LAKE OSWEGO · TIGARD WATER PARTNERSHIP

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MEMORANDUM

TO: Zach Pelz, Associate Planner

FROM: Eric Day, Lake Oswego Water Expansion Project, Senior Planner

SUBJECT: Lake Oswego WTP application (CUP 12-02) and RWP/FWP application (CUP 12-04)

DATE: September 27, 2012

The Lake Oswego Tigard Water Partnership (the Applicant) submitted a land use application for CUP 12-04 on June 25, 2012 and submitted revisions to CUP 12-02 on August 20, 2012. The purpose of this memorandum is to identify changes to the land use application materials that have evolved over the summer as the projects advanced toward 60 percent design completion. This memorandum contains an explanation of the changes made to the application materials for each project and it includes a matrix identifying the changes made to the application materials and the location of the changes within the materials. This memorandum also provides a brief discussion of the combined traffic impacts that will result from construction work associated with CUP 12-02 and CUP 12-04 on Mapleton Drive and Kenthorpe Way.

Narrative

Raw Water Pipeline (RWP), Finished Water Pipeline (FWP)

1. Cost Avoidance – the June 25, 2012 submittal of CUP 12-04 reported that the new RWP/FWP and updated WTP projects would result in $12.2M to $18.7M in avoided costs from work items identified in the West Linn Water System Master Plan (WSMP). Further analysis and consultation with the City of West Linn and the WSMP author has identified that the avoided costs from the RWP/FWP and updated WTP projects is actually $11.6M, consistent with the CUP 12-02 update submitted on August 20, 2012.

   Action: replace avoided cost value of $12.2M to $18.7M with $11.6M in all locations noted in the Table of Application Changes in this document.

2. Cost Avoidance – the cost of replacing the asbestos cement (AC) waterline in Mapleton Drive is listed at $314K in the June 25, 2012 submittal of CUP 12-04. This value was based on the cost schedule presented in the West Linn 2008 WSMP, escalation to 2012 dollars, and an allowance for engineering costs; however, the Applicant has since realized that engineering costs were already included in the WSMP values. Therefore the avoided cost for replacing the Mapleton Drive AC line is now estimated at $272K. However, additional AC waterline replacement opportunities have been identified by the Partnership, including repurposing the existing 18-inch suction line from the intertie pump station on Old River Road to replace 350 feet of 10-inch AC waterline with an estimated avoided cost of $72K

(based on WSMP values, escalation to 2012 dollars, and 10 percent for engineering). The total benefit for West Linn AC waterline replacement is therefore estimated at $344K.

Action: replace the cost avoided value $314K with the cost avoided value $344K for West Linn AC replacement discussion in all locations noted in the Table of Application Changes in this document.

3. Pipeline Schedule - the Mapleton AC waterline replacement is now broken out as a separate construction activity and further design analysis has resulted in slight changes to the schedule presented in the Construction Management Plan (CMP) in CUP 12-04.

Action: replace Section 10-2.3 "Project Phasing" in its entirety with the following *italicized* language and table.

Construction of the RWP and FWP projects within West Linn is anticipated to start in March 2014 and to finish in August 2015. Table 1 lists the anticipated construction start and end dates for each phase. Final street resurfacing will be weather dependent and may occur outside of the construction durations presented in Table 1.

Table 1. Project Phasing by Pipeline Segment

Phase	*Anticipated start of construction window*	*Anticipated end of construction window*	*Estimated construction duration*
HDD construction (access from Mapleton Drive)	*March 2014*	*October 2014*	*6 Months*
West Linn AC waterline replacement on Mapleton Drive	*October 2014*	*November 2014*	*6 Weeks*
Open-cut construction on Mapleton Drive	*November 2014*	*March 2015*	*3 Months*
Open-cut construction on Highway 43	*June 2014*	*August 2015*	*5 Months*

Action: replace Section 10-3.2.2 "Construction Duration" in its entirety with the following *italicized* language.

Open-cut pipe construction on Mapleton Drive is anticipated to occur between November 2014 and March 2015; construction activities on Mapleton Drive are expected to last for approximately 3 months. This duration includes mobilization, pipe installation, site restoration, and demobilization. Based on consultation with potential contractors, the pipeline installation rate is estimated at an average of 50 linear feet per day. The installation rate includes items 1 through 13 of the daily activities listed in Section 3.2.1. Item 3, saw cutting, may not be conducted on a daily basis. This means that saw cutting may be conducted for longer lengths of roadway than the contractor typically needs on a daily basis; in these cases, the contractor will be required to abide by all access requirements herein. Final street restoration will be a separate construction activity that will follow ~~several weeks~~ after daily pipeline installation activities are finalized and includes items 14 through 15 in Section 3.2.1. Final paving will be weather-dependent and subject to City of West Linn standards for environmental conditions.

Replacement of the West Linn-owned asbestos cement water line will occur approximately between ~~November~~ October 2014 and ~~March~~ November 2014~~5~~; construction activities for this portion of the project are expected to last for approximately 6 weeks. This work will be conducted by the same construction contractor and in coordination with the RWP and FWP open-cut work on Mapleton Drive. This duration includes mobilization, pipe installation, site restoration, and demobilization. Based on consultation with potential contractors, the pipeline installation rate is estimated *at an average of 100 linear feet per day.*

4. Pipeline Alignment - the RWP and FWP alignment on Mapleton Drive has been slightly revised since CUP 12-04 submittal on June 24, 2012 to allow for the West Linn AC waterline replacement and other utility conflicts, as shown on the maps submitted to you via e-mail on September 20, 2012. The pipeline alignment will be contained completely in public rights-of-way and with no impacts to water resource areas or trees. Updated plans will not be provided at this time due to the minor nature of the revisions.

   Action: none.

5. Arborist Report – in response to the minor pipeline alignment revisions on Mapleton Drive identified in item 4, the Project Arborist has examined the revised alignment and certified that the Tree Protection Plan provided in Section 7 of CUP 12-04 is still valid based on the slightly revised RWP and FWP pipeline alignment.

   Action: amend Section 7 "Arborist Report/Tree Protection Plan" with the attached letter that there will continue to be no impacts to trees as a result of the revised Mapleton pipeline alignment to Section 7.

6. Construction Traffic Volume – traffic data has been updated to reflect more detailed information now available regarding about the Mapleton AC line replacement and other design updates.

   Action: replace Section 10-4.2.1 "Construction Truck Trip Volume" in its entirety with the following *italicized* language.

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HDD Construction. *Dump truck and large truck trip volume is estimated based on the construction activities discussed in Section 3.1. Site mobilization activities will last for approximately 2 weeks and will result in approximately 12 average daily truck trips (ADTs), defined as one-way trips (i.e., 12 ADTs consist of six one-way trips in each direction), to deliver construction equipment and support mobilization activities. Most of the drilled material associated with HDD operations will be removed at the HDD entry location.*

Up to 60 cubic yards (cy) of material is anticipated to be removed each day for the pilot bore and reaming phases of HDD construction. A standard dump truck has a volume of 10 cy; therefore, the 60 cy of material could be transported by 12 ADTs. The pilot bore and reaming phases of the project will last approximately 6 months.

During the pipe pullback phase of HDD construction, which will occur over a continuous 24 to 48-hour period, approximately 144 ADTs may be required to handle excess drilling mud (up to six ADTs per hour over a 24-hour period). Truck trips required during the pipe pullback period will consist of Vactor trucks, which are vacuum trucks used to transport wet material such as drilling mud.

An average of 12 ADTs may be required for HDD demobilization.

Additionally, typical contractor activities such as lunch breaks and various other tasks could result in up to ten ADTs for pickup trucks and other small vehicles. Furthermore, an additional estimated ten ADTs will be produced to enable construction management and engineering inspection to occur. Therefore, it is anticipated that ~~22~~ 32 ADTs could be experienced on any working day during the HDD construction schedule, with the only exception being pipe pullback in which up to 144 ADTs could be experienced over a continuous 24- to 48-hour period. This daily truck trip traffic will result in ~~two~~ three truck trips per hour, which could be experienced during a typical 12-hour work day (7 a.m. to 7 p.m.), and up to six truck trips per hour over a 24-hour period for the 24- to 48- hour pullback period.

The contractor will be required to transport and deliver pipe to the HDD exit area on the east side of the river in Gladstone. This means that pipe transport and delivery will be kept to a minimum within the City of West Linn for the HDD operation. There is no alternative to excess drilling mud hauling from the OPRD site during the 24- to 48- hour pullback period since the pipe insertion point will block access for drilling mud removal on the Gladstone side of the HDD crossing. Therefore, Vactor truck operations must occur from the OPRD site.

West Linn AC Waterline Replacement on Mapleton Drive. *The contractor will haul approximately 56 cy of excavated material each day due to AC replacement construction activities on Mapleton Drive. This will result in approximately 12 ADTs of 10-cy dump trucks. An additional 54 cy on average of imported crushed rock will be hauled to the work area each day for trench backfill material. This results in an additional 11 ADTs of 10-cy dump trucks. Additional trips to deliver construction materials and equipment are estimated at five ADTs. Typical contractor activities such as lunch breaks and various other activities could result in up to five ADTs for pickup trucks and other small vehicles. Furthermore, an additional estimated five ADTs will be produced to enable construction management and engineering inspection to occur. Therefore, the cumulative truck trip impact during open-cut construction along the pipeline alignment on Mapleton Drive will be approximately 38 ADTs or three truck trips per hour during a typical 12-hour construction work period (7 a.m. to 7 p.m.).*

Mapleton Drive Open-Cut Construction. *The contractor will haul approximately 150 cy of excavated material each day due to construction activities on Mapleton Drive. This will result in approximately 30 ADTs of 10-cy dump trucks. An additional 130 cy on average of imported crushed rock will need to be hauled to the work area each day for trench backfill material. This results in an additional 26 ADTs of 10-cy dump trucks. Additional trips to deliver construction materials and equipment are estimated at ten ADTs. Typical contractor activities such as lunch breaks and various other activities could result in up to ten ADTs for pickup trucks and other small vehicles. Furthermore, an additional estimated ten ADTs will be produced to enable construction management and engineering inspection to occur. Therefore, the cumulative truck trip impact during open-cut construction along the pipeline alignment on Mapleton Drive will be approximately ~~76~~ 86 ADTs or ~~six~~ seven truck trips per hour during a typical 12-hour construction work period (7 a.m. to 7 p.m.).*

Highway 43 Open-Cut Construction. *The contractor will haul approximately 150 cy of excavated material each day due to construction activities on Highway 43. This will result in approximately 30 ADTs of 10-cy dump trucks. An additional 130 cy on average of imported crushed rock will need to be hauled to the work area each day for trench backfill material. This results in an additional 26 ADTs of 10-cy dump trucks. Additional trips to deliver construction materials and equipment are estimated at ten ADTs. Typical contractor activities such as lunch breaks and various other tasks could result in up to ten ADTs for pickup trucks and other small vehicles. Furthermore, an additional estimated ten ADTs will be produced to enable construction management and engineering inspection to occur. Therefore, the cumulative truck trip impact during open-cut construction along the pipeline alignment on Highway 43 will be approximately ~~76~~ 86 ADTs or ~~eight~~ ten truck trips per hour during a typical 9-hour construction work period (8 p.m. to 5 a.m.).*

Construction traffic for each pipeline construction phase discussed above is not cumulative due to the overall pipelines project schedule and phasing. To minimize truck trip volume, HDD construction on Mapleton Drive will not occur at the same time as open-cut work on Mapleton Drive. Even though the schedule for Mapleton Drive and Highway 43 work will overlap, truck trip volume will never overlap for the two open-cut phases due to ODOT nighttime work hour restrictions for Highway 43 construction work. Table 3 lists expected truck trip volume (trips per hour) for each project phase.

Table 3. RWP and FWP Truck Trip Volume by Phase[1]

Phase	Truck trips per Hour[2]	Typical work hours	Anticipated start of construction window	Anticipated end of construction window
HDD construction (via Mapleton Drive) – normal	~~2~~ 3	7 a.m. to 7 p.m.	March 2014	October 2014
HDD construction (via Mapleton Drive) – pullback	6	NA[3]	NA[3]	NA[3]
West Linn AC waterline replacement on Mapleton Drive	3	7 a.m. to 7 p.m.	October 2014	November 2014
Open-cut construction on Mapleton Drive	~~6~~ 7	7 a.m. to 7 p.m.	November 2014	March 2015
Open-cut construction on Highway 43	~~8~~ 10	8 p.m. to 5 a.m.	June 2014	August 2015

[1]Additional daily truck trips will result from WTP construction activities which are not included in this table.

[2]All truck trip volume reported is one-way (each round trip results in two (2) one-way trips).

[3]HDD pullback activities will occur once over a continuous 24- to 48-hour period.

7. Emergency Access – the emergency access plan has been refined to account for pipeline alignment updates on Mapleton Drive.

Action: replace Section 10 – 4.2.5 "Emergency Vehicle Access" in its entirety with the following *italicized* language (note, this update will also apply to Section 12 "DKS Traffic Memorandum).

Subject to the four localized exceptions described below, the contractor will be required to provide 12-foot-wide minimum emergency access at all times to all residential and commercial property through the construction work zone. The contractor will be required to move construction equipment ~~and materials~~ immediately to create access through the work zone suitable for emergency vehicles that will enable emergency response to any driveway or property within or beyond the work zone. No temporary stockpiling of materials will be allowed that will impede emergency access.

In four localized instances, the pipeline alignment on Mapleton Drive will cross the pavement such that the pipeline trench will interfere with a 12-foot-wide emergency access. At these locations, trench plating could be used to provide the emergency access, but this may result in significant time delays. When construction activity is occurring at three of these locations (west of Nixon Avenue), reliable emergency access will only be available around the construction work zone via a detour on Cedaroak Drive and Nixon Avenue. The construction duration at these three locations is expected to be no more than a total of 3 to 6 days. The fourth location is at the far southeast end of Mapleton Drive and so will not require use of the detour. In the event of an emergency at this location during the 1-2 days of adjacent pipeline construction activity, emergency vehicles will be able to get within 150 feet of the home. The same is true for the other three locations if an emergency were to occur at a home within those work zones.

Tualatin Valley Fire & Rescue's (TVF&R) Fire & Life Safety Requirements for Fire Department Access and Water Supplies requires that emergency response access be provided to within 150 feet of each building to enable use of typical firefighting equipment. As stated above, the contractor will be required to move all construction equipment ~~and materials~~ immediately to allow emergency access within the work area to private property frontages, or in rare instances of pipeline trench interference, provide access to within 150 feet of property frontages. The applicant and design team members met with TVF&R on June 7, 2012. TVF&R representatives confirmed that the proposed approach for accommodating emergency access is acceptable and will allow the agency to maintain emergency responsiveness throughout the project duration. TVF&R stated that emergency response on Mapleton Drive will be managed on a case-by-case basis, in which the responder will decide whether the property should be accessed through the work area via the available 12-foot-wide emergency access or via a detour from Cedaroak and Nixon. Correspondence from TVF&R is provided in Appendix B.

The contractor will be required to coordinate on a regular basis with TVF&R and the West Linn Police Department so that, in the case of an emergency ~~existing emergency response times to all areas affected by RWP and FWP construction activities will be maintained~~ <u>the emergency responder can determine the best possible way to access the property and maintain acceptable emergency response times</u>. TVF&R and West Linn Police Department representatives will be invited to all pipeline construction progress meetings to facilitate close coordination throughout the construction process. The contractor will be required to notify TVF&R and the West Linn Police Department via daily e-mails. Notifications will be sent from a contractor representative to the e-mail addresses for TVF&R Stations 57 (Mountain Road), 58 (Willamette), and 59 (Bolton,) and the West Linn Police Department noting activities, location, and duration of all expected construction work for the day.

8. Pedestrian Access - the access plan was modified to reflect that, in some reaches of the alignment, the proposed 5-foot buffer between walkway and construction area will not be provided. However, the proposed barrier will still ensure pedestrian safety through these zones.

