EXHIBIT 13
CUP16-02

SECTION 13 –30% PUBLIC ROADWAY DESIGN SUMMARY

MEMO

ROBERTSON ENGINEERING, PC
610 Esther Street, Suite 102, Vancouver, WA 98660
(360) 975-4995 | www.robertsonengineering.us

To: **City of Camas**

From: Jeremy Fick, PE
John Baldwin, PE
Robertson Engineering, PC

Date: November 10, 2016

Re: **Lacamas Heights E.S. Off-Site Road Improvements – 30% Design Summary**

Robertson Engineering is designing a new public roadway in association with the proposed Lacamas Heights Elementary School. The 40-acre school site is located northeast of the intersection of NE 232nd Avenue and NE 9th Street. Both 232nd Avenue and 9th Street are identified as future 3-lane arterials in the City of Camas's (City) Comprehensive Plan with 232nd Avenue as a local access road and trail south of 9th Street. The new road is being designed as the first phase (Phase 1) of the future 3-lane urban arterial planned by the City. The purpose of this memo is to provide the City with the information necessary to evaluate and approve the preferred alignment and basic design criteria used for the road design.

The 40-acre site has several documented wetlands and Oregon white oak trees, and is partially wooded in the SW quadrant where the new public roadway is planned. The new elementary school will be approximately 73,500 s.f. in size, and serve 700 students. It is estimated that the school will generate an average daily trip count of 774 during school days. The goal of the project is to provide the school with appropriate access via a new two-lane road that will function on an interim basis. The new roadway will be expanded and extended in the future by others to a 3-lane urban arterial. As such, the new interim (Phase 1) roadway will be designed to accommodate future expansion and to meet design standards for the urban arterial where feasible.

All of the land south of the proposed north right-of-way line (37' offset from the proposed future arterial centerline) is proposed to be dedicated to the City as right-of-way. This area totals approximately 222,524 square feet (5.11 acres). Dedicating this entire area allows for future improvements, such as road widening, local access, trailhead, wetland mitigation, and stormwater treatment and detention.

This 30% Design Summary Memo addresses the following:

- Typical roadway cross-section.
- Horizontal alignment for future urban arterial through the site (to be used as basis for Phase 1 roadway design), and right-of-way required for urban arterial
- Vertical alignment for construction of Phase 1 roadway and future urban arterial through site.
- Intersection layout at NE 232nd Ave. and at school entrance.
- Sight distance compliance for roadway and intersections.
- Preliminary stormwater management strategy.

CROSS-SECTION

The proposed cross-section of the Phase 1 roadway is slightly larger than half of the future 3-lane arterial, as shown in City of Camas Standard Detail ST5. The roadway pavement will be a minimum of 26 ft. wide, providing for two 13 ft. lanes of traffic. The north side of the road will have curb and gutter, a landscape planter (where appropriate), 6 ft. sidewalk, and 6 ft. public utility easement per Standard Detail ST5. The south side of the Phase 1 roadway will consist of an edge of asphalt and a 2 ft. gravel shoulder. The Phase 1 roadway will have a shed section, sloping towards the curb and gutter at 2% cross-slope.

Some modifications to Standard Detail ST5 are proposed to minimize impacts to existing mature trees. For approximately 240 lineal feet of the north side of the road, the typical section incorporates attached sidewalk and 2:1 slopes as opposed to detached sidewalks and 4:1 maximum slopes. These are reflected in the 30% roadway drawings. While the curb-tight sidewalk eliminates the planter strip where implemented, it maintains more of the existing large trees in the forested area. These two modifications save approximately 19 large established trees.

One additional potential modification to the standard section is to place the Public Utility Easement (PUE) under the sidewalk in the areas of large existing trees in order to further minimize the removal of trees. This also may help prevent root damage to the utilities in the future. This can be further discussed and explored, if desired.

HORIZONTAL ALIGNMENT

The new roadway departs from NE 232nd in a sweeping curve, then transitions to a tangent heading SE towards NE 9th St. In Phase 1, the roadway will terminate immediately after its intersection with the new school access road, providing passenger car, bus, and service truck access to the new elementary school. During Phase 1, connectivity between the new road and NE 232nd will be maintained by the addition of a new connector road.

