attempt to replace any invalid or unenforceable provision with another provision that is valid and enforceable, and which comes as close as possible to expressing the intent of the original provision. All terms and conditions of this agreement allocating liability between the client and Pacific Groundwater Group shall survive the completion of the services hereunder and the termination of this agreement.

PRECEDENCE. These terms and conditions shall take precedence over any inconsistent or contradictory provisions contained in any proposal, contract, purchase order, requisition, notice to proceed, or like document, regarding Pacific Groundwater Group's services

rev: 1/2001

Northwest
Geophysical
Associates, Inc.
A Zonge International Company
Parkside Business Center, Bldg. 1-B
8366 SW Nimbus Ave, Beaverton, OR 97008
Phone: 503-992-6723 FAX: 503-746-7094
www.nga.com

Zonge
Trusted Geophysics

April 3, 2012
Ref: ZO-12-021

Dan Matlock
Pacific Groundwater Group
2377 Eastlake Ave E, Suite 200
Seattle, WA 98102

Re: ***Revised Proposal for***
Geophysical Investigation
Groundwater Resource Development Project
Sitka, Alaska

Dear Mr. Matlock,

Zonge International, Inc. (Zonge) offers this proposal in support your groundwater resource development project for the City and Borough of Sitka, Alaska (CBS). Zonge proposes using electrical resistivity imaging (ERI) and seismic refraction in two drainage basins outside Sitka, the Indian River drainage and the Starrigavan Creek drainage. These geophysical techniques will determine depth to bedrock and characterize the alluvial sediments within the valleys.

For the Sitka groundwater investigation our primary technique will be electrical resistivity imaging as it generally provides more information about the character of the sediments overlying bedrock. The seismic refraction can provide better resolution of the bedrock surface and forms a good compliment to the ERI data when interpreting the alluvial stratigraphy.

This revision to our proposal of March 12, 2012, includes a local Sitka firm for line clearing/brushing and assistance in the field operations. Zonge will hire a local contractor to provide line clearing services. A Zonge geophysicist will be on site during the clearing operations to lay out the lines and oversee the brushing effort. In this revision we have also removed the three day option in our March 9 proposal as we do not feel it will provide adequate coverage to guide further exploration.

EARTH RESISTIVITY IMAGING

Earth Resistivity Imaging (ERI) provides a 2-dimensional cross section of the electrical resistivity of the earth, sometimes called a geoelectric section. Alluvial units with differing electrical properties (e.g., sand and gravel versus silt and clay) can be readily mapped using this technique. Bedrock should be evident as a resistive unit underlying the more conductive sediments. Additional information on the electrical resistivity imaging technique is included in the attached NGA flyer.

Zonge proposes to perform an ERI survey using a dipole-dipole configuration to locate the prospective units. Zonge will use an Iris Syscal system from Iris Instruments or a comparable system to complete the ERI survey. ERI data will be interpreted using the *EarthImager* 2D modeling software to create a 2D geoelectric cross section along each profile.

SEISMIC REFRACTION SURVEY

Seismic refraction is a commonly used geophysical method to map depth to bedrock when bedrock is less than 100 feet depth. It relies on the strong seismic velocity contrast between the overlying sediments and the higher velocity bedrock. It provides limited information about the overlying sediments, but generally assumes they are uniform. Additional information on the seismic refraction technique is included in the attached NGA flyer.

We anticipate using a 24 channel seismic system. Optimal line length with a 10 foot geophone spacing is 230 feet. For longer lines, geophone spacing may be increased, or two spreads will be run to cover the distance. For a seismic energy source we will utilize a 30 pound slide hammer. and/or seismic shot gun shells with a Betsy Gun. NGA will obtain relative elevations for the geophones using a transit level and staff. We will acquire differential GPS positions for the endpoints, or reference points on each line.

REPORTING

NGA will provide a report presenting our interpreted profiled for both ERI and refraction. Together with PGG we will attach a hydrogeologic interpretation to those profiles. That interpretation will be revisited and revised as necessary when borehole information becomes available. The report will also include a description the geophysical techniques and procedures and a site plan showing geophysical line locations.

COST PROPOSAL

Costs are provided below on a per field day basis for data acquisition and the data analysis, hence they can be scaled up of down by adding or reducing the field effort.

The current seven day program provides flexibility having both ERI and seismic refraction equipment in Sitka for the duration of the field effort. The field geophysicist, together with PGG personnel can monitor data quality and effectiveness of each technique and adjust the field program accordingly.

We have budgeted for a three person crew including one local hire. We will also hire a brushing contractor and provide one geophysicist to direct and assist in the brushing effort.

We estimate the cost of a seven day geophysical survey at $ 65,200. The cost breaks down as follows:

Mobilization/demobilization		$ 9,800
Line Layout and Clearing Costs		$ 13,000
Daily Field Costs:		
Field Costs	$ 4,200	
Data Processing Costs	1,600	
Total Costs per Field Day	$ 5,800	
Subtotal for 7 field days	x 7	40,600
Report		1,800
Total Project Costs:		$ 65,200

Field Productivity

Electrical resistivity imaging (ERI) spreads, with a 96 channel system and a 10 foot electrode spacing, are 950 foot in length. When combining two or more spreads into a line there should probably be 150 feet of overlap to get full coverage, i.e. 1750 feet. We anticipate acquiring data on two spreads per day, or 1750 feet per day, with the brushing and variable terrain.

For seismic refraction we will plan on 24-channel spreads with 10 foot geophone spacing, i.e. 230 feet per spread. We can expect to acquire data on 3-4 spreads per day, i.e. 700 to 900 feet per day.

Scheduling

We request 2 to 4 weeks between CBS's notice to proceed and the start of field work. Preliminary interpretations will be available to PGG and CBS within 2 to 4 weeks following completion of field work. A draft report will follow within four to seven weeks

after completion of field work. The final report may await the results of PGG's test-drilling program.

ASSUMPTIONS

In conducting the described geophysical investigation, Zonge makes the following assumptions:

- Earth resistivity measurements require an area free on conductive utilities (above ground and underground), fences, and other linear conductive objects. The area to the sides on the line of the profile should be clear for a distance of 1.5 times the desired depth-of-exploration.
- NGA assumes that CBS will arrange for site access for the duration of the site investigation.

We look forward to working with you and Pacific Groundwater Group and the City and Borough of Sitka on this project. Please call if you have questions or need additional information.

Sincerely,

Zonge International, Inc.

Rowland B. French, Ph.D., R.G.
Senior Geophysicist

Attachments:

File: Zonge Sitka Geophysics psl03.doc
Zonge Reference: ZO-12-021

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Electrical Resistivity Imaging

ELECTRICAL RESISTIVITY IMAGING

Applications:

- Aquifer & Aquitard Mapping
- Depth-to-Bedrock Determination
- Alluvial Paleo-Channel Mapping
- Salt Water Intrusion Delineation
- Fracture Zone Delineation
- Geologic Mapping

Benefits:

- Non-invasive
- Continuous Coverage
- 2D Profile Lines, or 3D Aerial Coverage
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INTRODUCTION

Electrical resistivity techniques measure earth resistivity by driving a direct current (D.C.) signal into the ground and measuring the resulting potentials (voltages) created in the earth. From these measurements, we can image the electrical structure of the earth, the ***geoelectric section***, and infer geologic structures that control groundwater flow.

Electrical resistivity of soils and rocks correlates with other soil/rock properties which are of interest to the geologist, hydrogeologist, geotechnical engineer and/or quarry operator. Several geologic parameters which affect earth resistivity (and its reciprocal conductivity) are listed below:

Electrical Resistivity correlates with:

- clay content,
- groundwater conductivity,
- soil or formation porosity,
- sediment thickness over bedrock, and
- degree of water saturation.