   Action: replace Section 10 -4.2.4 "Pedestrian and Bicycle Circulation Plan" in its entirety with the following *italicized* language.

   Pedestrians and bicycles will be accommodated at all times around all construction work areas including the HDD construction staging area at the end of Mapleton Drive, Mapleton Drive open-cut construction, and Highway 43 open-cut construction. Accommodations for persons with disabilities and visual impairments shall be in accordance with the Americans with Disabilities Act and Americans with Disabilities Act Accessibility Guidelines. Figure 5 shows the overall pedestrian and bicycle circulation and access plan for construction on Highway 43, Mapleton Drive, Kenthorpe Way, and Mary S. Young State Park. Since pedestrian and bicycle access will be maintained at all times, there will be no impacts to the present pedestrian and bicycle circulation in the area as a result of the project.

   Pedestrian and bicycle access along Mapleton Drive and Highway 43 will be provided via a dedicated 5-foot-wide temporary pathway that will be separated from the construction work zone by traffic channelizing devices, such as drums, tubular markers, cones, or chain-link fence~~. Channelizing devices will be placed at a safe distance, no less than 5 feet, from working construction equipment and will be adequately marked for the safety of pedestrians and bicyclists.~~ <u>as appropriate to maintain safety. Channelizing devices</u> will be adequately marked <u>and positioned</u> for <u>maximum</u> safety of pedestrians and bicyclists.

9. Seismic - the seismic memos submitted in the June 25, 2012 submittal identified additional investigation work that still needed to be completed to determine the risk of lateral spreading. This additional investigation has now been conducted and was used to conclude that the risk of lateral spreading in the event of a seismic event is low. This discussion is found on pages 13, 14, and 16 of the Kleinfelder letter and pages 6 and 8 of the Degenkolb memo.

   Action: replace Section 8 "Seismic and Geologic Hazards" in its entirety with the attached "Seismic and Geologic Hazards" prepared by Kleinfelder, dated August 23, 2012 and "Seismic Design Memorandum" prepared by Degenkolb, dated August 3, 2012.

<u>Water Treatment Plant (WTP)</u>

1. Construction Trailers – the Applicant amended the Construction Management Plan (CMP) and Construction Management Overview Figure, Section 21, Figure 6.0, to include information about the location and access of the proposed construction trailer area. Figure 6.0 shows that existing vegetation will provide adequate screening around the proposed construction trailer area. Contractors typically use construction trailers similar to the examples depicted in the attached photograph.

During construction, the contractor will place approximately six to eight construction trailers within the construction trailer area. The designated contractor trailer area is within the construction staging limits, shown in Figure 6.0. The contractor will connect the trailers to electricity, and in some cases, water and sewer.

Figure 6.0 shows 16 – 24 contractor parking spaces immediately east and adjacent to the trailer area. Access to the contractor parking area is provided by both Kenthorpe Way and Mapleton Drive. The figure also shows 15 parking spaces along Kenthorpe Way for WTP staff, construction management personnel, and visitors. We are not proposing any construction parking in the construction staging area adjacent to Mapleton Drive.

Action: replace Figure 6.0 of Section 21 and append Section 14A "Construction Management Plan" with the attached Appendix B – Construction Trailer Example.

2. Kenthorpe Avenue Entryways – the site plan and application narrative were changed to demonstrate that the existing driveway widths will be maintained and the TVF&R ingress and egress are maintained after construction activity ceases. The site plan the applicant submitted on August 20, 2012 portrayed inaccurate driveway widths on Kenthorpe Way. The existing driveway widths were approved as a nonconforming development in 1997. The applicant will revise all site plans to depict driveway widths of 59'-1" and 39'-1", west and east respectively. The attached "Fire Entrance" figure shows the correct driveway widths.

   The same figure also shows the proposed driveway widths and demonstrates that emergency response vehicles have access to the site consistent with the turning radius template provided by TVF&R.

   Action: append the attached "Fire Entrance" figure to Section 18A.

3. Structure Height – The applicant modified the height of the gravity thickener from 5' to 7'-6".

   Action: amend Section 4, page 35, Table 2.2 – Building and Structure Height: Replace Gravity Thickener Height from 5 feet (without railing) to 7.5 feet (without railing).

4. Kenthorpe Avenue Water Line – the Applicant has agreed to design and install approximately 2,800 feet of West Linn owned AC water line in Kenthorpe Way and easements between the Kenthorpe Way and Mapleton Drive rights-of-ways. This work will occur as part of the WTP construction contract and is anticipated to occur between April and May 2015. This work will be conducted per the construction method described for Mapleton Drive AC waterline replacement in the Pipelines application (CUP 12-04) submitted on June 25, 2012 and updated as part of this document. Construction impacts will be nearly identical to those described for the Mapleton AC waterline replacement.

   Action: none.

Table of Application Changes

Item	Section	Page	Figure
RWP/FWP			
1. Cost Avoidance – Benefit – amended	4	5, 11, 40, 41, 52, 55	NA
2. Cost Avoidance – AC line – amended	4	5, 11, 53, 55	NA
3. Pipeline Schedule – amended	10	5, 7, 8, 9	NA
4. Pipeline Alignment – change noted	19	NA	
5. Arborist Report – amended	7	NA	NA
6. Construction Traffic Volume – amended	10	10, 11	NA
7. Emergency Access – amended	10/12	13/14	NA
8. Pedestrian Access –amended	10	12	NA
9. Seismic – replaced	8	NA	NA
WTP			
1. Construction Trailers	14A, 12	NA	6.0
2. Kenthorpe Avenue Entryways	18A	NA	Fire Entrance
3. Structure Height	4	35	Table 2.2
4. Kenthorpe Avenue Water Line	NA	NA	NA

Combined Traffic Impacts from CUP 12-02 and CUP 12-04 (WTP and Pipelines)

Construction projects associated with both land use applications in West Linn will be sequenced to minimize cumulative traffic impacts. Attached Figures 1 and 2 show sequencing and the combined estimated traffic impacts on both Mapleton Drive and Kenthorpe Way over the 32-month construction duration of the two projects. To minimize traffic volume, WTP construction traffic will generally be evenly split between Mapleton Drive and Kenthorpe Way for most of the project duration. During Mapleton AC waterline replacement and open-cut RWP and FWP pipeline construction activities on Mapleton Drive between October 2014 and March 2015, WTP construction traffic will primarily use Kenthorpe Way to avoid work zone conflicts on Mapleton Drive.

The maximum one-way construction traffic on Mapleton Drive will occur during open-cut construction of the RWP and FWP between November 2014 and March 2015 at 86 trips per day. The maximum one-way construction traffic on Kenthorpe Way will occur during the Mapleton AC waterline replacement as a result of all WTP traffic being routed on Kenthorpe Way and will occur between October and November 2014 with a peak daily volume of 95 trips per day.

Current City of West Linn traffic counts show base residential traffic on Mapleton Drive and Kenthorpe Way are 350 and 200 one-way trips per day, respectively (refer to Section 12 in CUP 12-04 for more detail). Mapleton Drive west of Nixon Avenue has a functional class of Collector/Local and Kenthorpe Way has a functional class of Local according to the October 2008 West Linn Transportation System Plan. According to DKS Associates, a typical acceptable maximum average daily traffic (ADT, i.e. one-way trips per day) for a street such as Mapleton Drive would range from 1,500 to 3,500 trips per day and a typical acceptable maximum ADT for a street such as Kenthorpe Way would be approximately 1,500 trips per day (see attached email from DKS

Associates dated September 27, 2012). Even with the additional construction traffic, traffic volumes will remain well under these typical levels with values of 436 and 295 one-way trips per day on Mapleton Drive and Kenthorpe Way, respectively.

Please refer to Section 10 of CUP 12-04 (with updates submitted as part of this document) for a detailed breakdown of truck trip volume for construction of the various pipeline activities. Refer to Section 14A of CUP 12-02 for a detailed breakdown of truck trip volume resulting from the WTP construction.

Thank you for your consideration of these materials.

Figures:

1. Combined construction project traffic on Mapleton Drive
2. Combined construction project traffic on Kenthorpe Way

Attachments:

1. Letter from Project Arborist (Kay Kinyon) dated September 25, 2012
2. Updated version of "Seismic and Geologic Hazards" prepared by Kleinfelder, dated August 23, 2012
3. Updated version of "Seismic Design Memorandum" prepared by Degenkolb, dated August 3, 2012
4. Section 21, Figure 6.0, Construction Management Overview
5. Section 14A, Construction Management Plan, Appendix B, Construction Trailers Example
6. Section 18A, Tualatin Valley Fire and rescue Meeting Minutes, Fire Entrance
7. Email from DKS Associates dated September 27, 2012

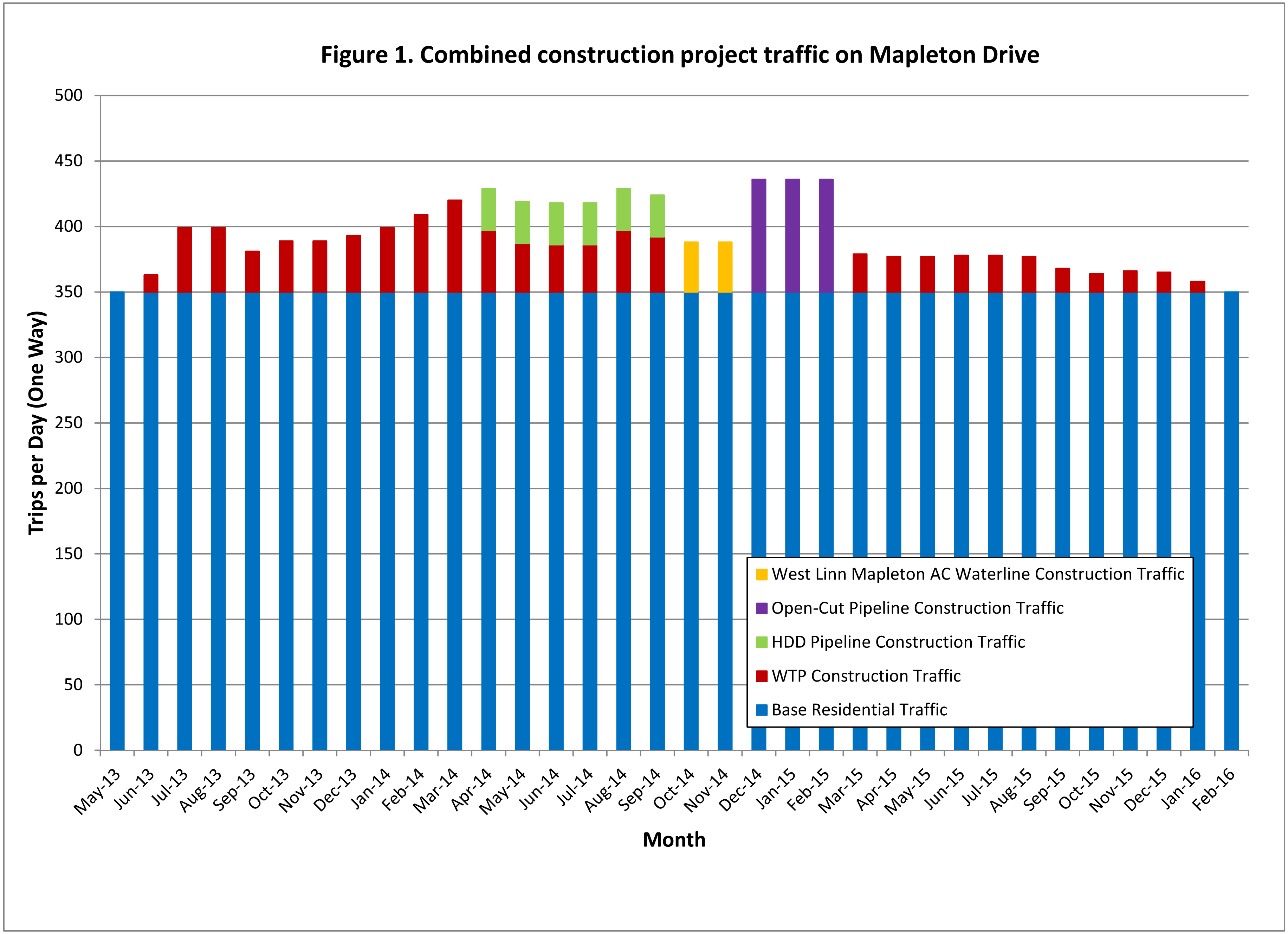
Figure 1. Combined construction project traffic on Mapleton Drive
Trips per Day (One Way)
500
450
400
350
300
250
200
150
100
50
0
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
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Nov-14
Dec-14
Jan-15
Feb-15
Mar-15
Apr-15
May-15
Jun-15
Jul-15
Aug-15
Sep-15
Oct-15
Nov-15
Dec-15
Jan-16
Feb-16
Month
West Linn Mapleton AC Waterline Construction Traffic
Open-Cut Pipeline Construction Traffic
HDD Pipeline Construction Traffic
WTP Construction Traffic
Base Residential Traffic

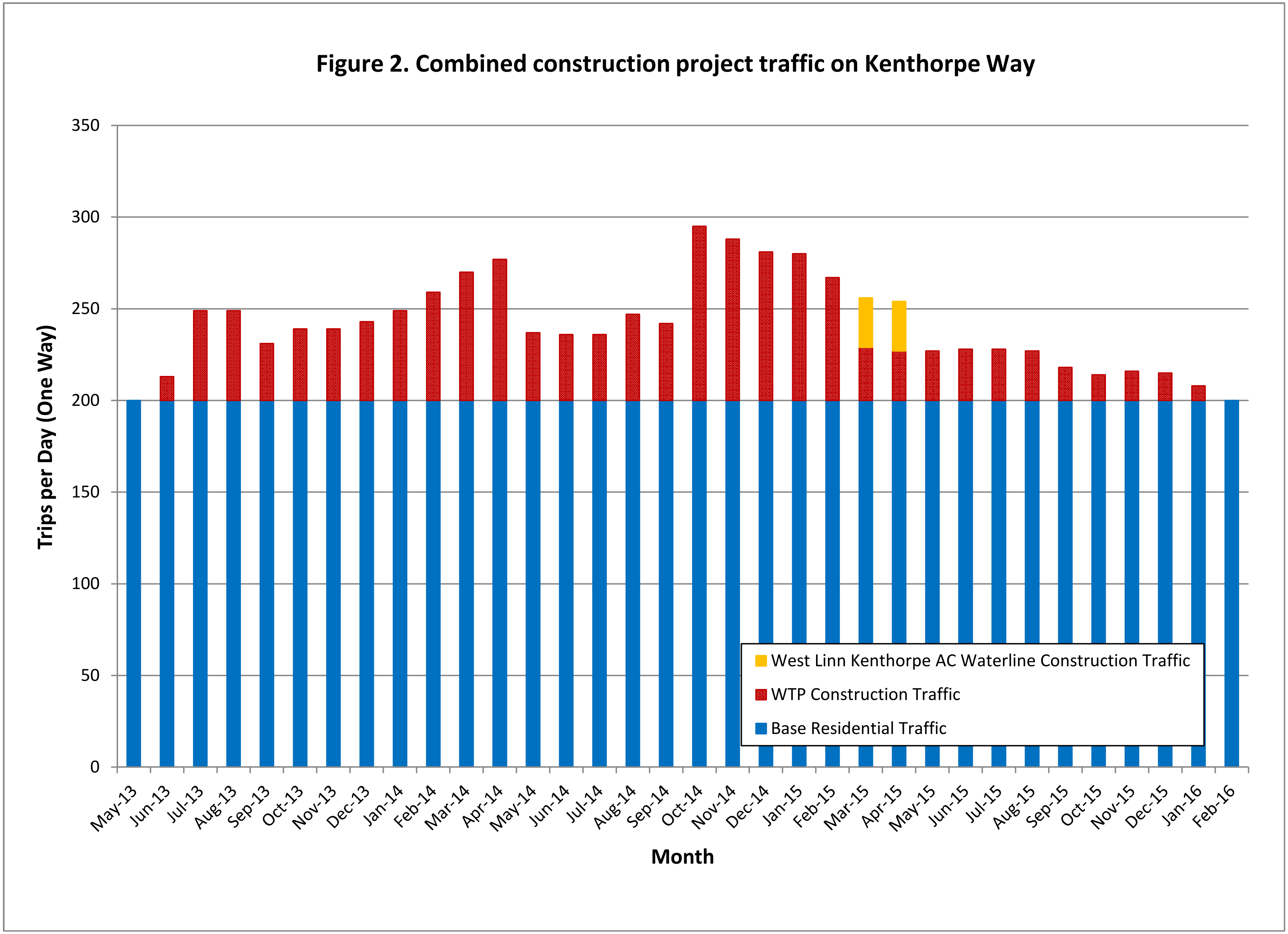
Figure 2. Combined construction project traffic on Kenthorpe Way
Trips per Day (One Way)
350
300
250
200
150
100
50
0
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
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Nov-14
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Feb-15
Mar-15
Apr-15
May-15
Jun-15
Jul-15
Aug-15
Sep-15
Oct-15
Nov-15
Dec-15
Jan-16
Feb-16
Month
West Linn Kenthorpe AC Waterline Construction Traffic
WTP Construction Traffic
Base Residential Traffic

TREECAREUNLIMITED

ARBORIST REPORT

Nature of the Report:	West Linn Mapleton Dr Pipeline Tree Protection
Address of the Report:	Mapleton Dr. West Linn, Oregon
Date of the Report:	September 25, 2012
Report Submitted To:	Pete Oveson Brown & Caldwell 6500 SW Macadam Ave. Portland, OR 97239

Summary

During our recent meeting on the date shown above we reviewed the realignment of the proposed water pipe line near Trees #48, #49, #50, #51, #52, #53 & #54 on the north side of Mapleton Dr. In the meeting you scaled the distance from these trees to the edge of excavation for the new alignment. These dimensions coincided with the current tree protection fence placement of the proposed tree protection plan. It appears that no adjustments will need to be made to the current tree protection plan.

Sincerely,

Kay Kinyon
Certified Arborist PN0409A
Tree Care & Landscapes Unlimited, Inc.

KLEINFELDER
Bright People. Right Solutions.

August 23, 2012
Project No. 120589

Kennedy-Jenks Consultants
200 SW Market St., Suite 500
Portland, Oregon 97201

Attn: Mr. Brad Moore, P.E., Senior Water Resources Engineer

Subject: West Linn Land Use Application
Seismic and Geologic Hazards
LOTWP Raw & Finished Water Pipelines
Lake Oswego, Oregon

Dear Brad:

INTRODUCTION

As part of the Land Use Application, Kleinfelder has reviewed and evaluated the seismic hazards for the pipeline segment in the West Linn area, which includes portions of the Raw and Finished Water Pipelines. The following reports were used for review and summary of the geologic and seismic conditions of the pipeline alignment through West Linn, Oregon.

- Geotechnical Data Report: Expansion of the City of Lake Oswego Water Supply System, Supplemental Explorations for Seismic Hazard Evaluation, Finished Water Pipeline, Clackamas County, Oregon, GeoDesign, Inc., August 2, 2012
- Geotechnical Data Report: Willamette River Crossing Alternatives, Lake Oswego Water Pipeline, Clackamas County, Oregon, GeoDesign, Inc., March 30, 2012.
- Draft Geotechnical Engineering Report: Lake Oswego & Tigard Water Treatment Plant Expansion Project, West Linn, Oregon, Shannon & Wilson, Inc., January 2012
- Liquefaction Analysis of Lake Oswego Tigard Water Treatment Plant, Shannon & Wilson, October, 2011.

14710 NE 87th Street, Suite A100, Redmond, WA 98052 p | 425.636.7900 f | 425.636.7901

- Seismic Hazard Assessment, GeoDesign, Inc., March 11, 2011
- Geotechnical Data Report: Finished Water Pipeline, GeoDesign, Inc., February 7, 2011
- Geotechnical Data Report: Raw Water Pipeline – Lake Oswego Water Pipeline, Clackamas County, Oregon, GeoDesign, Inc., November 9, 2010

Kleinfelder did not perform subsurface explorations or field mapping in the West Linn project area. Therefore, the information provided in the GeoDesign, Inc. (GeoDesign) reports is reviewed and summarized in this letter. Kleinfelder updated the seismic design parameters from the USGS 2002 deaggregations, used by GeoDesign in their Seismic Hazard Assessment Report (dated March 11, 2011), to the USGS 2008 deaggregations. In addition, the seismic event return period of 5 percent in 50 years (975 years return period) used by GeoDesign was changed to a return period of 2 percent in 50 years (2,475 years return period) to correspond with Shannon & Wilson's seismic report for the Water Treatment Plant (WTP) in West Linn.

Pipeline Summary Through West Linn

The new pipeline will convey water from a River Intake Pump Station (RIPS) located on the Clackamas River in Gladstone to the Bonita Pump Station (BPS) in Tigard. The area included in this Land Use Application is the western portion of the Raw Water Pipeline (RWP) on the west side of the Willamette River to the WTP and the Finished Water Pipeline (FWP) from the WTP to the City of Lake Oswego southern city limit near Arbor Drive along Highway 43. The RWP in this area will be constructed from the west bank of the Willamette River by way of a horizontal directional drill (HDD) underneath Mary S. Young Park, by open-excavation along Mapleton Drive, and will terminate at the WTP. The FWP will be constructed by open-excavation from the WTP, along Mapleton Drive, and along Willamette Drive/Pacific Highway (OR Highway 43) into Lake Oswego. The project area has been separated into reaches based on the geology and seismic hazards (Plate 1).

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GEOLOGIC SUMMARY

GeoDesign drilled 23 borings to depths of about 13 feet below ground surface (bgs) at 250- to 1000-foot spacings along the preliminary Raw and Finished Water Pipeline alignments in West Linn. GeoDesign also drilled borings to depths between 100 and 192 feet bgs along the Willamette shoreline and Mapleton Drive for the Willamette River HDD crossing. In June and July, 2012, eight additional geotechnical borings (B-1 to B-8) were drilled along Highway 43 and between the highway and the Willamette River to evaluate the subsurface conditions. Borings were drilled to depths ranging from approximately 28 to 61 feet below ground surface. Vibrating wire piezometers were installed in B-1, B-5 and B-7 to estimate depth to groundwater. Borings B-3 and B-4 were drilled within the city limits of Lake Oswego and are not included in this seismic discussion. Shannon & Wilson drilled five borings and seven CPTs advanced up to 65 feet below ground surface (bgs) at the WTP site.

In addition to the subsurface explorations, GeoDesign also mapped and field verified landslide and potential landslide locations along the west bank of the Willamette River and Highway 43. Information included in the GeoDesign reports was reviewed and is summarized in the landslide identification and fault sections below. The geology and known landslide and fault locations are presented on Plates 2A, 2B, 3A, or 3B.

GEOLOGY

The geology in the West Linn area is generally mapped as Pleistocene fine-grained facies deposits (Qff) by Beeson and Tolan (1989) originating from the Missoula Floods with exposed outcrops of Columbia River Basalt Group (CRBG) bedrock along the Willamette River bank and Highway 43. The Qff consists of unconsolidated sand, silt, and gravel and extended below GeoDesign's deepest boring of 40 feet. The CRBG bedrock outcrops were observed by GeoDesign north of the existing pipeline and at shallow depth (6 feet) in Boring HDD-5 near the river bank. Recent Quaternary alluvium (Qal) and Springwater Formation (QTs) are mapped along the river shoreline and on the east side of Mapleton Drive, respectively. The CRBG underlies all of these surficial deposits.

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Based on borings performed by GeoDesign, alluvial sediments (Qal, QTs, and Qff) extended to at least the depth explored in the RWP portion east of Boring HDD-5 and in the FWP portion in West Linn. In general, the thickness of the Qff above the CRBG was greater than 20 feet along Highway 43.

LANDSLIDES

Department of Geology and Mineral Industries (DOGAMI) LiDAR maps identify recent and historical landslides along the proposed alignment. The closest landslide to the RWP alignment as identified in the LiDAR imagery is approximately 300 feet north of the RWP alignment at the location the pipeline turns west along Mapleton Drive from the intersection with Nixon Drive, as shown in Figure 2A. No other landslides were identified on the LiDAR imagery or Statewide Landslide Inventory Database for Oregon (SLIDO-2). Based on an analysis of slope gradients derived from the LiDAR imagery, GeoDesign performed reconnaissance of slopes in Mary S. Young State Park, Highway 43 near Walling Circle, Highway 43 near Lazy River Drive, and Highway 43 near Arbor Drive in the West Linn area. Of these areas, a slope within Mary S. Young State Park was identified as a potential seismically-induced landslide hazard as shown in Figure 2A in the area marked with blue hatch marks. The area is primarily west of the alignment, but may extend towards the river's edge

LOCAL FAULTS

Review of available literature shows twelve faults mapped near the Portland Metro Area. Table 1 provided by GeoDesign shows the distances of the faults from the pipeline alignment and their estimated age. The only fault within the vicinity of the RWP and FWP alignments within the City of West Linn is the Bolton Fault at approximately 0.2 miles from the pipeline alignment. This fault extends north-south and is located to the west of Highway 43. Plates 2A, 2B, 3A, and 3B illustrate the location of the Bolton Fault. As can be seen in the Plates, the FWP alignment does not cross the Bolton Fault. The seismic potential resulting from each of these faults is discussed later in this report.

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Table 1. Local Faults in the Proximity of the Pipeline (GeoDesign (2011)

Fault Name	Proximity to Site (surface projection in miles)	Estimated Displacement Description	Estimated Age
Bolton	0.2	Offsets Columbia River Basalt flows and overlying fluvial and lacustrine deposits. Does not offset Missoula Flood deposits.	Quaternary (< 1.6 million years before present)
Oatfield	0.5	Offsets Columbia River Basalt flows and Boring Lava. Does not offset Missoula Flood deposits.	Quaternary (< 1.6 million years before present)
Canby-Molalla	1	Probable offset of Missoula Flood deposits.	Late Quaternary (< 15,000 years before present)
Portland Hills	1.5	Potential offset of Missoula Flood deposits by means of geophysical techniques and trench excavation.	Late Quaternary (< 15,000 years before present)
Grant Butte	4	Offsets Plio-Pleistocene deposits and Boring Lava. Does not offset Missoula Flood deposits.	Middle to Late Quaternary (< 750,000 years before present)
East Bank	6	Probable offset of unconformities and paleochannels associated with the Missoula Flood deposits.	Late Quaternary (< 15,000 years before present)
Beaverton Fault Zone	7	Offsets Columbia River Basalt flows and overlying fluvial and lacustrine deposits. Does not offset Missoula Flood deposits.	Middle to Late Quaternary (< 750,000 years before present)
Helvetia	12	Offsets Columbia River Basalt flows and overlying fluvial and lacustrine deposits. Does not offset Missoula Flood deposits.	Quaternary (< 1.6 million years before present)
Newberg	15	Controlled emplacement of Columbia River Basalt flows. No documented offset of overlying younger deposits.	Quaternary (< 1.6 million years before present)
Lacamas Lake	17	Offsets Plio-Pleistocene deposits and Boring Lava. Does not offset Missoula Flood deposits.	Middle to Late Quaternary (< 750,000 years before present)
Gales Creek Fault Zone	20	Offsets Columbia River Basalt flows and overlying fluvial and lacustrine deposits. Does not offset Missoula Flood deposits.	Quaternary (< 1.6 million years before present)
Mount Angel	20	Offsets late Pleistocene and Holocene deposits. Associated with earthquake swarms near Woodburn (1990) and ML 5.6 earthquake near Scotts Mills (1993).	Late Quaternary (< 15,000 years before present)

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REGIONAL FAULTS

The Cascadia Subduction Zone (CSZ) is the primary regional fault system in the project area and was created by the Juan de Fuca Plate subducting beneath the North American Plate. The subduction is occurring in the coastal region between Vancouver Island, British Columbia, Canada and the Mendocino Triple Junction in northern California.

SITE SEISMICITY

The project's seismicity was evaluated and provided in the Seismic Hazard Assessment report by GeoDesign dated March 11, 2011. Kleinfelder performed additional analyses to evaluate and confirm GeoDesign's findings and update the information based on the USGS 2008 information. Based on these analyses, three earthquake sources have the potential to affect the proposed FWP alignment:

- Cascadia Subduction Zone (CSZ) interface earthquakes
- CSZ intraplate earthquakes
- Local crustal earthquakes

The CSZ is the region where the Juan de Fuca Plate is being subducted under the North American Plate. The CSZ earthquake events have the potential to generate earthquake magnitudes up to 9.0.

Major earthquake events can occur from local crustal earthquakes as well. GeoDesign identified 12 local crustal faults as noted in Table 1, within 20 miles of the proposed pipeline alignment that have the potential to be active based on DOGAMI and/or USGS interpretations.

GeoDesign summarized the peak ground acceleration (PGA) for three soil/rock site classes found along the proposed alignment. Site Class B represents shallow bedrock. Site Class C represents firm soils and gravels or where up to 10 feet of soil overlays bedrock. Site Class D represents alluvial soils. Based on the borings, West Linn is primarily considered Site Class D. The PGA values generated by GeoDesign were based on 2002 Geohazard Maps developed by the USGS for a return period of 975 years, which resulted in a PGA of 0.38. The updated PGA values are based on 2008 USGS for a return period of 2,475 years with an estimated PGA of 0.55. The PGA value was updated in the analysis based on 2008 NSHMP Interactive Deaggregation tool by the USGS. Table 2 below presents the contribution of the individual seismic sources to the PGA.

Table 2. Seismic Source Data

Spectral Acceleration Period (sec)	Seismic Source	Contribution to Seismic Hazard (percent)	Approx. Distance from Site (km)	Postulated Magnitude (M_w)
2 Percent in 50 years (2475-year event)				
PGA	CSZ Floating	20.2	113.3	8.5
	CSZ Megathrust	41.8	106.8	9.0
	WA-OR Cascades-West crustal faults	15.5	4.3	6.7
	WUS Gridded	7.1	8.7	6.4
	CSZ Intraplate	12.7	63.1	7.0
	Individual Crustal Faults			
	Portland Hills fault	5.2	3.7	7.0
	Portland Hills fault, GR	6.8	5.0	6.8
	Bolton fault	2.8	0.4	6.2
1sec	CSZ Floating	8.8	102.3	8.5
	CSZ Megathrust	23.8	102.5	9.0
	WA-OR Cascades-West crustal faults	24.1	4.7	6.7
	WUS Gridded	26.7	9.3	6.0
	CSZ Intraplate	15.6	65.0	6.9
	Individual Crustal Faults			
	Portland Hills fault	7.0	3.7	7.0
	Portland Hills fault, GR	10.2	5.3	6.8
	Bolton fault	5.0	0.4	6.2

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SEISMIC HAZARD ANALYSIS

To address the potential hazards to the RWP and FWP pipelines through West Linn and the remaining alignment, we completed the following analyses based on the Site Class D and subsurface and groundwater conditions:

- Ground Surface Rupture
- Ground Shaking
- Wave Propagation Damage
- Liquefaction Hazard and Seismically Induced Settlement
- Lateral Spreading Potential
- Seismically Induced Slope Failure

The selection of these analysis methods is based on guidance from the following sources and our professional judgment:

- American Lifeline Alliance (ALA) Seismic Manual published by the American Society of Civil Engineers (ASCE), 2001
- Geotechnical Earthquake Engineering by S. Kramer, 1996
- Geotechnical Earthquake Engineering Manual by FHWA, 1999

GROUND SURFACE RUPTURE

Based on USGS deaggregated data, relatively significant crustal seismic sources in the RWP and FWP segments in the vicinity of the pipeline in West Linn include the Bolton Fault, the Marythrust Fault, and the River Forest Fault. We consider the risk of fault rupture from these faults to be negligible to low during the pipeline design life based on a lack of displacement evidence during the Quaternary (1.6 million years to present) as well as the mapped locations.