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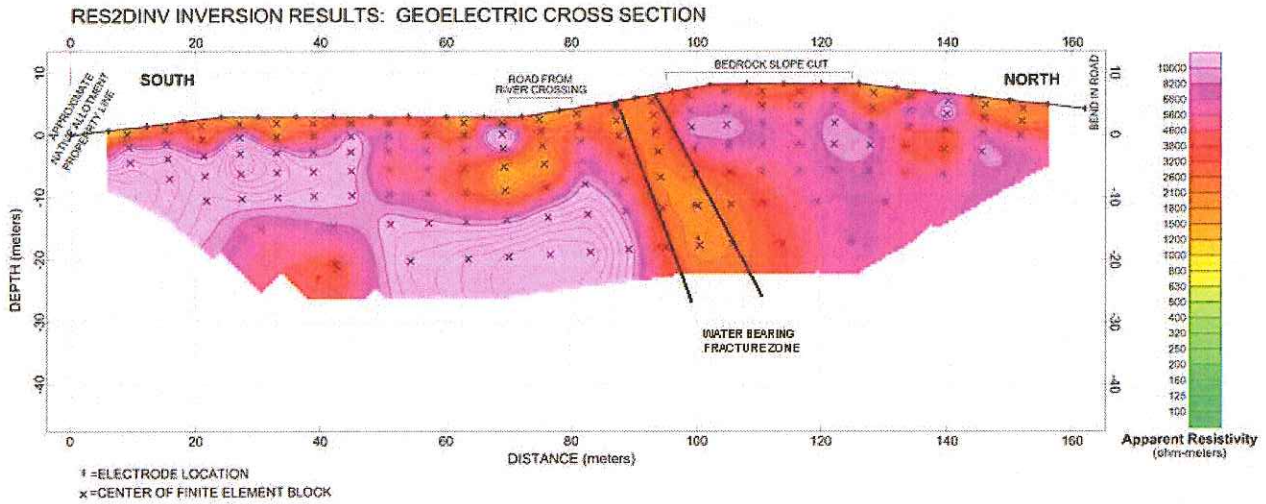

FIGURE 1 -GEOELECTRIC MODEL FROM ELECTRICAL RESISTIVITY SURVEY

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www.nga.com · info@nga.com

Electrical Resistivity Imaging

THEORY OF OPERATION

Figure 2 is a schematic diagram showing the basic principle of electrical resistivity measurements. Two short metallic stakes (electrodes) are driven about 1 foot into the earth to apply the current to the ground. Two additional electrodes are used to measure the earth voltage (or electrical potential) generated by the current.

Depth of investigation is a function of the electrode spacing. The greater the spacing between the outer current electrodes, the deeper the electrical currents will flow in the earth, hence the greater the depth of exploration. The depth of investigation is generally 40% to 20% the outer electrode spacing, depending on the earth-resistivity structure.

State of the art equipment, as shown in Figure 3, uses multi-electrode cables, often extending several hundred feet. The control unit then automatically switches through pairs of current and potential electrodes to obtain a complete 2-D dataset.

FIGURE 3 - MULTI-ELECTRODE RESISTIVITY SURVEY

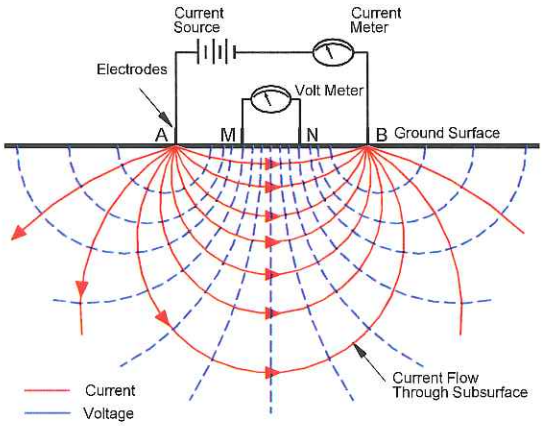

FIGURE 2 - SCHEMATIC ILLUSTRATING BASIC CONCEPT OF ELECTRICAL RESISTIVITY MEASUREMENT

DATA ANALYSIS & INTERPRETATION

ERI resistivity data is generally interpreted using the "modeling" process: Hypothetical models of the earth and its resistivity structure (geoelectric sections) are generated. The earth model is then adjusted to create a response which most accurately fits the observed data while observing geologic and borehole constraints. Figure 1 is an example of the modeling results.

TERMINOLOGY

In geophysical and geotechnical literature, the terms "electrical resistivity," "D.C. resistivity," are used synonymously. The term "vertical electric sounding" (VES) is also used referring to soundings using the D.C resistivity method. Electrical Resistivity Imaging (ERI) or Earth Resistivity Tomography (ERT) refer to the method of acquiring and processing resistivity data to obtain a two or three dimensional model of the geoelectric section, as described in this document.

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Seismic Refraction

SEISMIC REFRACTION SURVEYS

Applications:

- Depth-to-Bedrock
- Fault Mapping
- Competence of Bedrock -
- Rippability
- Groundwater Investigations

Benefits:

- Non-invasive
- Continuous Coverage
- Reduce Permitting Effort
- Cost Effective
- Provides Valuable Information
- Reduce/Target Drilling

INTRODUCTION

Seismic refraction is a commonly used geophysical technique to determine depth-to bedrock, competence of bedrock, depth to the water table, or depth to other seismic velocity boundaries.

PHYSICAL PRINCIPLES

The seismic refraction technique is illustrated in the photos and schematic drawing, Figure 2. An impulsive source creates a seismic wave (sound wave) which travels through the earth. When the wave-front reaches a layer of higher velocity (e.g. bedrock) a portion of the energy is refracted, or bent, and travels along the refractor as a "head wave" at the velocity of the refractor (bedrock). Energy from the propagating head wave leaves the refractor at the "critical angle" of refraction and returns to the surface, where its arrival is detected by a series of geophones and recorded on a seismograph. The angle of refraction depends on the ratio of velocities in the two materials (Snell's Law). Travel times for the impulsive wave-front to reach each geophone are measured from the seismograph records. From those travel times and distances, seismic velocities in each layer, and depths to each layer can be calculated and physical properties inferred.

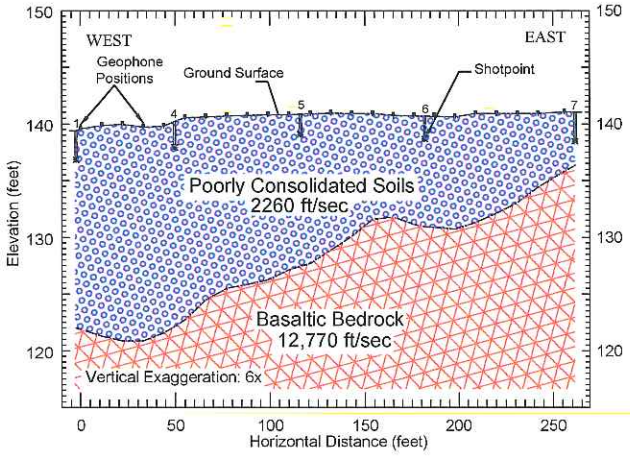

FIGURE 1 - TWO LAYER SEISMIC INTERPRETATION

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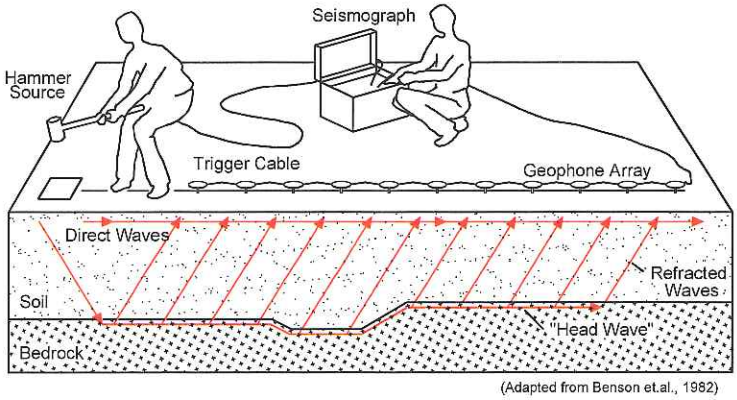

FIGURE 2 - SCHEMATIC OF SEISMIC REFRACTION METHOD

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Seismic Refraction

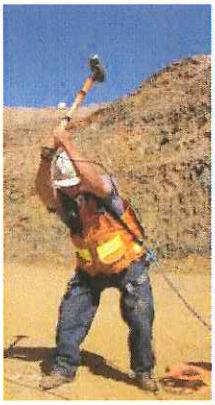

PHOTO 1
SLEDGEHAMMER

PHOTO 2
SEISMIC SPREAD

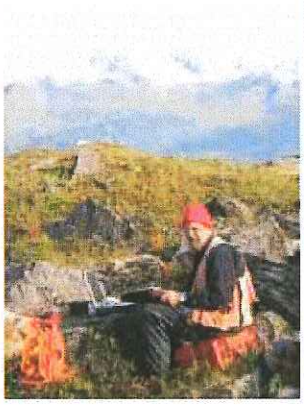

PHOTO 3
SEISMIC OBSERVER

PHOTO 4 - PROPELLED
ENERGY GENERATOR (PEG)

APPLICATIONS

The product or "deliverable" from a seismic refraction survey is generally a profile, or cross section, along the seismic line showing depth-to-bedrock (or other primary refractor) at each geophone, and seismic velocities in the bedrock and the "overburden." Often layers with intermediate velocities (corresponding to layers or units with varying consolidation or lithology) can be identified and resolved.