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GROUND SHAKING

Based on the boring logs and site geology, the site class in the West Linn area is "D". For the pipeline, Kleinfelder considered the ground shaking associated with return period of 2,475 years (i.e., 2% probability of exceedance in 50 years). The peak ground accelerations (PGA), spectral acceleration at a period of 1 second (S_1), and associated mean and modal magnitudes were estimated using USGS interactive deaggregation tool (2008). The results are summarized in Table 3 and were generated from the WTP located at latitude and longitude 45.3855°N and -122.636°W, respectively. The values of PGA and magnitude were used to evaluate liquefaction potential. The value of S_1 is used to estimate wave propagation.

Table 3. Estimated PGA and S_1 (Return Period = 2475 years)

Site Class	PGV (inches/sec)	Spectral Acceleration Period	Spectral Acceleration	Mean Magnitude & Distance	Modal Magnitude & Distance
D	28.5 to 37.7	PGA	0.55 g	7.5 (62.6 km)	9.0 (93.1 km)
		S_1	0.70 g	8.2 (81.1 km)	9.0 (93.1 km)

Site Class D is based on an assumed V_s^{30} of 270 m/sec.

$S_1 = S_{1\_site\ B} \times Fv = 0.370 \times 1.66 = 0.61$

WAVE PROPAGATION

We estimated the pipe damage associated with wave propagation using the empirical correlation presented in ALA (April 2001). For the West Linn area, we estimated the spectral acceleration at the period of 1 second (S_1) for the return period of 2,475 years by using the correlation of peak ground velocity (PGV) with S_1 that Norm Abrahamson developed (NCHRP 611, 2008). Using a value of S_1 of 0.70g as shown in Table 3, we estimated PGV values ranging from 28.5 to 37.7 inches/sec.

LIQUEFACTION HAZARD AND SEISMICALLY-INDUCED SETTLEMENT

Earthquake-induced soil liquefaction can be described as a significant loss of soil strength and stiffness caused by an increase in pore water pressure resulting from cyclic loading during shaking. Liquefaction is most prevalent in loose to medium dense, sandy and gravely soils below the groundwater table, but it can also occur in low- and non-plastic silts. In the process, the soil acquires mobility sufficient to permit both horizontal and vertical movements if the soil mass is not confined. If liquefaction occurs, ground surface settlement will generally be expected.

The geologic profile along most of the West Linn area is mapped as Missoula Flood deposits (fine-grained facies, Qff). The unit consists of unconsolidated silt, sand, and gravel. Based on DOGAMI maps for the site vicinity, the deposits are reported to range from 30 to 60 feet thick (Madin, 1990). Along this pipeline segment the flood deposits are likely underlain by Springwater Formation gravels. Subsurface data documented from deep water wells near the site vicinity indicate the Springwater Formation is up to 90 feet thick (Madin, 1990).

For our liquefaction analysis, we assumed the groundwater is located at 10 feet below ground surface for borings where groundwater was not encountered. We selected borings for the liquefaction evaluation by considering the soil type and SPT blow counts. We screened out the boring when the soil type was clay or rock, and when SPT blow counts with correction for overburden and hammer energy were greater than 30.

For the selected boring data, we evaluated liquefaction susceptibility triggering using methodologies proposed by Cetin et al. (2004), Moss et al. (2006), and Idriss & Boulanger (2006, 2008). In interpreting the variable results observed with these three methods, we generally considered a soil layer liquefiable if two or more of the methods showed factors of safety less than about 1.1. Post-liquefaction reconsolidation settlements were analyzed using the methods of Cetin et al (2009), and Idriss & Boulanger (2008). For the analyses, we used a peak ground acceleration of 0.55 g and the magnitude of M9.0 as shown in Table 3.

The liquefaction potential of soil is affected by the fines content and plasticity, especially when the soil is silt. The likelihood of liquefaction can vary depending on uncertainties in soil density, ground water location, and lack of information such as laboratory data.

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Therefore, the liquefaction potential is often expressed in a descriptive manner such as "low", "moderate", and "high".

Along Highway 43 from Glenmorrie Drive to the WTP, including borings FWP-10 through -1, FWP-66 through -64, and B-1 and B-2, the liquefaction potential is generally moderate to high except at a few boring locations with low potential: borings FWP-5, -7,-8, and -65. Within 13.5 feet of boring depth and below the groundwater depth of 10 feet, most of the soil type is loose sandy silt. Based on the liquefaction analysis on FWP-3 within West Linn (from the WTP, west along Mapleton, and north along Highway 43 to Arbor Drive), we estimated 2.5 to 3.5 inches of settlement including approximate additional settlement of up to 1 inch in the soils below 13.5 ft. For the RWP between Mary S. Young State Park and the WTP along Mapleton Drive (including MA-1 through MA-4), the liquefaction potential is none to low except MA-4. The liquefaction analysis on MA-4 indicated about 2.5 to 3.5 inches of liquefaction-induced settlement.

At the WTP, GeoDesign report (2011) addressed that a 1975 boring completed by CH2MHill indicates the presence of very loose to loose sand between approximately 30 and 40 feet below ground surface. The report addressed that the liquefaction-induced settlement at the surface is low because the measured groundwater table is 30 feet below the ground surface and the upper soils are not subject to liquefaction. However, Shannon & Wilson performed a liquefaction evaluation at the water treatment plant site in October 2011 and determined up to 7½ inches of total liquefaction settlement and differential settlement of up to 1.6 inches over a distance of 40 feet could occur during a seismic event. Their findings were based on five borings and seven CPTs advanced up to 65 feet below ground surface (bgs). The pipeline design must include appropriate liquefaction mitigation to ensure that no damage will occur as a result of liquefaction during a major seismic event. Since the treatment plant site is situated within an area of relatively deep alluvium and the hills to the west are underlain by shallow bedrock and a boring near the river indicated shallow bedrock to the east, the transition between the liquefiable and non-liquefiable areas along the pipeline alignment is anticipated to be located near the east edge of the alluvium near Boring MA-3. Another type of seismically induced ground failure that can occur as a result of seismic shaking is dynamic compaction or seismic settlement. Such phenomena typically occur in unsaturated, loose, granular material or uncompacted fill soils. The subsurface conditions encountered in the borings performed for this study are not considered conducive to such seismically induced ground failures. Therefore, the potential for their occurrence along the proposed alignment is considered low. The estimated liquefaction induced settlement along specific locations of the RWP and FWP alignment is summarized in Table 4. The locations listed in Table 4 are approximate based on the current available boring data from GeoDesign and Shannon & Wilson.

Table 4. Liquefaction Potential and Liquefaction-Induced Settlement

Pipeline	Reach	Location	Boring	Liquefaction Potential	Liquefaction Settlement (inch)	Differential Settlement (inch)
RWP	1	HDD crossing, lower portion of Mapleton Drive slope	MA-1 through MA-3	None to very low	Negligible	Negligible
	2	Middle portion of Mapleton Drive slope to 300 feet east of WTP	MA-4	Moderate to High	2.5 to 3.5	0.6 to 1.6 over 40 feet
WTP and access area	3	Mapleton Drive within 300 feet of the WTP to east and west	B-1 to B-5; CPT-1 to CPT-7[a]	High	Up to 7 ½ Inches	0.6 to 1.6 over 40 feet
FWP	4	Mapleton Drive 300 feet west of WTP, along HWY 43, to Arbor Drive	FWP-10 through -1 and FWP-66 through -64; B-1, B-2, B-5 to B-8	Moderate except low potential at the borings including FWP-5, -7,-8, and -65	2.5 to 3.5	0.6 to 1.6 over 40 feet

[a] – Shannon & Wilson borings and CPTs (2011)

LATERAL SPREADING POTENTIAL

Lateral spreading is a post-liquefaction phenomenon consisting of blocks of soil "laterally spreading" due to either a gently sloping ground or an open face such as an open creek channel. During lateral spreading, blocks of non-liquefied soil could "float" on top of liquefied soils below. Lateral spreading has been observed in previous large earthquakes, even for gently sloping sites (slopes less than 0.5% slope). Lateral spread movements are typically greatest near a free face (such as the creek channels) and diminish with distance from the free face (Youd et al., 2002 and Zhang et al., 2004).

Due to low potential for liquefaction, lateral spreading potential is very low in Seismic Reach 1. Although liquefaction potential is high in Reaches 2 and 3, due to presence of relatively shallow basalt ridge near the river which serves as a buttress, the potential of lateral spreading is low. Eight additional geotechnical borings (B-1 to B-8) were drilled from Highway 43 to near the Willamette River to evaluate the subsurface conditions (Plate 4). Borings B-3 and B-4 were drilled within the city limits of Lake Oswego and have not been included. Borings were drilled to depths ranging from approximately 28 to 61 feet below ground surface. Vibrating wire piezometers were installed in B-1, B-5 and B-7 to estimate depth to groundwater. Based on the results field investigation, the potential for liquefaction is moderate. Potentially liquefiable materials below groundwater were encountered in boring B-2 along Highway 43. The thickness of potentially liquefiable materials ranges from 4 to 6 feet in Boring B-2. Therefore, the potential of liquefaction is moderate in the vicinity of this boring. Additional borings were also drilled east towards the Willamette River to estimate the extent of potentially liquefiable materials. Based on the results of lateral spread analysis performed using data from borings B-2 and B-7, we estimate lateral spreading of about 1 to 3 inches at the pipeline location on Highway 43, which translates into low potential of lateral spreading.

SEISMICALLY INDUCED SLOPE FAILURE

GeoDesign (2011) performed an infinite slope stability analysis to estimate the slope gradient for which failure could occur during a seismic event. Then, the critical slope gradient was compared with ground slopes gradient mapping from LiDAR data contours. After field reconnaissance, GeoDesign identified a high slope gradient area within and near Mary S. Young State Park. GeoDesign's 2011 report indicated a potential for seismically induced slope failure and considered the hazard was low to moderate in this area. The RWP alignment and installation method have been revised since the 2011 GeoDesign slope failure analysis. The RWP will now be now be installed via HDD methods to a location north of boring MSY-4 and MSY-5 and outside of the slope gradient area that GeoDesign determined had a low to moderate risk (see Figure 2A). The HDD alignment will be 30 to 60 feet below ground surface (bgs) within this area. The potential for slope failure affecting the HDD alignment at this location will be low because of its deep profile in rock. Based on GeoDesign's report, the open-cut portion of Reach 1 (starting north of MSY-4, MSY-5, and the slope gradient area) and Reaches 2, 3, and 4 have a low potential for seismically induced slope failure.

SUMMARY OF FINDINGS

Based on our review of the data, we have the following findings:

- Ground Surface Rupture – Based on the present analysis, the threat of damage to the RWP and FWP pipelines due to ground surface rupture is considered negligible to low. No additional design considerations are required to mitigate ground surface rupture.
- Ground Shaking – Pipeline design of the RWP and FWP should be based on a peak ground acceleration (PGA) of 0.55 g and a spectral acceleration at a 1 second period (S_1) of 0.7 g.
- Wave Propagation Damage – There is a low potential for RWP or FWP damage from seismic wave propagation. Pipeline design for the RWP and FWP shall be based on a peak ground velocity (PGV) of 28.5 to 37.7 inches per second.
- Liquefaction Hazard and Seismically-Induced Settlement – Based on data provided by GeoDesign and Shannon & Wilson, the liquefaction hazard along the RWP and FWP ranges from negligible to high depending on location. See Table 4 for expected seismically-induced settlement values that shall be used for RWP and FWP pipeline design. Total settlement values range from negligible at the HDD entrance location (at the bottom of Mapleton Drive) to 7.5 inches at the WTP site. Whereas, the differential settlement values range from 0.6 to 1.6

inches within a distance of 40 feet. These settlements should be considered in the pipeline design.

- Lateral Spreading Potential – Based on the available subsurface data, GeoDesign's seismic report, and the preliminary liquefaction analyses, the potential for lateral spreading around the pipelines is low. Based on the results of additional field investigation, lateral spreading potential is low for Reach 4.
- Seismically Induced Slope Failure – GeoDesign (2011) performed an infinite slope stability analysis to estimate the slope gradient for which failure could occur during a seismic event. Then, the critical slope gradient was compared with ground slope gradient mapping from LiDAR data contours. The risk of seismically induced slope failure for the open-cut portion of Reach 1 (north of MSY-4 on Figure 2A) and Reaches 2, 3, and 4 is considered low. No additional design considerations are required to mitigate the potential for seismically induced slope failures at this time.

CLOSURE

We appreciate the opportunity to provide these services to Kennedy-Jenks for the LOTWP project. Should you require additional information or have questions, please feel free to call Chad at (425) 636-7900 or Mark at (503) 644-9447.

Sincerely,

KLEINFELDER, INC.

Chad R. Lukkarila, PE
Senior Geological Engineer

Mark Swank, RG, CEG
Senior Engineering Geologist

Attachments: Seismic Figures

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KLEINFELDER

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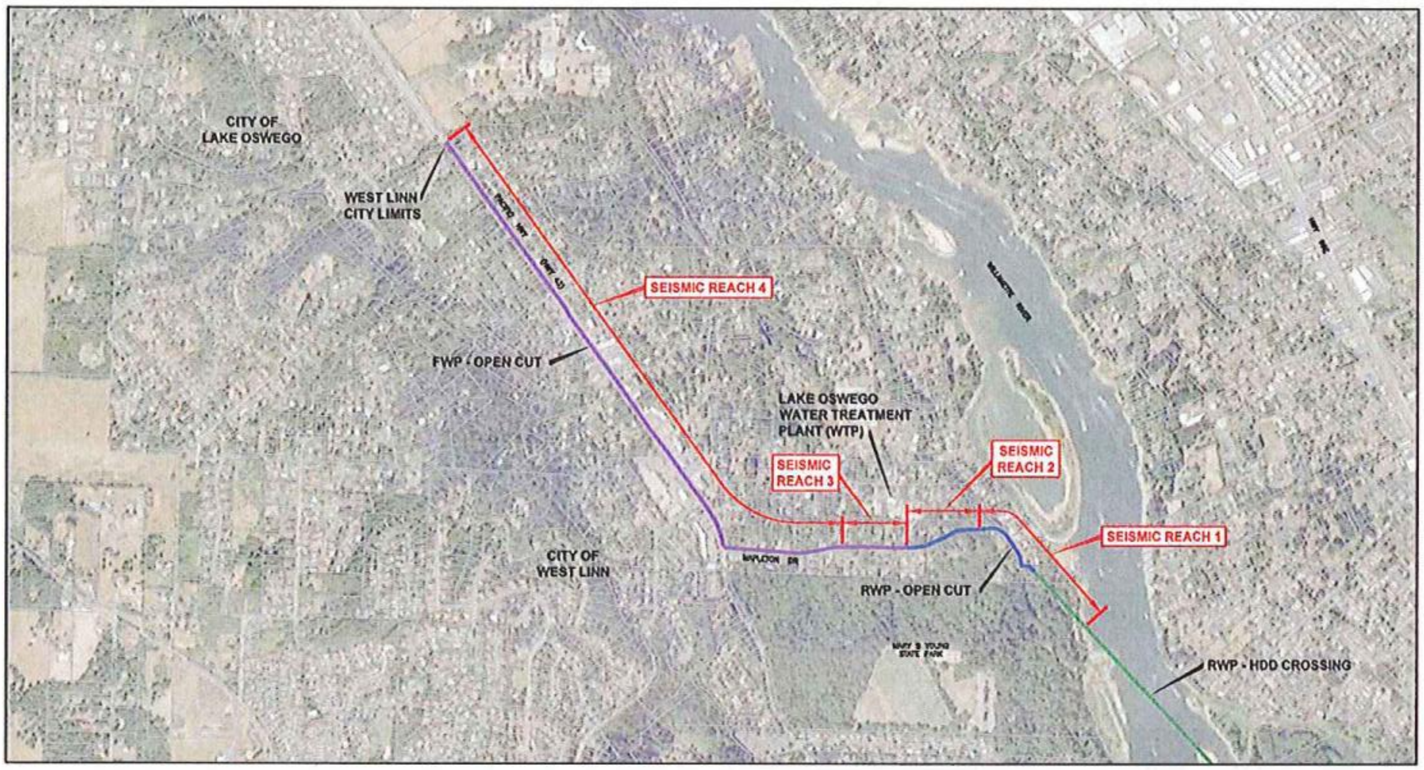
Plates



LEGEND

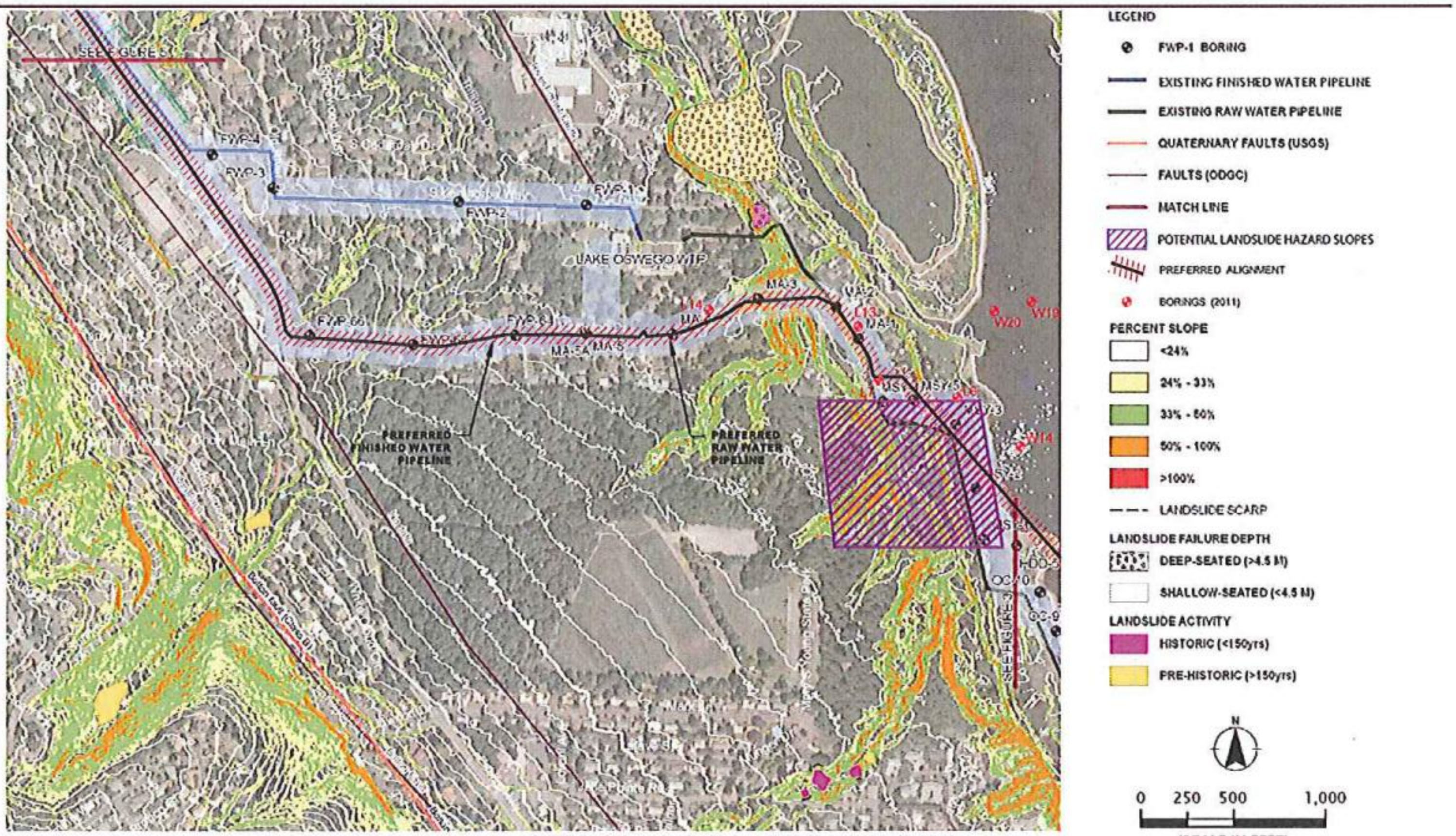
- RWP - OPEN CUT
- RWP - HDD CROSSING
- FWP - OPEN CUT

Reference: Kennedy-Jenks Consultants
June 2012

APPROXIMATE SCALE IN FEET

KLEINFELDER Bright People. Right Solutions. www.kleinfelder.com	PROJECT NO. 120587	REACH MAP	PLATE
	DRAWN: MAY 2012		1
	DRAWN BY:		
	CHECKED BY: MS		
	FILE NAME: rwp pipeline dwg	LAKE OSWEGO FINISHED & RAW WATER PIPELINE CLACKAMAS COUNTY, OREGON	

ATTACHED IMAGES: Images: Landslide and Fault Maps 1.jpg Images: Landslide and Fault Maps 2.jpg Images: Landslide and Fault Maps 3.jpg Images: Landslide and Fault Maps 4.jpg
ATTACHED XREFS: XRef_Eng-B_11x17_L_StyleA
PLEASANTON, CA CAD FILE: C:\Users\OSala\appdata\local\temp\AcPublish_4916\ LAYOUT: 1B PLOTTED: 30 May 2012, 5:02pm, JSala



REFERENCE: GeoDesign, Inc., Site Plan,Figure 4A, 4B, 5A and 5B, dated March 2011;
GeoDesign, Inc., Willamette River Crossing Alignment Alternatives Site Plan,Figure 2, dated March 2012.

10-FOOT TOPOGRAPHIC CONTOURS DERIVED FROM 2007 OREGON LIDAR CONSORTIUM
BORING LOCATIONS SURVEYED BY WESTLAKE CONSULTANTS OF LAKE OSWEGO, OREGON, OR FIELD LOCATED BY GEODESIGN PERSONNEL

LANDSLIDE DATA FROM DOGAMI LANDSLIDE INVENTORY (2010)
ORTHOPHOTO FROM OREGON IMAGERY EXPLORER
QUATERNARY FAULT DATA DERIVED FROM USGS (2009) ONLINE DATABASE

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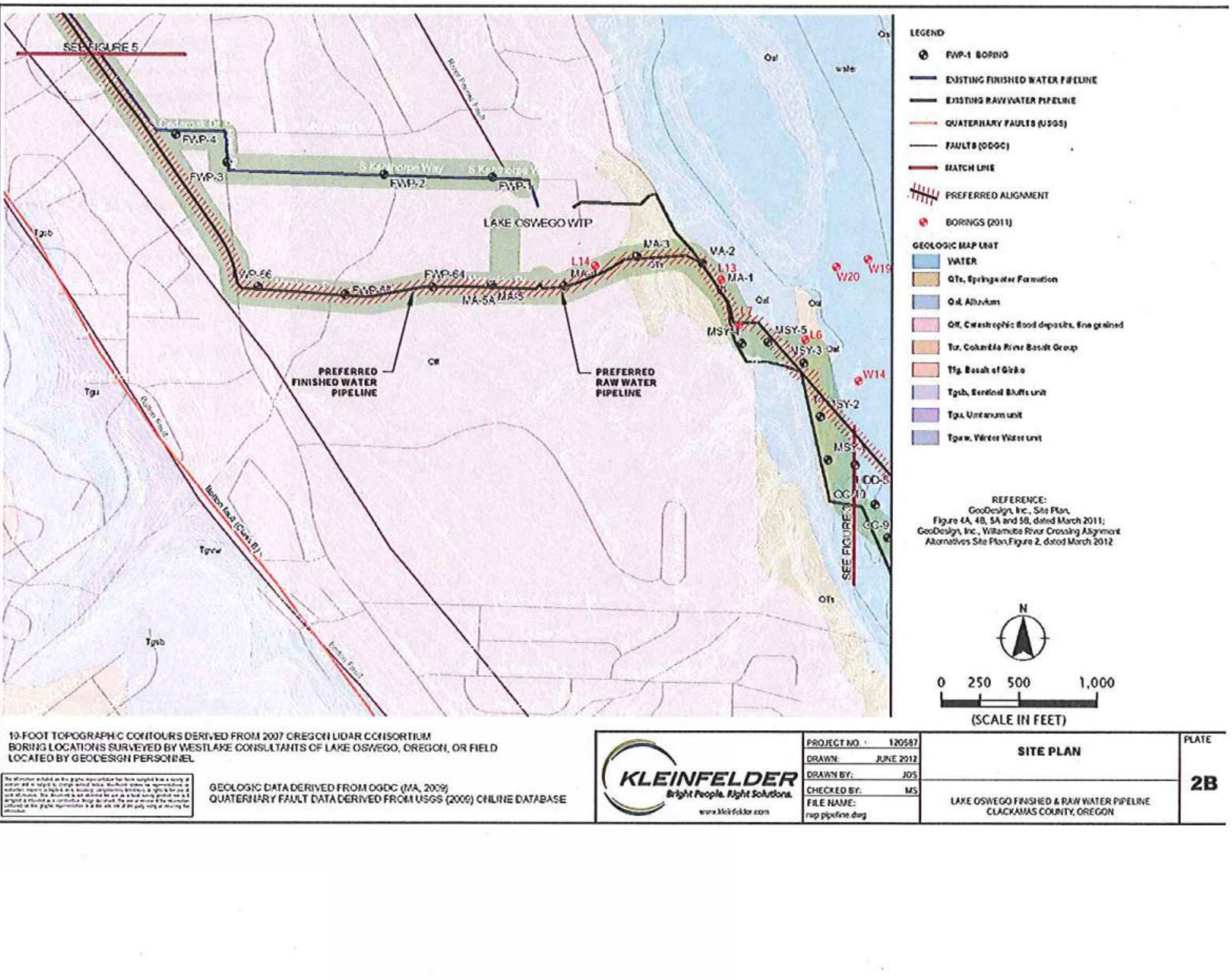
PROJECT NO.	120587
DRAWN:	MAY 2012
DRAWN BY:	JDS
CHECKED BY:	MS
FILE NAME:	rwp pipeline.dwg

SITE PLAN

LAKE OSWEGO FINISHED & RAW WATER PIPELINE
CLACKAMAS COUNTY, OREGON

PLATE
2A



ATTACHED IMAGES: Images: BrownCald-49-12-033012-geor 10.jpg Images: Landslide and Fault Maps 1.jpg Images: Landslide and Fault Maps 2.jpg Images: Landslide and Fault Maps 3.jpg Images: Landslide an
ATTACHED XREFS: XRef: Eng-B_11x17_L_StyleA
PLEASANTON, CA CAD FILE: C:\Users\JStewart\appdata\local\temp\AcPublish_6628 LAYOUT: 2B PLOTTED: 31 Jul 2012, 3:03pm, JStewart

10-FOOT TOPOGRAPHIC CONTOURS DERIVED FROM 2007 OREGON LIDAR CONSORTIUM
BORING LOCATIONS SURVEYED BY WESTLAKE CONSULTANTS OF LAKE OSWEGO, OREGON, OR FIELD LOCATED BY GEODESIGN PERSONNEL

GEOLOGIC DATA DERIVED FROM ODGC (MA, 2009)
QUATERNARY FAULT DATA DERIVED FROM USGS (2009) ONLINE DATABASE

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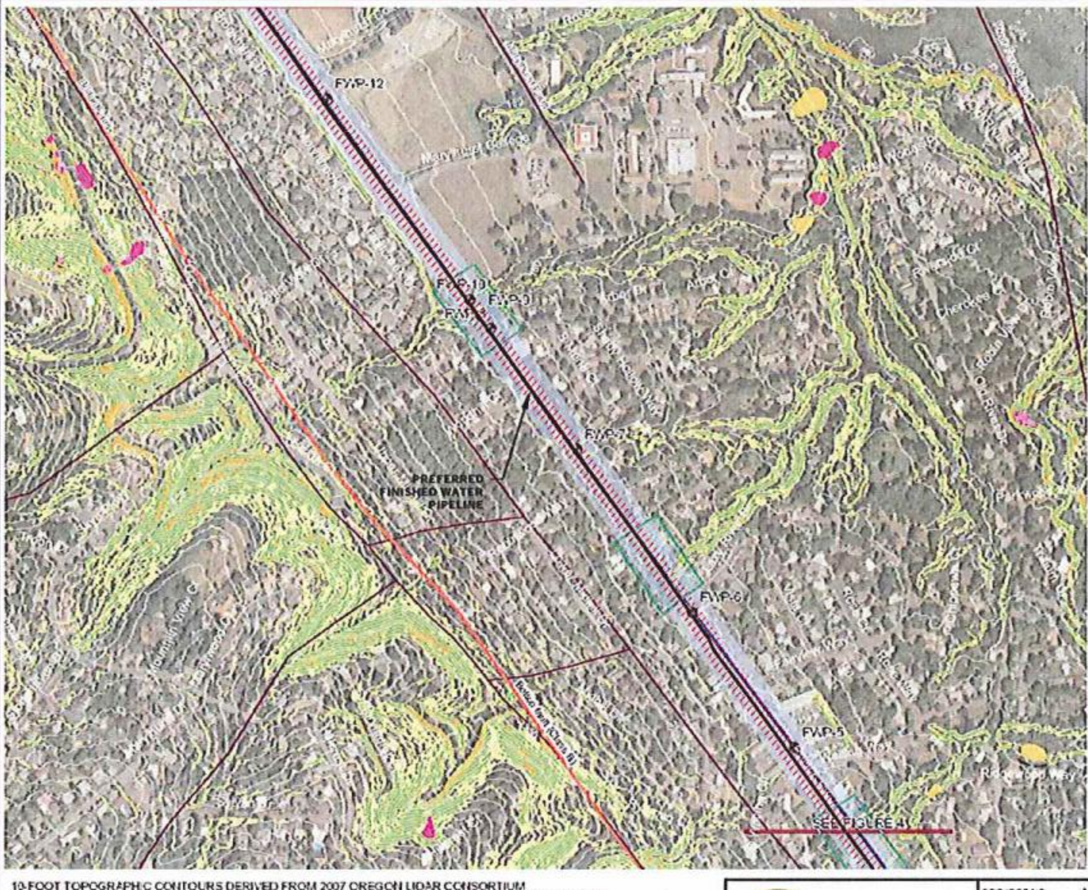
DRAWN:	JUNE 2012
DRAWN BY:	JOS
CHECKED BY:	MS
FILE NAME:	rwp pipeline.dwg

SITE PLAN

LAKE OSWEGO FINISHED & RAW WATER PIPELINE
CLACKAMAS COUNTY, OREGON

PLATE
2B



LEGEND

- FWP-1 BORING
- EXISTING FINISHED WATER PIPELINE
- EXISTING RAW WATER PIPELINE
- QUATERNARY FAULTS (USGS)
- FAULTS (ODGC)
- MATCH LINE
- FIELD-OBSERVED SLOPES
- PREFERRED ALIGNMENT

PERCENT SLOPE

- <24%
- 24% - 33%
- 33% - 50%
- 50% - 100%
- >100%
- LANDSLIDE SCARP

LANDSLIDE FAILURE DEPTH

- DEEP-SEATED (>4.5 M)
- SHALLOW-SEATED (<4.5 M)