Seismic velocities relate to the "soundness" or competence of rock, and to the degree of consolidation, cementation, and/or saturation in soils. The Caterpillar Tractor Co. has developed a series of tables which empirically relate seismic velocities to the "rippability" of bedrock with their equipment (such as a D8 or D9 with one or several ripper teeth).

In geotechnical engineering, depth-to-bedrock and rippability surveys are commonly used for design and cost estimates for road cuts, pipelines, and other civil engineering projects. Groundwater applications of seismic refraction include mapping bedrock channels, identifying faults and fracture zones, and delineation of geologic boundaries to constrain hydrogeologic models.

FIELD PROCEDURES

Each seismic refraction "spread" consists of a series of 12 or 24 geophones placed along the line at a set distance or "geophone interval." The geophone interval is generally 10 to 50 feet depending on the desired resolution and the desired depth of exploration. The length of the seismic "spread" must be 3 to 5 times the depth of exploration.

A series of 5 to 7 "shots" are initiated for each spread, one at each end, one or more beyond the ends ("off end"), and one or more along the spread. These additional "shotpoints" provide better resolution of the subsurface. Several spreads may be put together to form a longer refraction profile line.

Several options are available for the impulsive seismic source. A sledgehammer (Photo 1) as an energy source may be effective if the bedrock is not deeper than 20 or 25 feet, and if the overburden is sufficiently consolidated. A higher energy source, such as a propelled energy generator (PEG) (Photo 4), or a two-component explosive, may be required if the overburden is loose and poorly consolidated, or if the bedrock interface is significantly deeper.

FILE: Refraction Aug 11.pub, REVISION: 14-SEPT-2011

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Electrical Resistivity Imaging

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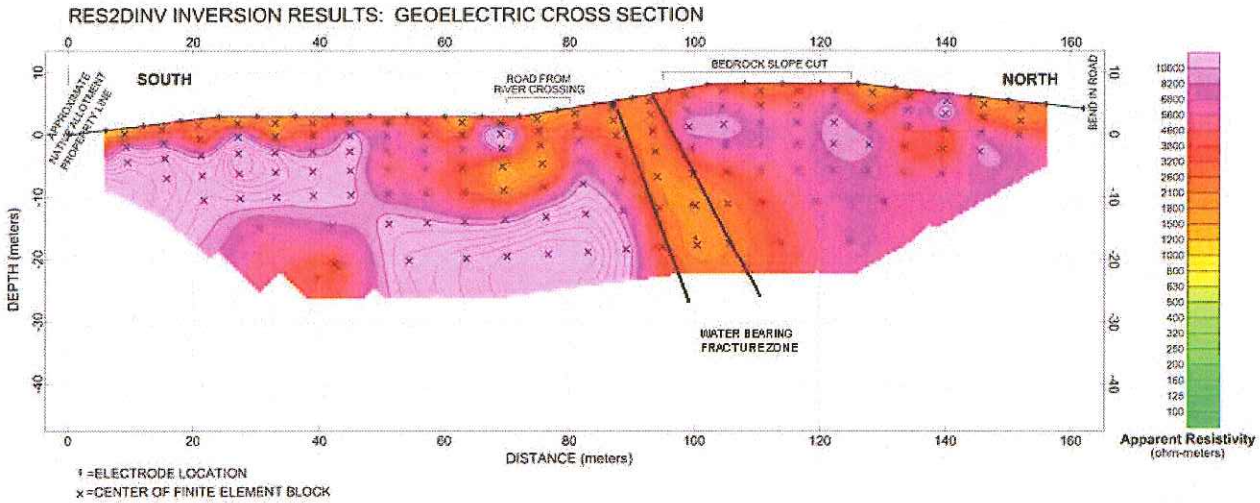

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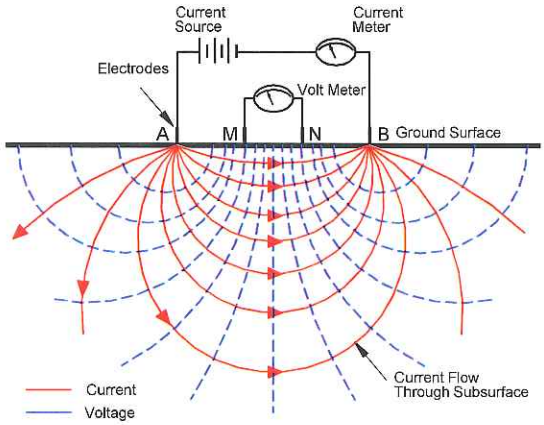

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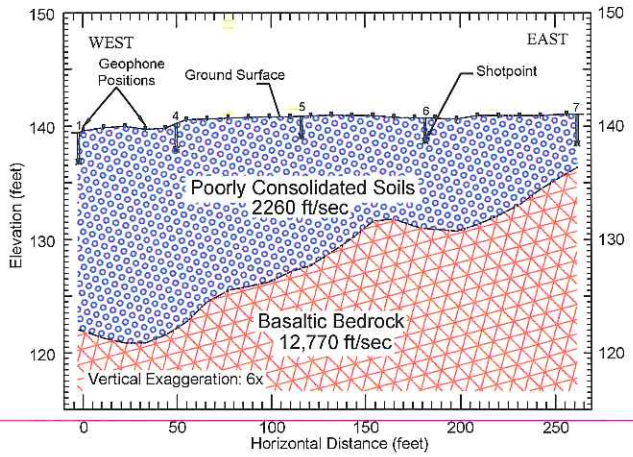

FIGURE 1 - TWO LAYER SEISMIC INTERPRETATION

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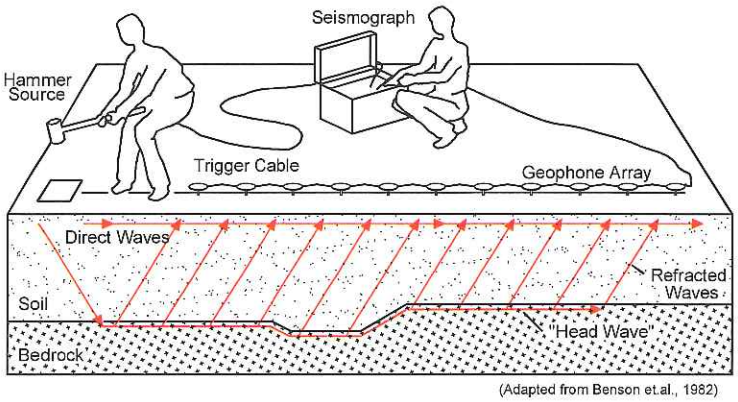

(Adapted from Benson et.al., 1982)

FIGURE 2 - SCHEMATIC OF SEISMIC REFRACTION METHOD

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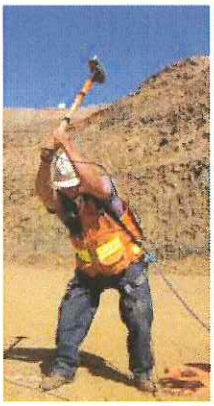
Seismic Refraction



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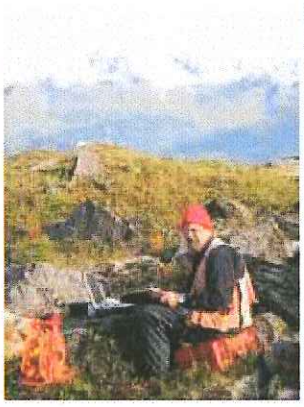

PHOTO 3
SEISMIC OBSERVER

PHOTO 4 - PROPELLED
ENERGY GENERATOR (PEG)

APPLICATIONS

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In geotechnical engineering, depth-to-bedrock and rippability surveys are commonly used for design and cost estimates for road cuts, pipelines, and other civil engineering projects. Groundwater applications of seismic refraction include mapping bedrock channels, identifying faults and fracture zones, and delineation of geologic boundaries to constrain hydrogeologic models.

FIELD PROCEDURES

Each seismic refraction "spread" consists of a series of 12 or 24 geophones placed along the line at a set distance or "geophone interval." The geophone interval is generally 10 to 50 feet depending on the desired resolution and the desired depth of exploration. The length of the seismic "spread" must be 3 to 5 times the depth of exploration.

A series of 5 to 7 "shots" are initiated for each spread, one at each end, one or more beyond the ends ("off end"), and one or more along the spread. These additional "shotpoints" provide better resolution of the subsurface. Several spreads may be put together to form a longer refraction profile line.

Several options are available for the impulsive seismic source. A sledgehammer (Photo 1) as an energy source may be effective if the bedrock is not deeper than 20 or 25 feet, and if the overburden is sufficiently consolidated. A higher energy source, such as a propelled energy generator (PEG) (Photo 4), or a two-component explosive, may be required if the overburden is loose and poorly consolidated, or if the bedrock interface is significantly deeper.

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Electrical Resistivity Imaging

ELECTRICAL RESISTIVITY IMAGING

Applications:

- Aquifer & Aquitard Mapping
- Depth-to-Bedrock Determination
- Alluvial Paleo-Channel Mapping
- Salt Water Intrusion Delineation
- Fracture Zone Delineation
- Geologic Mapping

Benefits:

- Non-invasive
- Continuous Coverage
- 2D Profile Lines, or 3D Aerial Coverage
- Cost Effective
- Reduce Permitting Effort
- Valuable Exploration Tool

INTRODUCTION

Electrical resistivity techniques measure earth resistivity by driving a direct current (D.C.) signal into the ground and measuring the resulting potentials (voltages) created in the earth. From these measurements, we can image the electrical structure of the earth, the ***geoelectric section***, and infer geologic structures that control groundwater flow.

Electrical resistivity of soils and rocks correlates with other soil/rock properties which are of interest to the geologist, hydrogeologist, geotechnical engineer and/or quarry operator. Several geologic parameters which affect earth resistivity (and its reciprocal conductivity) are listed below:

Electrical Resistivity correlates with:

- clay content,
- groundwater conductivity,
- soil or formation porosity,
- sediment thickness over bedrock, and
- degree of water saturation.

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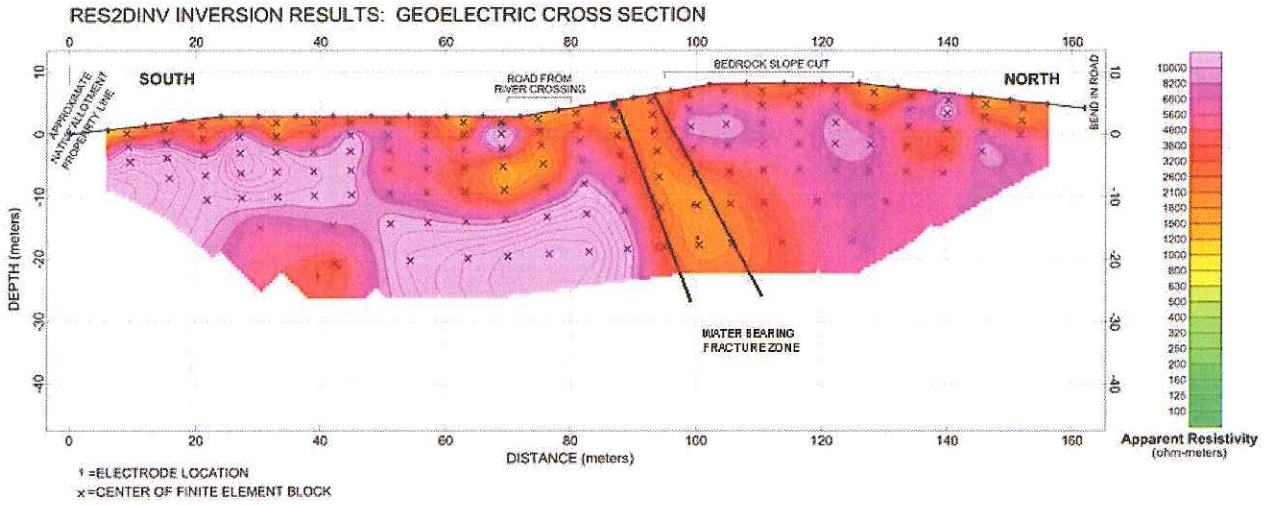

FIGURE 1 -GEOELECTRIC MODEL FROM ELECTRICAL RESISTIVITY SURVEY

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8366 SW Nimbus Avenue, Beaverton, OR 97008
(503) 992-6723 Fax: (503) 746-7094
www.nga.com · info@nga.com

Electrical Resistivity Imaging

THEORY OF OPERATION

Figure 2 is a schematic diagram showing the basic principle of electrical resistivity measurements. Two short metallic stakes (electrodes) are driven about 1 foot into the earth to apply the current to the ground. Two additional electrodes are used to measure the earth voltage (or electrical potential) generated by the current.

Depth of investigation is a function of the electrode spacing. The greater the spacing between the outer current electrodes, the deeper the electrical currents will flow in the earth, hence the greater the depth of exploration. The depth of investigation is generally 40% to 20% the outer electrode spacing, depending on the earth-resistivity structure.

State of the art equipment, as shown in Figure 3, uses multi-electrode cables, often extending several hundred feet. The control unit then automatically switches through pairs of current and potential electrodes to obtain a complete 2-D dataset.

FIGURE 3 - MULTI-ELECTRODE RESISTIVITY SURVEY

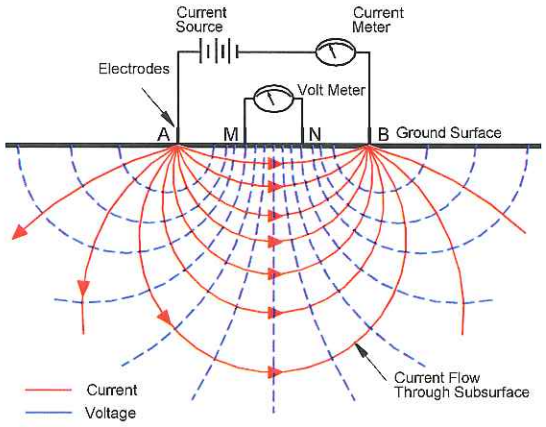

FIGURE 2 - SCHEMATIC ILLUSTRATING BASIC CONCEPT OF ELECTRICAL RESISTIVITY MEASUREMENT

DATA ANALYSIS & INTERPRETATION

ERI resistivity data is generally interpreted using the "modeling" process: Hypothetical models of the earth and its resistivity structure (geoelectric sections) are generated. The earth model is then adjusted to create a response which most accurately fits the observed data while observing geologic and borehole constraints. Figure 1 is an example of the modeling results.

TERMINOLOGY

In geophysical and geotechnical literature, the terms "electrical resistivity," "D.C. resistivity," are used synonymously. The term "vertical electric sounding" (VES) is also used referring to soundings using the D.C resistivity method. Electrical Resistivity Imaging (ERI) or Earth Resistivity Tomography (ERT) refer to the method of acquiring and processing resistivity data to obtain a two or three dimensional model of the geoelectric section, as described in this document.

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Seismic Refraction

SEISMIC REFRACTION SURVEYS

Applications:

- Depth-to-Bedrock
- Fault Mapping
- Competence of Bedrock -
- Rippability
- Groundwater Investigations

Benefits:

- Non-invasive
- Continuous Coverage
- Reduce Permitting Effort
- Cost Effective
- Provides Valuable Information
- Reduce/Target Drilling

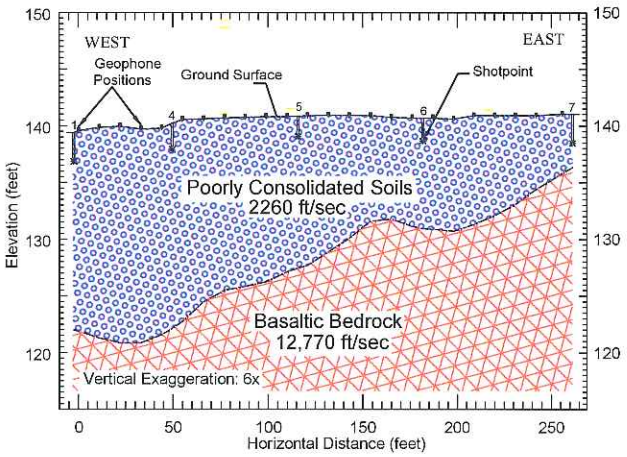

FIGURE 1 - TWO LAYER SEISMIC INTERPRETATION

INTRODUCTION

Seismic refraction is a commonly used geophysical technique to determine depth-to bedrock, competence of bedrock, depth to the water table, or depth to other seismic velocity boundaries.