LANDSLIDE ACTIVITY

- HISTORIC (<150yrs)
- PRE-HISTORIC (>150yrs)

N

0 250 500 1,000

(SCALE IN FEET)

REFERENCE:
GeoDesign, Inc., Site Plan,Figure 4A, 4B, 5A and 5B, dated March 2011

10-FOOT TOPOGRAPHIC CONTOURS DERIVED FROM 2007 OREGON LIDAR CONSORTIUM
BORING LOCATIONS SURVEYED BY WESTLAKE CONSULTANTS OF LAKE OSWEGO, OREGON, OR FIELD LOCATED BY GEODESIGN PERSONNEL

LANDSLIDE DATA FROM DOGAMI LANDSLIDE INVENTORY (2010)
ORTHOPHOTO FROM OREGON IMAGERY EXPLORER
QUATERNARY FAULT DATA DERIVED FROM USGS (2009) ONLINE DATABASE

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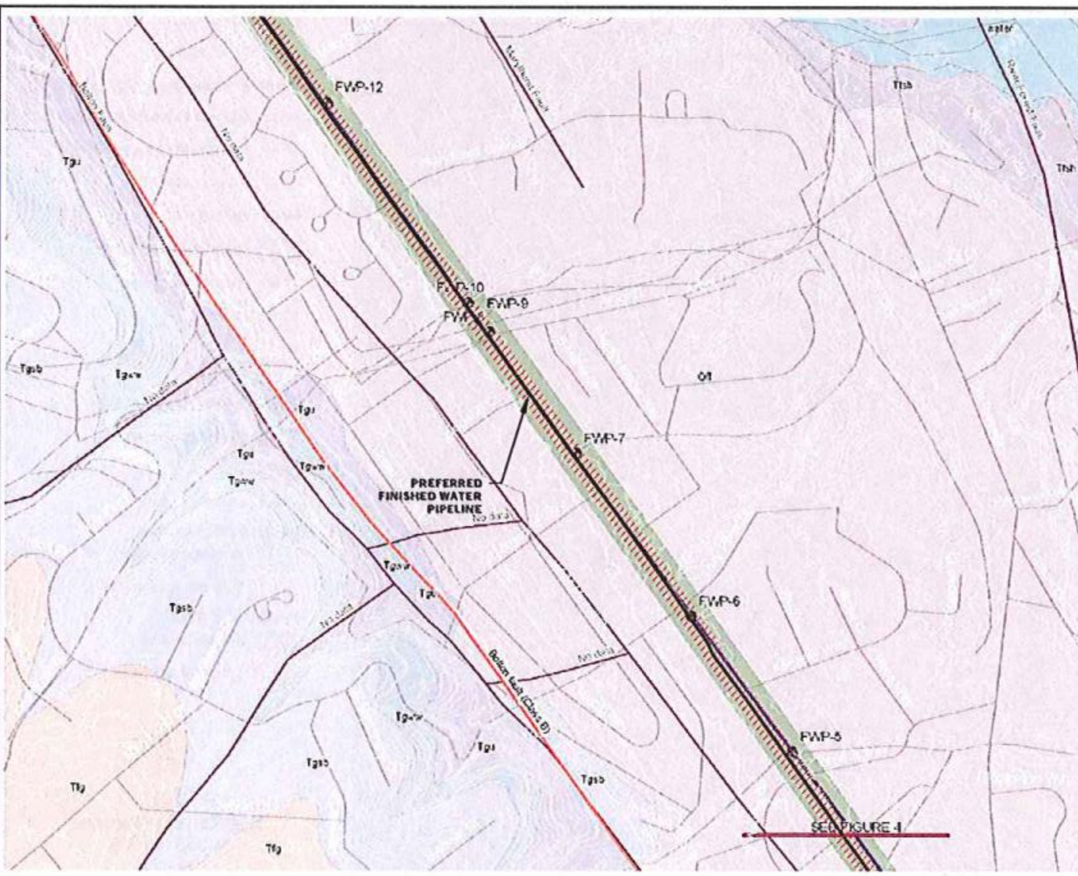
PROJECT NO.	120587
DRAWN:	JUNE 2012
DRAWN BY:	JDS
CHECKED BY:	MS
FILE NAME: rwp pipeline dwg	

SITE PLAN

LAKE OSWEGO FINISHED & RAW WATER PIPELINE
CLACKAMAS COUNTY, OREGON

PLATE
3A



LEGEND

- FWP-1 BORING
- EXISTING FINISHED WATER PIPELINE
- EXISTING RAW WATER PIPELINE
- QUATERNARY FAULTS (USGS)
- FAULTS (ODGC)
- MATCH LINE
- PREFERRED ALIGNMENT

GEOLOGIC MAP UNIT

- WATER
- QTs, Springwater Formation
- Qal, Alluvium
- Qff, Catastrophic flood deposits, fine grained
- Tcr, Columbia River Basalt Group
- Tfg, Basalt of Ginkgo
- Tgsb, Sentinel Bluffs unit
- Tgu, Umtanum unit
- Tgww, Winter Water unit

REFERENCE:
GeoDesign, Inc., Site Plan,
Figure 4A, 4B, 5A and 5B, dated March 2011

N

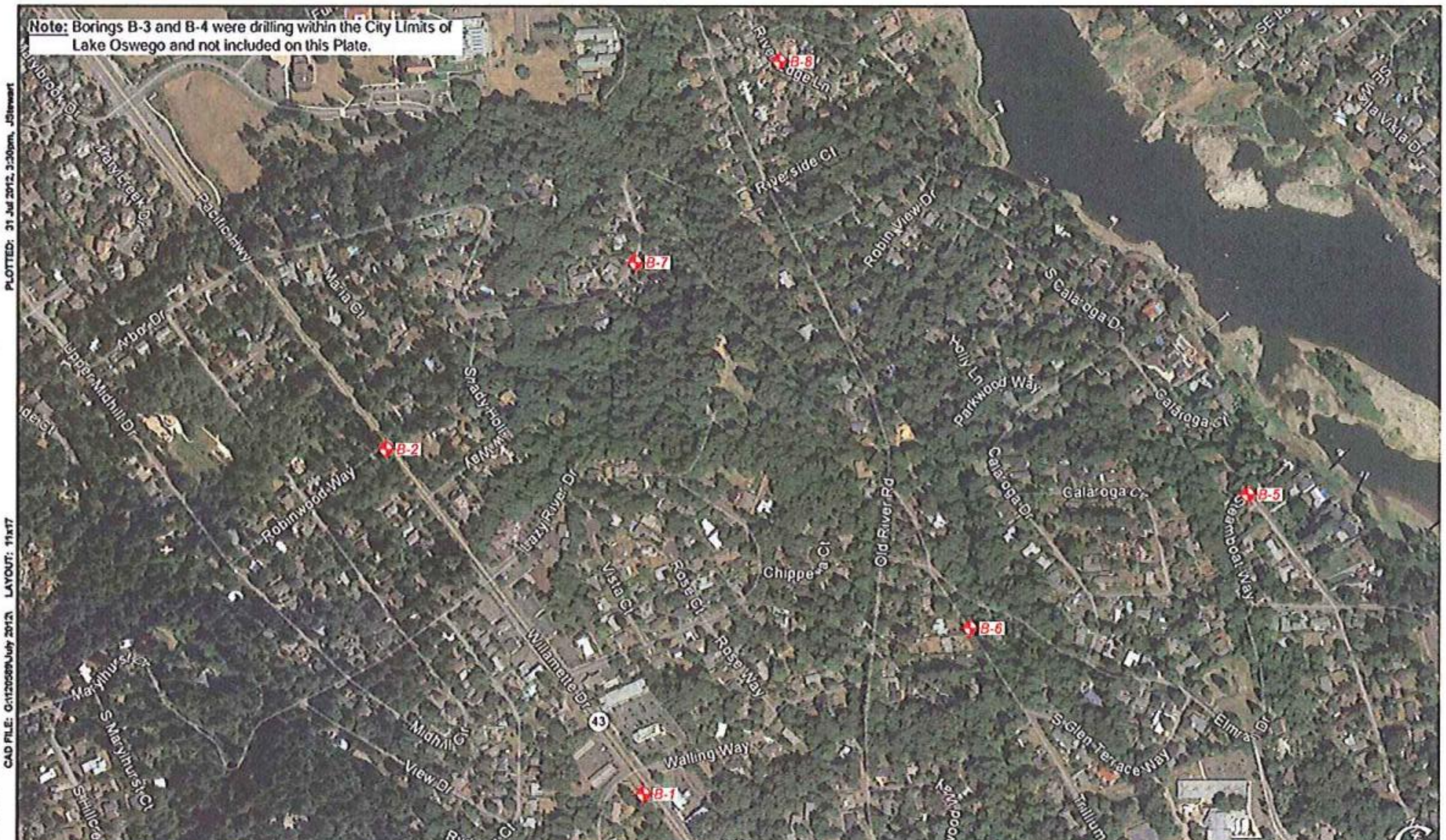
0 250 500 1,000
(SCALE IN FEET)

10-FOOT TOPOGRAPHIC CONTOURS DERIVED FROM 2007 OREGON LIDAR CONSORTIUM
BORING LOCATIONS SURVEYED BY WESTLAKE CONSULTANTS OF LAKE OSWEGO, OREGON, OR FIELD LOCATED BY GEODESIGN PERSONNEL

GEOLOGIC DATA DERIVED FROM OGDC (MA, 2009)
QUATERNARY FAULT DATA DERIVED FROM USGS (2009) ONLINE DATABASE

KLEINFELDER Bright People. Right Solutions. www.kleinfelder.com	PROJECT NO. 120587 DRAWN: JUNE 2012 DRAWN BY: JDS CHECKED BY: MS FILE NAME: rwp pipeline.dwg	SITE PLAN LAKE OSWEGO FINISHED & RAW WATER PIPELINE CLACKAMAS COUNTY, OREGON	PLATE 3B

Note: Borings B-3 and B-4 were drilling within the City Limits of Lake Oswego and not included on this Plate.



N

0 400

Scale in Feet

Legend

B-1 Additional Boring Locations (2012)

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PROJECT NO.	120587
DRAWN:	JULY 2012
DRAWN BY:	JJS
CHECKED BY:	MS
FILE NAME: Additional Explorations.dwg	

SITE PLAN ADDITIONAL HIGHWAY 43 EXPLORATIONS

LAKE OSWEGO FINISHED & RAW WATER PIPELINE
CLACKAMAS COUNTY, OREGON

PLATE
4

ATTACHED IMAGES: Images: Aerial_1600.jpg
ATTACHED XREFS:
SEATTLE, WA
CAD FILE: G:\120589\July 2012\ LAYOUT: 11x17
PLOTTED: 31 Jul 2012, 3:30pm, JStewart

Degenkolb Engineers

235 Montgomery Street, Suite 500
San Francisco, CA 94104-2908
Phone: 415.354-6486

Technical Memorandum

Date	August 3, 2012	**Job**	Lake Oswego Seismic Pipeline Design
To	Joel Komarek - Lake Oswego	**Job Number**	B2863004.00
	David Prock – Lake Oswego	**Subject**	Seismic Design Memorandum
From	Don Ballantyne		Final
	cc. Brad Moore – Kennedy Jenks		

Introduction and Overview

This memorandum reviews the seismic hazards and presents the pipeline mitigation proposed for the 42-inch raw water pipeline (RWP) and 48-inch finished water pipeline (FWP) for the Lake Oswego-Tigard Water Project (refer to Figure 1). The seismic hazard information on which this memorandum is based is contained in the attached letter from Kleinfelder to Kennedy/Jenks Consultants (K/J) dated August 3, 2012 and titled *West Linn Land Use Application Seismic and Geologic Hazards*. The identified risks and goals of this pipeline design are consistent with the *West Linn Natural Hazards Mitigation Plan*.

Historically, water pipelines have been vulnerable to earthquakes, particularly permanent ground deformation (PGD) due to liquefaction and associated lateral spreading. Many older pipeline systems were constructed with brittle pipe materials, unrestrained joints, and brittle welds all of which contributed to failures in earthquakes. Over the past several decades, engineers have developed pipeline systems that are resistant to these PGD hazards. The pipeline systems that perform the best when subjected to PGD include steel pipe with welded joints, ductile iron pipe (DIP) with restrained joints, and high density polyethylene pipe (HDPE) with fused joints (Ballantyne, 1994). The Owner/Engineer team has selected steel pipe with welded joints for this project. Steel pipe with welded joints is one of the best seismic resistant pipeline systems and will provide adequate mitigation for this project’s seismic environment.

Earthquake Risk and Geologic Hazards

Pipelines may be vulnerable to earthquake hazards including shaking and PGD. PGD includes liquefaction and associated settlement and lateral spread, landslide, lurching (movement of blocks of soil occurring in very intense shaking), and fault displacement. Lateral spread displacements occur when a layer of soil liquefies, and the soils above it flow downhill or towards a free face. Displacements can range from less than an inch to tens of feet.

The shaking intensity and probability and extent of PGD are a function of the specific earthquake event. The selected earthquake groundmotion is probabilistic, that is an earthquake with a probability of occurrence within 50 years and associated recurrence interval will produce a given groundmotion.

The American Society of Civil Engineers (ASCE) Section 7 and the International Building Code (IBC) approach the development of a seismic design event by starting with the groundmotion from an earthquake with a 2 percent probability of exceedance in 50 years (2,475 year return) and then multiplying that number by a factor of two-thirds for general building design. That seismic design event is then increased by a factor of 25 percent for important structures and by 50 percent for very important structures. The water system, including pipelines, can be considered very important because it provides water used for fire suppression following earthquakes. When the general building seismic design event is increased by a factor of 50 percent, the resulting design event is the full 2 percent in 50-year earthquake groundmotion. The design earthquake selected for the RWP and FWP projects is the 2 percent in 50-year groundmotion, which is consistent with the Lake Oswego Water Treatment Plant (WTP) upgrade design event. This level of earthquake is also consistent with the highest level of earthquake that is currently accepted worldwide for design and is typically used for life sustaining structures such as hospitals and other emergency response buildings.

Earthquake shaking results in differential movement of the soil along the pipeline corridor. Shaking may result in differential movement between pipe segments or, for continuous pipe, may impart strains along the pipe.

Liquefaction may result in consolidation of any existing liquefiable layers and may result in differential settlement in the overlying soils. Differential settlement is a function of the changing thickness of the liquefiable layer. If the liquefiable soils, or soil blocks above liquefiable soils are on a slope, they can move laterally down gradient, commonly referred to as lateral spread. A pipe that is buried in these moving soils will either be strained, or, if not properly designed, may have its joints pulled apart. In a similar fashion, landslides can exert strains on buried pipe. The goal of pipeline seismic design is to design a pipeline that will be able to withstand the stress and movement imparted into the pipe resulting from shaking and PGD. The next section of this report identifies design practices that enable pipelines to withstand these risks.

Mitigation – Pipe Design

There is no widely adopted seismic design code, standard, or guideline for water pipelines. The San Francisco Public Utility Commission (SFPUC) and the Los Angeles Department of Water and Power (LAPWP) are agencies that are on the forefront of addressing earthquake design issues, and are designing for levels of risk reduction comparable to those proposed for this project. The SFPUC has used welded steel pipe through much of its transmission system and installs welded steel pipe for all new pipe in its transmission system. In areas subjected to high values of PGD, SFPUC designs the joints to accommodate the expected stresses and strains using double lap weld joints and butt welded joints depending on the situation. The Los Angeles Department of Water and Power (LADWP) also uses steel pipe with welded joints for new pipe installed in their transmission system. In areas that are expected to be subject to high values of PGD, LADWP adjusts steel pipe wall thickness and welded joint design to accommodate the expected stresses and strains.