PHYSICAL PRINCIPLES

The seismic refraction technique is illustrated in the photos and schematic drawing, Figure 2. An impulsive source creates a seismic wave (sound wave) which travels through the earth. When the wave-front reaches a layer of higher velocity (e.g. bedrock) a portion of the energy is refracted, or bent, and travels along the refractor as a "head wave" at the velocity of the refractor (bedrock). Energy from the propagating head wave leaves the refractor at the "critical angle" of refraction and returns to the surface, where its arrival is detected by a series of geophones and recorded on a seismograph. The angle of refraction depends on the ratio of velocities in the two materials (Snell's Law). Travel times for the impulsive wave-front to reach each geophone are measured from the seismograph records. From those travel times and distances, seismic velocities in each layer, and depths to each layer can be calculated and physical properties inferred.

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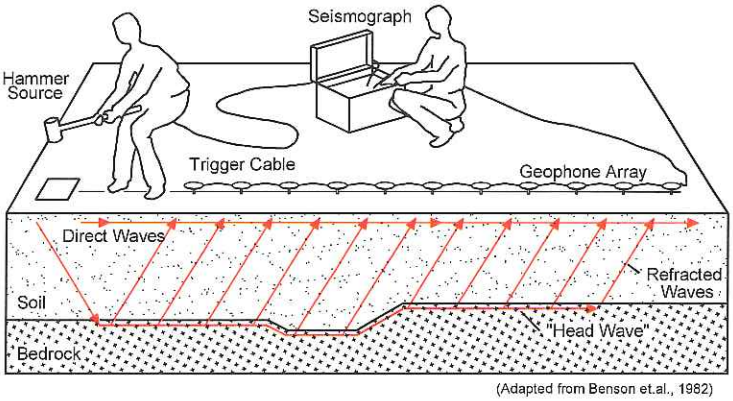

FIGURE 2 - SCHEMATIC OF SEISMIC REFRACTION METHOD

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8366 SW Nimbus Avenue, Beaverton, OR 97008
(503) 992-6723 Fax: (503) 746-7094
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Seismic Refraction

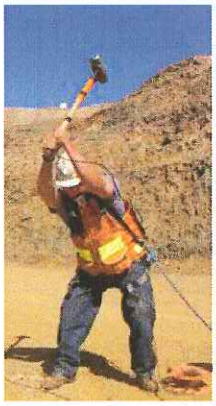

PHOTO 1
SLEDGEHAMMER

PHOTO 2
SEISMIC SPREAD

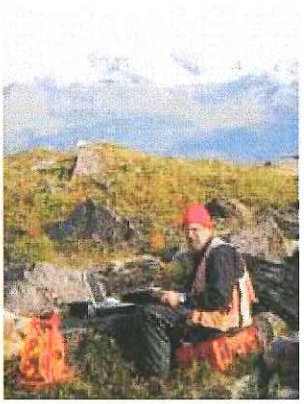

PHOTO 3
SEISMIC OBSERVER

PHOTO 4 - PROPELLED
ENERGY GENERATOR (PEG)

APPLICATIONS

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FILE: Refraction Aug 11.pub, REVISION: 14-SEPT-2011

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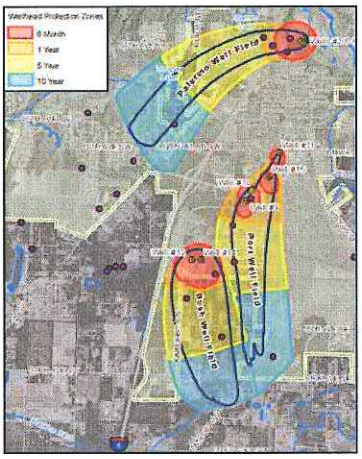
PACIFIC GROUNDWATER GROUP
WATER RESOURCE AND ENVIRONMENTAL CONSULTING

Pacific Groundwater Group (PGG) is a water resource and environmental consulting firm that specializes in groundwater supply development, water-resource management, contaminant assessment, and groundwater remediation. Since 1987 we have assisted a wide variety of clients in solving complex water resource and environmental challenges throughout the Pacific Northwest. While our hydrogeologic and environmental strengths are broad, this Statement of Qualifications focuses on PGG's unique water-resource and water-right services.



PGG offers extensive consulting experience and recognized expertise in groundwater and surface water evaluations that incorporate disciplines ranging from geology, hydraulics and chemistry to climate and soil science. We assist our clients with all aspects of water supply development including feasibility studies, well development, testing, and rehabilitation, and regulatory permitting. We use advanced tools for modeling groundwater flow, surface water/groundwater connections, wellhead capture, and contaminant fate and transport. We also support clients with innovative water management approaches such as Aquifer Storage and Recovery (ASR), recharge management, Geographic Information Systems (GIS) analysis, and database management. Our experience allows us to accurately identify key issues. We work closely with clients to develop highly focused solutions that secure regulatory approval and satisfy client objectives.

WATER RESOURCE

Rapid growth in the Pacific Northwest continues to place critical demands on groundwater systems in rural, urban, coastal, and island areas. PGG provides the hydrogeologic tools and analytical expertise required to ensure the quantity and quality of groundwater resources for the future. We work with state and local governments on basin-scale hydrologic studies and watershed plans that shape future allocation policies. We also assist water purveyors in managing their water-supply sources by developing water system plans and wellhead protection plans.

Through our extensive knowledge of Pacific Northwest hydrogeology, PGG successfully develops groundwater supplies and acquires water rights for municipalities, Public Utility Districts, housing developments, and private industries. PGG also provides planning services that feature basin-scale knowledge and GIS analyses to help regional planning groups make good decisions for the future of their communities.

Our use of groundwater flow and transport models allows us to predict the effects of pumping in an aquifer as well as movement of contaminants. We assist clients with evaluating land use influences on groundwater recharge, designing and testing facilities for infiltration of reclaimed water and stormwater, and performing regional and site-specific feasibility evaluations for ASR. We use GIS to integrate hydrogeologic, geographic and infrastructure data, which is particularly useful for managing, viewing, and analyzing water-resource and water quality information. In addition, our environmental database is an excellent tool for managing large amounts of water quality, water quantity, and other analytical data required by today's regulations.

- Groundwater resource evaluation
- Well development
- Well rehabilitation
- Wellhead protection
- Water system planning
- Water rights acquisition
- Groundwater modeling
- Aquifer storage and recovery (ASR)
- Stormwater & reclaimed water recharge
- Saltwater intrusion studies
- Expert witness services

WATER RIGHT SERVICES

PGG strives constantly to keep abreast of changing water-right policy and legal issues so we can provide prompt and cost-effective guidance to clients on issues that affect their water-right portfolios. Our clients range from large municipalities to individual private land owners.

The specialized staff at PGG has unique expertise, both in acquiring new water rights and in transferring and changing existing water rights. Our successful application-support packages include creative mitigation plans and the use of programs like the State Trust Program. We have used the Trust Program to leverage new water rights, protect and "bank" existing rights, and enhance instream flows.

PGG works closely with the Washington State Department of Ecology to process our client's water-right applications through the Cost Reimbursement program. This program offers applicants an opportunity to expedite the regulatory decision-making process by working with consultant teams. PGG has played a key role in many Cost Reimbursement projects, including the City of North Bend's innovative water-right permit, Seattle Public Utility's pioneering rainwater collection project, and new permits for the City of Ocean Shores, Mason County Water District No. 1, and Chinook Water District. We excel in researching the extent and validity of water rights, and in preparing beneficial use and historical use assessments to meet Ecology's information needs.

- Ecology's Cost Reimbursement Program
- Water Rights Changes and Transfers
- Water Conservancy Boards
- Expert testimony

Commissioners on county Water Conservancy Boards have found PGG to be a valuable asset in evaluating water-right applications for change. Key projects that have benefitted from our participation include Thurston County's transfer of irrigation rights to the Grand Mound water system, the Cities of Olympia, Lacey and Tumwater's transfer of the Olympia Brewery water rights to municipal supply, and support to both the City of Sunnyside and the City of Yelm to develop and permit additional wells. Some of these projects are described in the Experiences Section of this submittal.

CLIENTS

PGG works on behalf of municipal water purveyors, Public Utility Districts, more than 25 cities and in nearly all counties within the State of Washington, as well as for the Washington Departments of Ecology and Health. Some of our clients include:

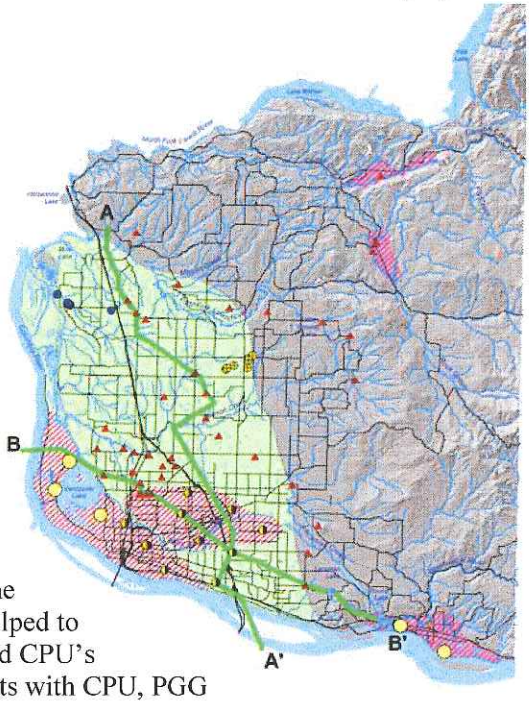
City of Arlington
City of Auburn
City of Battle Ground
City of Bonney Lake
City of Camas
Clallam County
Clallam County PUD No. 1
Clark Public Utilities
City of Federal Way
City of Fife
Foster Creek Conservation District
City of Goldendale
Island County
Jefferson County
Jefferson County PUD No. 1
King County
City of Lacey
Lower Columbia Fish Recovery Board
City of Ocean Shores
City of Olympia
Pierce County
Point Allen Water Association
City of Redmond
City of Renton
San Juan County
City of Seattle
City of Shelton
Skamania County
City of Sunnyside
City of Tacoma
Thurston County
City of Tumwater

EXPERIENCE

Water Supply Planning and Development Services for Clark Public Utilities

Pacific Groundwater Group has provided resource management, water supply planning and development services to Clark Public Utilities (CPU) for the past 16 years. We have worked on a number of projects for CPU, including:

- Groundwater feasibility assessments
- Comprehensive Water System Planning
- Wellhead Protection Planning
- Well and wellfield development
- Well rehabilitation
- Watershed assessment and planning
- Development of computer groundwater flow models
- Water rights permitting assistance
- Development and maintenance of long-term surface water and groundwater monitoring systems
- Groundwater quality investigations
- Database development and management



PGG is current assisting CPU with development of a 38 MGD wellfield in the Vancouver Lake lowland area. The wellfield will be used to meet future water demands over the next 50 years. To date, PGG has designed, installed, and helped to permit more than 20 production wells, which have increased CPU's supply capacity by over 20 MGD. Through its many projects with CPU, PGG has developed an in depth understanding of Clark County's aquifer systems and resource development opportunities. In addition, PGG has compiled extensive databases of water resource information that can be used to assess future issues as they arise.

Water Supply Development for City of Sunnyside

The City of Sunnyside is experiencing significant growth in water demand and retained PGG to develop additional groundwater supply. To provide flexibility for the water system expansion, PGG worked with the Yakima County Water Conservancy Board to complete a water-right transfer from an old City well to the preferred location for a new wellfield. Our work involved hydrogeologic analysis of expected impacts, public meeting presentations, and writing the Report of Examination. PGG provided new insights into the structural geology of the Sunnyside Basin and characterized the sedimentary and basaltic aquifers that underlie the City's service area. We evaluated potential wellfield sites for future development and constructed a well at the preferred site capable of producing 500 gpm of excellent quality water. Currently, PGG is completing installation and testing of another new water supply well for the City.

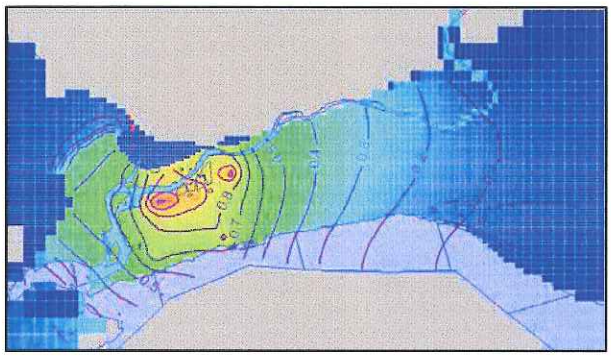
Groundwater Resource Evaluation for City of Tumwater

The City of Tumwater selected PGG to evaluate its existing and potential future groundwater supplies. We assessed the regional hydrogeology to locate additional sources of groundwater for the City, compiling and analyzing hydrogeologic and water rights information. We also identified areas where aquifers were most vulnerable and where conflicts between surface water and groundwater resources were likely, and recommended areas for groundwater exploration. Subsequent drilling and testing confirmed that well yields up to 2,350 gpm could be developed from recommended areas. In addition, we assisted the City in installing production wells and addressing water rights.

Water Supply Development and Water Right Acquisition for the City of Camas

PGG has been assisting the City of Camas with water supply planning and development projects since 1997. Explosive growth in the Camas' service area has required that the City aggressively pursue expansion of their water supply sources. PGG has conducted feasibility studies of several potential water supply areas and installed test wells to evaluate water availability and water quality conditions. These investigations include:

- Grass Valley water supply feasibility study to characterize supply aquifers within the City's western service area.
- Westside test well drilling program to evaluate water supply development potential at five exploration sites.
- Columbia River test well drilling program to assess supply options in both shallow and deep aquifers in the City's southwestern service area.
- Bybee Road test well to assess water supply potential from the deep Sand and Gravel aquifer
- Washougal wellfield water supply evaluation to assess options for securing additional supplies and water rights from the City's current wellfield supply area.



PGG's feasibility, exploratory drilling and testing projects have help to define a set of preferred options for meeting the City's 20 to 50 year growth needs. As part of a recent water right procurement process, PGG developed a groundwater flow model of the City's Lower Washougal wellfield area to be used as a basis for evaluating groundwater availability and hydrologic impacts associated with additional groundwater withdrawals. Based on the model results, PGG was able to identify opportunities to develop new groundwater sources while mitigating impacts to streamflow, which ultimately led to increased overall water-supply availability and habitat benefits on local streams. Additional services provide by PGG included: water right negotiations and procurement, and design and installation of high yield production wells (7 MGD additional capacity).

McAllister Springs Well Field Development for the City of Olympia

McAllister Springs has served as the City of Olympia's principal source of supply since 1949. Studies of the Springs by PGG and others highlighted its susceptibility to land use impacts and its potential for diminished water quality during periods of heavy water demand and drought. In response to these concerns, the City decided to replace this supply source with high-capacity wells, selecting PGG to develop and test them. Our services included:

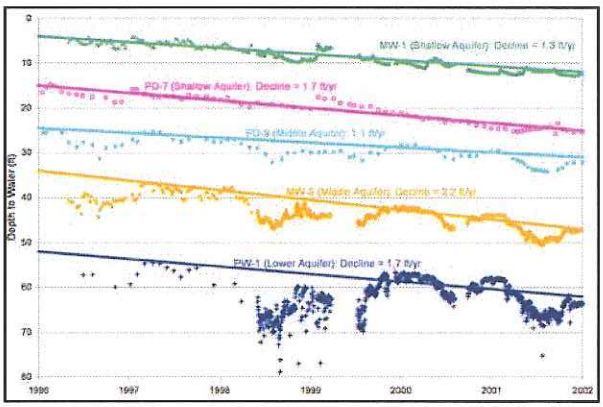
- Selecting an optimum well field location based on yield, water quality, and impact considerations
- Assisting with regulatory issues related to procuring water rights
- Installing and testing high-capacity test and production wells
- Assessing the environmental effects of well field operation, effects that included impacts to nearby water users, surface water bodies, habitat, and aquatic resources
- Developing a comprehensive monitoring network to monitor long-term hydrologic trends

Well Development & Aquifer Analysis for Chambers Creek Properties, Pierce County

PGG provided hydrogeologic services related to development of a 1000-foot deep well at Chambers Creek Properties for Pierce County. PGG's preliminary design and technical drilling specifications helped secure a cost-effective bid from a qualified contractor. Our personal, long-term relationship with local well drillers helped secure three bids that straddled our own cost estimate. In addition, PGG completed a regional scale groundwater model that was used to evaluate potential for salt-water intrusion by developing the deep (Unit G) aquifer. This aquifer, known to exist beneath Chambers Creek Properties, was mapped by PGG to occur beneath most of the southern Puget Sound region, including the Gig Harbor area. We developed a regional conceptual model by drawing multiple hydrogeologic cross-sections based on existing information and personal knowledge of the area.