Using the design approaches of these utilities in highly seismic areas, most earthquake hazards that affect buried pipelines can be mitigated through proper selection and design of the pipe system. While soil improvement techniques have been shown to mitigate certain seismic risks such as liquefaction, lateral spread and differential settlement, for long linear pipe systems, such techniques are cost prohibitive. For long linear pipelines like those proposed for the RWP and FWP projects, these risks are best mitigated through proper selection of pipe materials, joint design and stringent quality control and quality assurance practices for weld inspection and installation.

The *Pipeline Research Council International Guidelines for the Seismic Design and Assessment of Natural Gas and Liquid Hydrocarbon Pipelines* (Honegger, 2004) provides guidelines for welded steel pipe design subjected to seismic loading. For bending such as due to differential settlement, pipe strains are a function of the pipe diameter. The pipe's resistance to buckling is a function of the pipe steel properties, the wall thickness, and joint design. The document provides two performance levels:

1. Maintain Pressure Integrity
2. Maintain Normal Operation.

The Maintain Pressure Integrity performance level allows the pipe to become oval and/or wrinkle as long as the pipe does not develop a leak. Pipe designed to this level of performance may have to be replaced in the years following the design earthquake, but will not rupture or leak. The Maintain Normal Operation performance limits stresses and strains in the pipe to a level which will prevent the pipe from ever experiencing ovaling and/or wrinkling. For this project, the Maintain Pressure Integrity performance criteria will be used.

Specific Design Considerations for Seismic Hazards

The following pipeline design factors are commonly considered for proper seismic mitigation. Seismic risks can be mitigated through pipe material selection, pipe joint selection, use of flexible joints, use of expansion sleeves, and use of pipe coatings and wrappings. This section will discuss the available options within each of these design considerations and the pros and cons of each option.

<u>Pipe Material:</u>

The current industry standard pipe material for pressurized water transmission lines similar to the RWP and FWP is either steel or ductile iron.

- <u>Welded Steel Pipe</u> – The welded steel pipe barrel has sufficient ductility to accommodate strains induced by ground shaking and PGD. Welded steel pipe wall thickness is customizable and can be slightly increased to provide additional accommodation to strains induced by seismic loading without overly affecting cost. Welded steel pipe is the standard used by many water utilities in high seismic risk areas, such as SFPUC and LADWP as previously discussed.
- <u>Ductile Iron Pipe</u> – Ductile iron pipe has sufficient ductility to accommodate bending loads due to PGD. The pipe is designed to accommodate PGD in its joints and is only considered equal to welded steel pipe when restrained joints and supplemental expansion joints are employed along the alignment.

Pipe Joint Connections:

Steel pipe welded joints must be sufficiently robust to be able to withstand stresses and strains induced by ground shaking and PGD. Ductile iron pipe joints must be designed to stay together and relieve strain in cases where significant PGD may be experienced. Ductile iron pipe systems sometimes employ expansion sleeves to relieve excess pipe strain that cannot be accommodated in the joints.

- Welded Steel Pipe – There are several different methods to weld joints together for welded steel pipe. Welding methodologies include butt welding, double-lap welding, and single lap welding. Additionally, some steel pipe uses gasketed bell and spigot joints.
  - Butt Welding – Butt welding involves welding two flush pieces of pipe together end to end. Steel pipelines with butt welded joints are commonly used in the oil and gas industry and are the strongest welded joint currently used for steel pipe. In the water industry, they are used where pipelines can be subjected to significant PGDs such as at fault crossings and areas of lateral spread. Butt welds are 1-1/2 to 2 times stronger than double-lap welds. This difference can be made up by using thicker wall pipe if using double-lap welds. Butt welding may result in longer construction durations than other steel pipe welding designs.
  - Double-lap Welding – Double-lap welding involves welding two pieces of pipe together where the spigot end slides inside the bell end. One weld is made on the outside and one on the inside of the pipe. As noted above, double-lap weld pipeline systems can be made as strong as butt-weld pipe systems by increasing the pipe wall thickness. This double weld geometry makes the longitudinal loading along the pipe wall more symmetrical across the joint. Steel pipelines with gasketed bell and spigot joints sometimes employ lap welds near bends to provide restraint for thrust. Installing pipe with double-lap welds is faster than with butt welds.
  - Single Lap Weld – Single lap welding is the industry standard for welded steel pipe water lines. It is similar to double-lap welding, but only the inside or the outside of the pipe bell connection is welded. Many agencies in high seismic areas such as the SFPUC and LADWP use single lap welds for pipelines except for where PGD and/or particularly high ground motions are expected.
  - Restrained Push-On Joints – Restrained bell and spigot steel joints are sometimes used for thrust resistance in a pipeline system otherwise using unrestrained joints. Restrained joints are suitable for use in seismic areas as they can be designed to accommodate bending.
  - Unrestrained Push-On Joints – Unrestrained bell and spigot steel joints are commonly used in areas where restrained pipeline joints are not needed. These joints are comparable to standard ductile iron push-on joint pipe. Unrestrained joints are typically not recommended in areas with shaking that is significant enough to result in joint separation.
- Ductile Iron Pipe – There are two main ways that sticks of ductile iron pipe are connected, restrained and unrestrained push-on joints.

- Restrained Push-On Joints – Restrained ductile iron joints are achieved by modifying typical ductile iron unrestrained push-on joints with a mechanical restraining device. There is a limited amount of ductile iron pipe with restrained joints that has been subjected to earthquakes. While ductile iron pipe has been used since the 1970s, very small amounts have been installed with joint restraints, typically used for thrust restraint. The last major earthquake in the U.S. mainland was in 1994. However, the Japanese have been using ductile iron pipe with a special seismic joint with significant exposure in major earthquakes starting with Kobe in 1995. The special seismic joint provides restraint as well as some extension/compression capacity. There have been no reported failures of this type of pipe. Additional expansion sleeves must be added to the pipe system to relieve pipe strain in areas with high expected PGD values.
- Unrestrained Push-On Joints – Unrestrained bell and spigot ductile iron joints are commonly used in areas where restrained pipeline joints are not needed. These joints are comparable to unrestrained push-on joint steel pipe. Unrestrained joints are typically not recommended in areas with shaking or PGD that is significant enough to result in joint separation.

Flexible Joints and Expansion Sleeves:

Mechanical joints and/or expansion sleeves are used to allow movement in location where PGD would otherwise create stresses too high for the pipe material or pipe joints to handle.

- Flexible Joints – Flexible joints are designed to allow joint rotation. They are used in pipe systems where the pipe joints cannot accommodate the expected rotation that may occur as a result of differential settlement such as the interfaces between pile supported structures and direct buried pipe. A segmented ductile iron pipe system with flexible joints installed at regular intervals can be designed to withstand shaking and PGD forces equivalent to a continuous welded steel pipe system.
- Expansion Sleeves – Expansion sleeves are used to relieve the expected strain due to lateral spread or landslide. They would be used if the pipe does not have adequate ductility to accommodate the pipe strain. A segmented ductile iron pipe system with expansion sleeves integrated into the system at regular intervals can be designed to withstand shaking and PGD forces equivalent to a continuous welded steel pipe system. The City of Seattle has employed this design in a liquefaction area.

Pipe Coatings and Wrappings:

The pipe will be lined and coated with a ductile material that will move with the pipe wall up to 2% strain. If mortar coating is used on the interior, there is potential for it to crack off when the pipe deforms. While this is not a structural issue, it can hamper pipeline operation following an earthquake. The pipe will be tape wrapped which will allow the steel pipe wall to maintain its ductility, important to achieve its intended seismic performance.

A combination of a pipe coating and wrapping, or two layers of wrapping should be used to reduce friction between the pipeline and surrounding soils if the pipe is designed to move through the soil when subjected to lateral spreading.

Design for Specific Hazards

The specific risks of ground surface rupture, ground shaking, wave propagation, liquefaction and seismically induced settlement, lateral spreading potential, and seismically induced slope failures as identified in the Kleinfelder seismic hazard identification letter are discussed in this section. A general design methodology is provided as a framework for each identified risk. The general design methodology framework will then be applied to determine the seismic design recommendations for each specific Seismic Reach as defined by Kleinfelder.

Ground Surface Rupture

There is negligible to low risk of ground surface rupture. There are no active faults (activity within the last 10,000 years) within the area where the pipelines will be installed.

Ground Shaking

These are measures of shaking intensity. The peak ground acceleration (PGA) is 0.55 times gravity for the design earthquake (2,475-year return period or 2 percent probability of exceedance in 50 years). This is used to determine the potential for the occurrence of various geotechnical hazards. The 1-second spectral acceleration is 0.70 times gravity and is related to the PGA. The spectral acceleration is used to calculate the peak ground velocity (PGV) that is used to assess the reliability of the pipe joint. The maximum PGV is 37.7 inches per second. Steel pipe with welded joints can accommodate this level of PGV without damage.

Liquefaction, Seismically Induced Settlement, and Seismically Induced Differential Settlement

The liquefaction potential is based on PGA, duration of shaking, the groundwater table, and various soil properties. Seismically induced settlement is based on the thickness and properties of the liquefiable soil layer. Liquefaction settlement does not directly affect the pipeline design except at the interface between pile supported and direct buried pipe. The seismically induced differential settlement is a function of the varying thickness of the liquefiable layer and the non-homogeneity of the liquefiable layer. These three parameters vary by Pipeline Reach. Refer to Table 1 for values by Reach.

Lateral Spreading Potential

Lateral spreading potential for Reach 1 is none to very low because the liquefaction potential is none to very low. The lateral spread potential for Pipeline Reaches 2 and 3 is low because of the presence of a shallow basalt ridge which serves as a buttress. The lateral spread potential for Pipeline Reach 4 is low based on geotechnical analysis of data from borings B-2 and B-7 (see Kleinfelder report for locations). The pipe wall thickness/joint combination will be designed in accordance with *Guidelines for the Seismic Design and Assessment of Natural Gas and Liquid Fuel Hydrocarbon Pipelines* (Honegger, 2004) to the “Maintain Pressure Integrity” level of service.

Seismically Induced Slope Failures

Based on the Kleinfelder letter, the risk of seismically induced slope failure for Reaches 1 through 4 is low.

Hazard Evaluation and Proposed Mitigation by Pipeline Reach

The RWP and FWP pipelines are shown in "reaches" on Figure 1. The liquefaction potential, liquefaction settlement, and differential settlement for each of those reaches are summarized in Table 1. The earthquake risk for the other hazards discussed above is none to low.

Table 1. Liquefaction Potential and Liquefaction-Induced Settlement (from Kleinfelder Letter)

Pipeline	Reach	Liquefaction Potential	Liquefaction Settlement (inch)	Differential Settlement (inch)	Pipe Wall Thickness
RWP	1	None to very low	Negligible	Negligible	¼ inch
	2	Moderate to High	2.5 to 3.5	0.6 to 1.6 over 40 feet	¼ inch
WTP and access area	3	High	Up to 7 ½ Inches	0.6 to 1.6 over 40 feet	¼ inch
FWP	4	Moderate except low potential at the borings including FWP-5, -7,-8, and -65	2.5 to 3.5	0.6 to 1.6 over 40 feet	¼ inch

Steel pipe will be used for the RWP and FWP within West Linn city limits. The steel pipe will be designed in accordance with *Guidelines for the Seismic Design and Assessment of Natural Gas and Liquid Hydrocarbon Pipelines* (Honegger, 2004). The steel pipe will use a minimum 36 ksi yield strength steel. The pipe wall thickness is as shown on Table 1. The steel stress-strain curve should contain no plateau regions so as to redistribute strains when plastic deformation begins to occur (PRCI, 2004).

Reach 1

Reach 1 is subjected to negligible liquefaction and differential induced settlement and low potential for seismically induced slope failures. Welded steel pipe with a wall thickness of ¼" with double-lap welds will be able to accommodate these earthquake hazards.

Reach 2

Reach 2 is subjected up to 1.6 inches in differential settlement and low potential for seismically induced slope failures. Welded steel pipe with a wall thickness of ¼" with double-lap welds will be able to accommodate these earthquake hazards.

Reach 3

Reach 3 is subjected up to 1.6 inches in differential settlement and low potential for seismically induced slope failures. Welded steel pipe with a wall thickness of ¼" with double-lap welds will be able to accommodate these earthquake hazards. Reach 3 is subjected up to 7-1/2 inches of liquefaction settlement. A specially designed mechanical pipe connection system (such as two ball joints separated by an expansion sleeve) designed to accommodate differential settlement between the WTP pile supported structures and the direct buried pipe should be employed.

Reach 4

Reach 4 is subjected up to 1.6 inches in differential settlement and low potential for seismically induced slope failures. Welded steel pipe with a wall thickness of ¼" with double-lap welds will be able to accommodate these earthquake hazards.

Conclusion

This memo addresses the seismic risks identified in the attached letter from Kleinfelder and proposes design mitigation so the pipelines will be able to withstand the design seismic event. The design earthquake used to identify pipeline seismic risks has a recurrence of 2,475 years and is consistent with the standards used for hospitals and other emergency response buildings. These risks will be minimized and mitigated through the proposed design methods in this memorandum. The pipeline is being seismically designed in accordance with the *Pipeline Research Council International Guidelines for the Seismic Design and Assessment of Natural Gas and Liquid Hydrocarbon Pipelines* (Honegger, 2004) to the Maintain Pressure Integrity performance level. Welded steel pipe with a 1/4-inch wall thickness will be used with double-lap welds to accommodate earthquake hazards identified in the Kleinfelder letter.

References

American Society of Civil Engineers, 2010, ***ASCE/SEI 7-10, Minimum Design Loads for Buildings and Other Structures,*** American Society of Civil Engineers, Washington, DC.

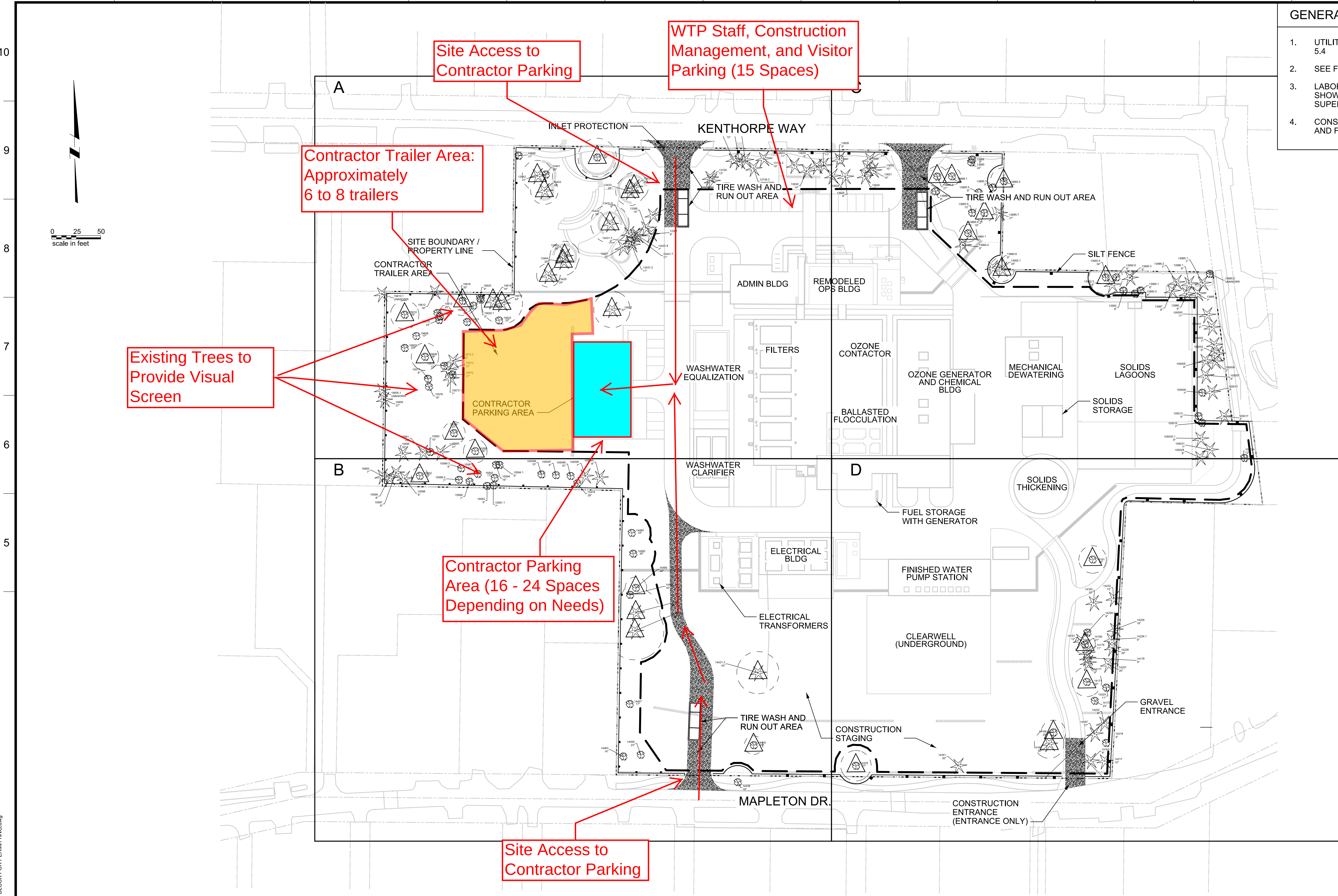
Ballantyne, Donald, 1994, ***Minimizing Earthquake Damage, A Guide for Water Utilitie***s, American Water Works Association, Denver Colorado.

Ballantyne, Donald; CB Crouse, 1997, ***Reliability and Restoration of Water Supply Systems for Fire Suppression and Drinking Water Following Earthquakes,*** NIST GCR 97-730, National Institute of Standard and Technology, Gaithersburg Maryland.

Ballantyne, Donald, 2010, "Seismic Vulnerability Assessment and Design of Pipelines", ***Journal of the American Water Works Association*** 102:5, AWWA, Denver Colorado, May.

International Building Code, 2012, International Code Council, Washington, DC.

Honegger, D.G., and D.J Nyman, 2004, ***Guidelines for the Seismic Design and Assessment of Natural Gas and Liquid Fuel Hydrocarbon Pipelines***, prepared for the Pipeline Design, Construction & Operations Committee of the Pipeline Research Council International, Contract PR-268-9823, Houston Texas.



GENERAL SHEET NOTES

1. UTILITIES NOT SHOWN FOR CLARITY. SEE FIGURES 5.0 - 5.4
2. SEE FIGURES 11.0 - 12.6 FOR PLANTING PLAN.
3. LABORER PARKING WILL BE OFF-SITE. CONTRACTOR PARKING SHOWN IS FOR VISITORS, MANAGEMENT STAFF, AND SUPERVISORY PERSONAL ONLY.
4. CONSTRUCTION STAGING AREAS SHOWN MAY BE USED FOR RWP AND FWP CONSTRUCTION.

LEGEND

- INLET PROTECTION
- TREE PROTECTION FENCE
- GRAVEL SITE ENTRANCE
- SILT FENCE/SECURITY FENCE
- CONSTRUCTION STAGING LIMIT
- TREE OF SIGNIFICANCE

MWH
806 SW BROADWAY, SUITE 200
PORTLAND, OREGON 97205

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2" - SCALE ACCORDINGLY)

DESIGNED: ####
DRAWN: ####
CHECKED: ####
CHECKED: ####
APPROVED: ####

REVISIONS

REV.	DESCRIPTION	BY		APP.

OWNER:
CITY OF LAKE OSWEGO
380 A AVENUE
LAKE OSWEGO, OR 97034
PHONE: 503-635-0270

Lake Oswego · Tigard Water Partnership
sharing water · connecting communities

LAKE OSWEGO AND TIGARD WATER TREATMENT PLANT
DESIGN REVIEW AND CONDITIONAL USE
CONSTRUCTION MANAGEMENT OVERVIEW

PRINT DATE 08/20/12
PROJECT NUMBER
SCALE 1" = 50'
DRAWING/FIGURE NUMBER 6.0
OF

PLOT DATE: September 10, 2008 - 1:55PM USER: albrast
FILE: C:\pwworking\dms52971\38564- TITLE BLOCK FOR PERMITTING.dwg

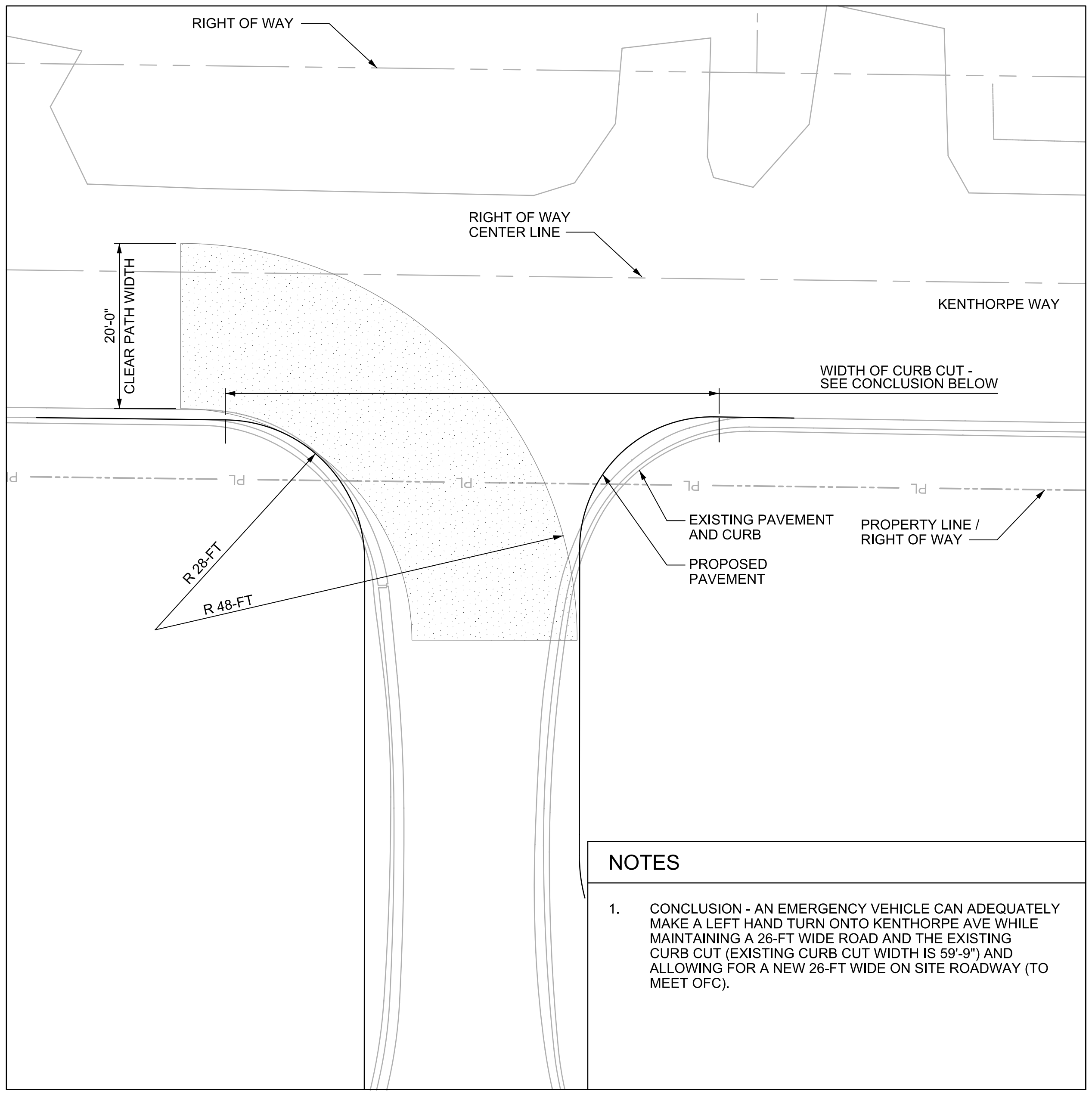
SECTION 14A - APPENDIX B

CONSTRUCTION TRAILERS EXAMPLE

Contractors typically use construction trailers similar to the examples depicted in the photograph above. Construction trailers are single story and less than 14’ in height. The contractor and owner representative will use the trailers for on site office space to manage construction. The contractor will connect the trailers to electricity, and in some cases, water and sewer. Trailers will be located at the WTP site for the duration of construction only. Trailers are not illuminated at night. At the WTP, the trailers will provide additional buffer to the neighbors from the contractor parking area and construction activity.

GENERAL SHEET NOTES

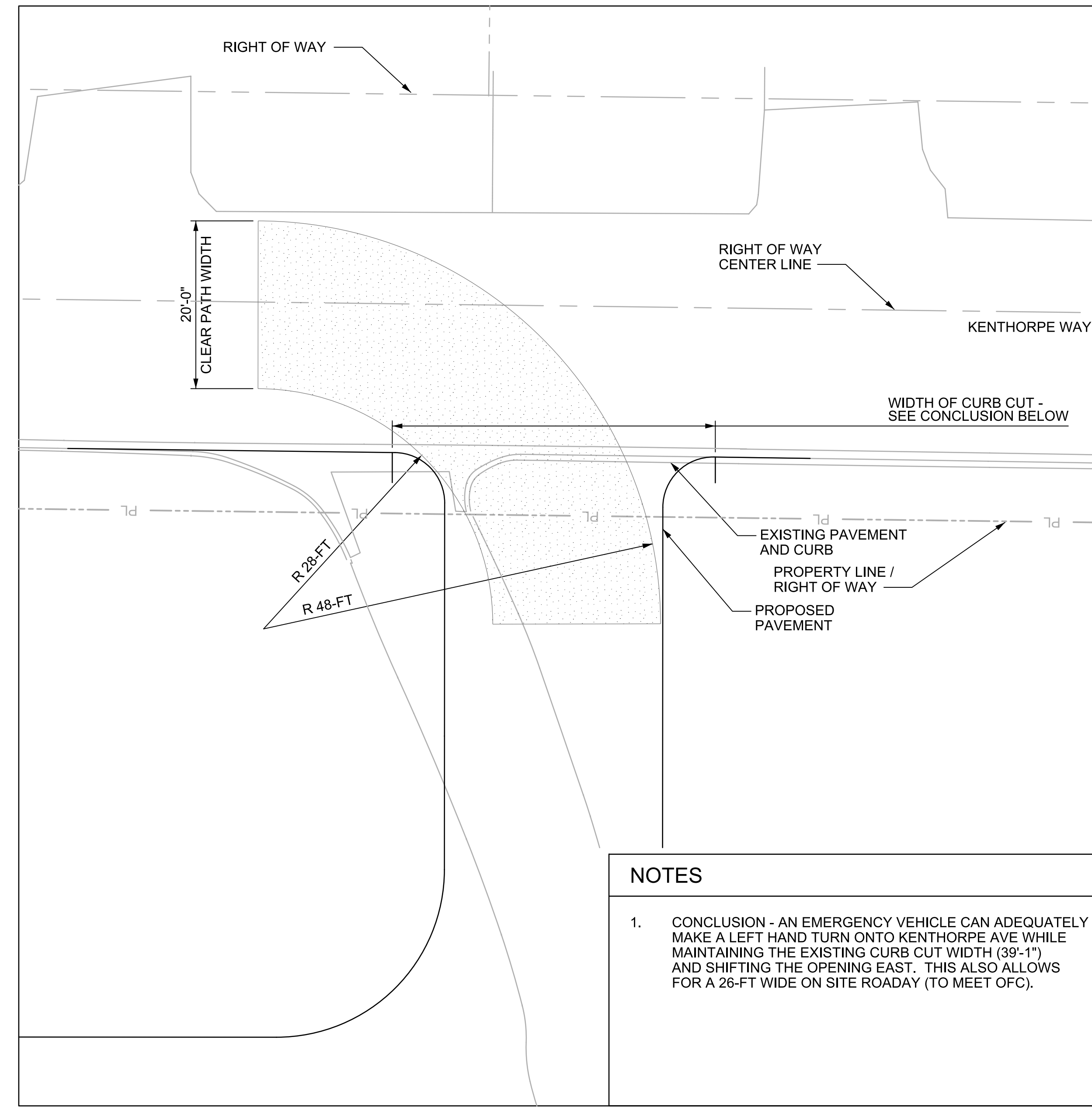
1. DESIGN CRITERIA TAKEN FROM CAPTAIN KAREN MOHLINGS LETTER DATED OCTOBER 28, 2011: RADIUS DATA TAKEN FROM ITEM # 12 AND 'CLEAR PATH WIDTH' TAKEN FROM ITEM # 7. CAPTAIN MOHLING ALSO PROVIDED A 'TEMPLATE' WHICH CONFIRMS THE REQUIRED TURNING RADIUS AND ROAD WIDTH.
2. EAST BOUND TURNS FROM EITHER ACCESS POINT ARE NOT NECESSARY AS KENTHROPE IS A DEAD END STREET.



NOTES

1. CONCLUSION - AN EMERGENCY VEHICLE CAN ADEQUATELY MAKE A LEFT HAND TURN ONTO KENTHORPE AVE WHILE MAINTAINING A 26-FT WIDE ROAD AND THE EXISTING CURB CUT (EXISTING CURB CUT WIDTH IS 59'-9") AND ALLOWING FOR A NEW 26-FT WIDE ON SITE ROADWAY (TO MEET OFC).

WEST PLANT ENTRANCE



NOTES

1. CONCLUSION - AN EMERGENCY VEHICLE CAN ADEQUATELY MAKE A LEFT HAND TURN ONTO KENTHORPE AVE WHILE MAINTAINING THE EXISTING CURB CUT WIDTH (39'-1") AND SHIFTING THE OPENING EAST. THIS ALSO ALLOWS FOR A 26-FT WIDE ON SITE ROADAY (TO MEET OFC).

EAST PLANT ENTRANCE

MWH

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2" - SCALE ACCORDINGLY)

DESIGNED: A ODELL
DRAWN: A ODELL
CHECKED:
CHECKED:
APPROVED:

APPROVED: ______ (DESIGN FIRM NAME) DATE: ______

REVISIONS

REV.	DESCRIPTION	BY		APP.

60% DESIGN

Lake Oswego · Tigard Water Partnership
sharing water · connecting communities

LAKE OSWEGO - TIGARD WATER TREATMENT PLANT

CIVIL

FIRE ENTRANCE

FILENAME: 138564- TITLE BLOCK
PROJECT NUMBER: (PROJECT #)
SCALE: 1" = 10'
DRAWING/FIGURE NUMBER: -
OF

PLOT DATE: September 10, 2008 - 1:55PM USER: slbraat
FILE: C:\pwworking\mwa\d5529\138564- TITLE BLOCK.dwg

Oveson, Pete

From: Oveson, Pete
Sent: Thursday, September 27, 2012 11:18 AM
To: Oveson, Pete
Subject: FW: Quick question this morning

From: Brian Copeland [mailto:bkc@dksassociates.com]
Sent: Thursday, September 27, 2012 10:46 AM
To: Oveson, Pete
Cc: Brad Moore; Monica Leal
Subject: Re: Quick question this morning

Hi Pete -

Although "acceptable" levels of traffic in residential areas vary from community to community, a typical acceptable maximum ADT (average daily traffic) on a local residential roadway (such as Kenthorpe) would be approximately 1,500. For a neighborhood collector in a residential area (such as Mapleton), traffic volumes would typically range from 1,500 to 3,500 ADT. Even with the additional construction traffic, traffic levels on Mapleton and Kenthorpe will remain well within these typical volume ranges.

Please let me know if you need additional information or have any more questions.

Thanks,

brian

Brian K. Copeland, PE, PTOE

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