Water Supply Development and Management for City of Sequim

Pacific Groundwater Group has supported the City of Sequim in groundwater development and management since the early 1990's. PGG managed drilling, design and testing of two new high-capacity production wells at the City's Port Williams wellfield. We evaluated water-level trends at the City's Silberhorn Wellfield, provided recommendations for wellfield optimization, and supported the City for water rights certification with Department of Ecology. We have also assisted the City with hydrologic data collection and analyses, and recently produced a report that summarizes the monitoring data and discusses the complex relationship between groundwater level trends, pumping withdrawals (by the City, other water systems, and domestic wells), and changes in irrigation practices.



Groundwater Supply Development Program for City of Lacey

The northern Thurston County area has grown rapidly in recent years. To help ensure that there is adequate water for the community in the future, the City of Lacey retained PGG to direct a long-term program to develop and manage their water supply. The program has included:

- Identifying and characterizing major supply aquifers
- Installing and testing exploration wells
- Designing, installing, and testing production wells
- Procuring water rights
- Water system and wellhead protection planning
- Well evaluation and rehabilitation
- Water level monitoring

In 1994 PGG installed six exploratory/test wells in the southern portions of Lacey's service area to characterize aquifer occurrence, well productivity, and water quality conditions. Based on the findings of this program, the City proceeded ahead with development of new wellfields at Madrona Park, McAllister Park, and Evergreen Estates.

PGG has assisted the City in the design, testing and permitting of five new supply wells at these sites, which has increased the City's peaking capacity by about 10 million gallons per day. PGG also assisted the City in transferring existing rights from older sources to the Madrona and McAllister Park wellfields in order to support their use. PGG assisted the City with development of their 2003 water system plan and wellhead protection plans that were prepared in 1994 and again in 2002. PGG has provided on-going assistance with testing and evaluation of existing supply wells, and where necessary, corrective actions to

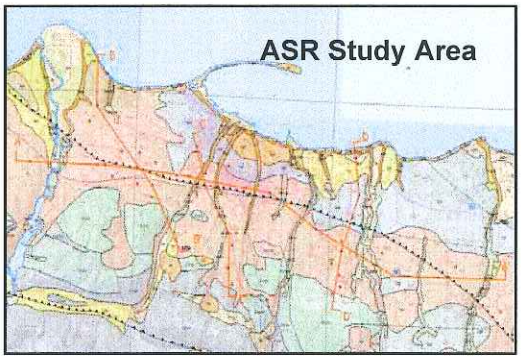
restore lost capacity. PGG developed and continues to maintain a water level monitoring network that provides trends on groundwater levels for the City's East Lacey aquifer system.

Wellhead Protection Plan for City of Tumwater

PGG directed groundwater investigations in support of the City of Tumwater's wellhead protection program. We also assisted the City in developing a Centennial Grant Application to fund the program. We delineated wellhead protection zones around four major City pumping centers and assisted with well installation, monitoring, water quality management, and risk assessment. Monitoring wells were installed to help evaluate threats from specific sources of contamination that include two known petroleum hydrocarbon spills. We used existing wells to monitor pollution that originates from multiple sources, such as nitrates from agriculture and septic influences. A major challenge for the project was coordinating the City, County, and Port of Olympia jurisdictions, all of which control lands within the protection areas.

Aquifer Storage Recovery Studies for Clallam County

PGG evaluated the potential for Aquifer Storage and Recovery (ASR) in the western portion of WRIA 18 in Clallam County, Washington. Possible uses of ASR in the area include instream flow enhancement to the Elwha River and to Morse Creek as well as for potential storage of public drinking water. This preliminary feasibility study provided stakeholders with baseline planning information used to drive decisions about implementation of ASR.



The project assessed the availability and quality of potential water sources, identified suitable aquifers, assessed environmental impacts associated with ASR, and estimated costs for various facility options. The project compared threshold benefits to both the Elwha River and Morse Creek with potential storable volumes associated with ASR.

Assessment of Groundwater Recharge of Reclaimed Water for LOTT

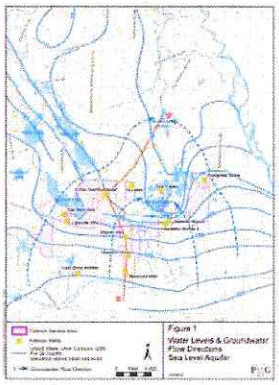
The Cities of Lacey, Olympia, and Tumwater, along with Thurston County (LOTT) plan to expand their sewage treatment facility substantially. They are exploring various discharge alternatives, including recharging the treated wastewater to local groundwater systems. PGG investigated the feasibility of recharging large volumes of water using infiltration basins and injection wells. We prepared maps of soils, land use, depth to water, subsurface geology, locations of water supply wells, and wellhead protection areas. Based on our evaluation, we identified areas in Thurston County that are most suited for recharge by infiltration and by injection. We reviewed the literature on operational facilities to assess how to treat water to meet regulatory standards for water quality. We also evaluated potential loading rates and soil treatment processes for recharge basins and identified land requirements for a 20 MGD facility.

Groundwater Evaluation of Wastewater Infiltration for the Tulalip Tribe

The Tulalip Tribe developed a new casino in an area which overlies shallow groundwater. To expedite opening of the casino in the absence of a surface water discharge permit, an innovative process of tertiary wastewater treatment followed by groundwater infiltration was planned. However, the presence of shallow groundwater raised concerns about the feasibility of the design. PGG was hired to evaluate the feasibility of infiltrating 250,000 gallons per day of treated wastewater from the new casino. PGG compiled long-term regional water level data and predicted the maximum elevation of natural groundwater in the area proposed for infiltration. Borings and field tests were conducted to evaluate the soil structures and aquifer properties. PGG developed a method of assessing the feasibility of wastewater infiltration that maximized the use of field data and supplemented it with model-predicted groundwater mounding associated with wastewater infiltration. PGG predicted that the wastewater infiltration system would work if a trench were used for infiltration, but that nearby stormwater disposal systems (that were

also modeled) would back-up as a result of groundwater mounding caused by stormwater infiltration. Subsequent system performance monitoring has confirmed PGG's conclusions.

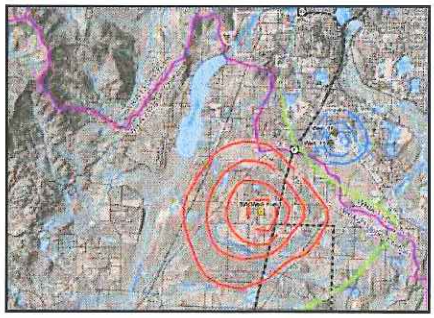
Water Supply Planning and Water Right Transfers for Pattison Water District



PGG has been assisting the Pattison Water District with water supply planning, well testing, redevelopment, and water right transfer projects for the past three years. We completed a feasibility study to characterize their supply aquifers and evaluate potential well yields and water quality. In addition, we assessed the District's water rights portfolio and made recommendations for transfers that would optimize their supply capabilities. Pumping tests were conducted by PGG to assess well efficiencies and well yields at the District's X-mas Tree, Reservoir, and Summer Shores well sites. Subsequently, we provided well redevelopment services at the Reservoir well site. PGG has assisted the District transfer three water rights from sites with declining yields and water quality problems to sites where the water rights could be fully exercised. Currently, we are working with the District develop a new well source at their Fox Hill site.

Water Right Transfers for Thurston County

PGG obtained approval for two change applications that transferred several surface-water and groundwater rights from farms in Lewis County to groundwater rights for Thurston County's municipal water system in Grand Mound. The surface-water to groundwater transfers was unusually complex due to the State's concerns about the change from seasonal to year-round withdrawals. PGG filed the change applications, provided supporting assessments of the groundwater flow system and hydraulic continuity with surface waters, and managed processing of the applications by the Thurston County Water Conservancy Board. The hydrogeologic assessment included development of a two-dimensional groundwater-flow model to simulate changes in streamflow that would result from the transfers. PGG also prepared a creative mitigation plan that included habitat and streamflow monitoring and artificial recharge with treated wastewater to enhance baseflow in a nearby creek.



Water Right Transfers for Olympia Brewery

PGG is working with the Cities of Lacey, Olympia, and Tumwater to change the water rights at the former Olympia Brewery from industrial to municipal supply. The Cities need the Brewery's extensive water rights to meet future water demand. Ten Applications for Change are under review by the Thurston County Water Conservancy Board. The key to obtaining approval will be frequent communication with Board representatives and quick responses to their requests for additional information. To date, PGG has filed the change applications, provided supporting assessments of historic water use, evaluated the relationship between the groundwater flow system and the Deschutes River, and evaluated the potential for impairment of senior water rights. We have also prepared draft Reports of Examination and are continuing to work closely with them as they prepare the final decisions.

Water Right Support for Rainier View Water Company (RVW)

RVW holds an extension portfolio of water rights associated with management of four major and ten smaller Pierce County water systems. PGG provides assistance to RVW on a number of fronts including assessing their water right options, developing mitigation plans to support new water rights, securing extensions and administrative modifications of existing water rights, preparing water right self-assessments for Department of Health required water system plans, and managing metering compliance efforts. PGG has facilitated five Applications for Change through Ecology, and negotiated on the purveyor's behalf with both the Departments of Ecology and Health.

KEY PERSONNEL

Dan Matlock, Principal Hydrogeologist
Dan has 22 years of experience in many areas related to managing and developing groundwater supplies. His specialties include evaluating and testing regional aquifers, developing plans for wellhead and watershed protection, developing databases, assessing water quality, developing groundwater management strategies, and designing monitoring systems. His extensive background in well hydraulics is an asset to the many water purveyors for whom he has developed well fields, conducted artificial recharge studies, and evaluated surface water and groundwater interactions.

Charles (Pony) Ellingson, Principal Hydrogeologist
Pony has 22 years of consulting experience in aquifer protection, contaminant hydrogeology, waste isolation and monitoring, and water supply. His educational background in groundwater hydraulics complements his experience working in a variety of groundwater regimes: single- and multi-aquifer systems, unsaturated soils, fractured aquifers, and two-phase flow systems. Other areas of expertise include managing groundwater, assessing the distribution of contaminants, designing remedial measures, and modeling the effects of waste disposal practices.

Janet Knox, Principal Environmental Geochemist
Janet has over 20 years of experience in the investigation and remediation of soil, sediment, surface water, and groundwater. She has designed and implemented sampling and analysis programs to assess the types, sources, and receptors of contamination. Her innovative strategies reflect a commitment to keep up with the changing world of environmental cleanup under many regulations. She has also served as an expert witness in complex environmental litigation. As an active participant in the MTCA Policy Advisory Subcommittees, Janet helped make MTCA more scientifically defensible and practical.

Stephen Swope, Principal Hydrogeologist
Steve has 20 years of experience in local hydrogeologic site assessment, water-supply development, and contaminant hydrogeology. He specializes in designing databases and statistically analyzing hydrologic and water-quality data. Steve implements flow and transport models to help design optimal systems for controlling groundwater and to predict the extents of contaminant plumes. As part of his thesis Steve wrote a statistically based model to predict heavy metals concentration in groundwater related to leaching.

Peter Schwartzman, Principal Hydrogeologist
Peter has 16 years of experience in hydrogeologic consulting focusing on groundwater resource development, hydrogeologic site assessment, groundwater flow modeling, and contaminant hydrology. His diverse professional responsibilities have included characterizing site hydrogeology; defining groundwater flow regimes; assessing interactions between streams, aquifers, and saltwater; delineating contaminant distribution; and analyzing hydraulic data. He has developed a variety of regional and local groundwater flow models, and applied them to evaluation of groundwater management alternatives, changes in recharge, stream-aquifer continuity, wellhead capture and contaminant transport. In the field, Peter has extensive experience designing, testing, and logging production and monitoring wells.

Linton Wildrick, Associate Hydrogeologist
Linton has 22 years of experience as a senior hydrogeologist in Dept. of Ecology's Water Resources Program and 8 years in consulting as a project manager. He has been the primary investigator in many hydrogeologic studies and published over 40 papers. He has also lead basin-wide watershed assessments throughout Washington State in a variety of hydrogeologic environments. Linton has special expertise in the analysis of seawater intrusion, interactions between surface water and groundwater, and water rights. While at Ecology, he advised managers on hydrologic aspects of water-rights policy and served as the lead scientist on the *Technical Committee for Capture of Surface Water by Wells*. He has extensive experience as an expert witness in water rights cases.

Jill Van Hulle, Water Right Specialist
Jill worked for the Washington State Department of Ecology's Water Resource Program from 1991 until recently, and served as the Southwest Regional Office's Lead Permit Writer. She has worked on the full range of water acquisition projects that affect communities and water users throughout Washington. She has worked cooperatively with a broad range of water-right applicants – from individual landowners to large public water purveyors and industrial users. She understands Washington's water-resource policy issues, because she worked on the teams that developed many of the current guidelines used statewide. These include municipal water law, water reuse guidance, and Water Resource Program policies.

Russell Prior, Senior Geologist
Russ has over 21 years of experience in water resource and environmental investigations. He has conducted and managed many resource protection, groundwater development, and groundwater remediation projects. These projects involved characterizing hydrogeology, designing groundwater monitoring and remediation systems, and negotiating with state and federal agencies. One area of his expertise is the planning, construction, design, and testing of large-capacity municipal supply wells. Another is his extensive knowledge of the geology of Washington State.

Inger Jackson, Senior Hydrogeologist
Inger has 13 years of experience in geology, hydrogeology, and geochemistry. Her professional responsibilities include the design and implementation of field investigations, management and analysis of analytical data. Her field investigations have featured environmental and resource protection, groundwater, surface water, and sediment sampling, logging wells, conducting pumping tests, and designing, installing, and maintaining complex data logging systems to measure water levels and stream flows. She has also helped develop a water-level database that she currently manages. Other capabilities include evaluating chemical data for compliance with MTCA and with the quality assurance/quality control requirements of SW-846. Finally, Ms. Jackson conducted field work in Changli County during construction of a water-supply well field.

Dawn Chapel, Hydrogeologist
Dawn has 7 years' experience in hydrogeologic and water resources investigations. She develops groundwater and contaminant transport computer models to study flux and flow paths and contaminant migration paths. She also delineates recharge areas for wellhead protection programs, investigates groundwater and surface water interactions, evaluates aquifer storage and recovery, and assesses land-use impacts on groundwater resources. Dawn's field experience includes well installation and logging, borehole geophysical logging, conducting and analyzing slug tests and pump tests, borehole inflatable packer testing, collection of water and soil samples, stream gaging, and geologic mapping.

J. Glenn Mutti-Driscoll, Hydrogeologist
Glenn's background includes geologic and hydrogeologic studies in groundwater hydraulics, contaminant fate and transport, geochemistry, and groundwater and catchment modeling. His training also includes numerous hydrologic and geologic field studies. Glenn has used ArcView and ArcMap to examine relationships between groundwater and surface water quality with land use. He has also installed pressure transducers, sampled groundwater and surface water, and mapped small-scale geologic features.

Jeffrey Parker, Hydrogeologist
Jeff has 10 years experience in geology and geomorphology, with 3 years as a consulting hydrogeologist. Jeff's strength's include hydrogeologic site characterization for environmental and water resource issues, and communication of complex scientific information. His experience includes aquifer test analysis, water supply and monitoring well siting & design, and vapor intrusion assessments. His field experience includes well installation and logging, soil and water sampling, oversight, aquifer pump tests, borehole geophysical logging, and geologic mapping.

Glen Wallace, Ph.D, Hydrogeologist
Glen has 11 years of experience in geology, including 5 years in consulting. He has experience in environmental remediation, groundwater sampling, analysis of geochemical data, statistical analysis, structural evaluation of geologic structures, and developing complex computer-based data analysis routines. Glen's field experience includes groundwater and geotechnical sampling, geologic mapping, and detailed geologic description. He also has extensive experience teaching field and classroom geology courses at the University of California and University of Washington. Glen has published several peer-reviewed research articles on igneous petrology and structural geology in leading geoscience publications.

Wayne Rennick, GIS Analyst
Wayne has extensive experience developing Geographic Information Systems (GIS) solutions for complex problems. His work has involved designing and creating interfaces, custom tools and over 375 cartographic products, including an award-winning poster. He has extensive experience with data collection, creation, manipulation, and documentation. Wayne is proficient with ArcView and the Avenue programming language. He also has experience with ArcInfo, Spatial Analyst, Visual Basic and HTML.

REFERENCES

Eric Levison – City of Camas
(360) 834-2457 ext 4251
elevison@ci.camas.wa.us

Dan Smith, Water Resource Manager
City of Tumwater (360) 754-4140
desmith@ci.tumwater.wa.us

Steve Prather, Water Quality Manager
Clark Public Utilities (360) 992-8023
sprather@clarkpud.com

We look forward to putting our skills to work for you. Please contact us at:

www.pgwg.com
(206) 329-0141