The preferred alignment presented (design alignment) will be the centerline of the future urban arterial roadway. The design alignment generally runs 3.0' north of the south edge of pavement of the Phase 1 roadway. The Phase 1 roadway is being designed to allow for final build-out of the urban arterial while limiting reconstruction. The Phase 1 roadway will conform to the same geometrical standards and design speed as the built-out urban arterial. Upon future build-out, the Phase 1 roadway will be sawcut at the centerline of right-of-way. All features north of the sawcut will remain, and everything south of the sawcut will be reconstructed.

The preferred alignment was determined by physical site constraints and geometrical design standards. The road is constrained by a wetland to the south and will impact a forested area north of the wetland. The preferred alignment skirts the northern boundary of the wetland, with no soil disturbance within the wetland (only indirect wetland impact due to soil disturbance inside the wetland buffer). Keeping the roadway close to the wetland helps to limit earthwork to the north and minimize tree removal. One Oregon white oak tree is proposed to be removed, as it is in direct conflict with the connector road. All indirect wetland and white oak impacts for this project will be included in the school's on-site mitigation plan.

The 2011 AASHTO Green Book was used to determine horizontal and vertical design standards. The City expressed in preliminary discussions that their preferred design speed for urban arterials is 35 mph or 40 mph. The design speed is assumed equal to the proposed posted speed. Horizontal curve alternatives were considered for 35 and 40 mph, with and without a superelevation of 2%.

Minimum curve radii were applied at the inside of the controlling traffic lane in the final build-out stage. See the following table for resulting minimum curve radii:

HORIZONTAL GEOMETRY CRITERIA

Based on 2011 AASHTO Green Book

35 MPH

CROWN W/2% SLOPES	Min. Horz. Curve Radius*	510'	Inside of southbound lane
	Resulting C/L Radius	504'	
2% SHED (SUPERELEV.)	Min. Horz. Curve Radius*	408'	Inside of northbound lane
	Resulting C/L Radius	426'	

* Min. curve radius from AASHTO Table 3-13b.

40 MPH

CROWN W/2% SLOPES	Min. Horz. Curve Radius*	762'	Inside of southbound lane
	Resulting C/L Radius	756'	
2% SHED (SUPERELEV.)	Min. Horz. Curve Radius*	593'	Inside of northbound lane
	Resulting C/L Radius	611'	

* Min. curve radius from AASHTO Table 3-13b.

A design speed of 35 mph was used for the preferred alignment. The smaller curve radius results in significantly less impact to existing trees and the lower speed presents a safer condition along the frontage of an elementary school. The preferred alignment assumes a crowned section when fully built-out, and utilizes a minimum centerline radius of 504'. Though a superelevated section results in a smaller required radius, and less impact to trees, it was not feasible because of geometric constraints at the new intersection with NE 232nd Ave and the new connector road. A uniform crown section is preferred in final build-out for its simplicity and for easier access from the south (where the terrain is lower), and for consistency with other local urban arterials.

VERTICAL ALIGNMENT

The vertical alignment was dictated by significant site grades, efforts to minimize earthwork and impacts to trees, and AASHTO vertical curve standards. The AASHTO Green Book specifies the following minimum K values for vertical curves based on stopping sight distance:

- 35 mph Sag Vertical Curves: Kmin. = 49
- 35 mph Crest Vertical Curves: Kmin. = 29

A single sag vertical curve can be used for the vertical alignment of the Phase 1 new road. The proposed vertical alignment has a sag vertical curve with a length of 615', and K value of 49.2.

A maximum grade of 6.5% was utilized for one of the two tangents for the single vertical curve design in order to best match the existing topography. Camas Municipal Code Section 17.19.040(B)(12) states that "Grades shall not exceed six (6) percent on major and secondary arterials." We are requesting an exception to this requirement because meeting the 6% limit would result in:

- Excessive cut and/or fill.
- Challenging vertical connectivity at the new intersection and the school access road.
- Challenging vertical connectivity at other properties at final build-out (as much as 10 feet of cut at existing driveways).
- More impacts to existing trees and wetlands.

As a comparison, Clark County design standards allow for grades up to 8% in rolling terrain.

CONNECTOR ROADWAY ALIGNMENT

The new connector roadway is designed assuming a 15 MPH design speed for both horizontal and vertical curvature, as drivers are either stopping or slowing as they move through the tee intersection. The horizontal radius is proposed at 100', which is double the minimum required 50' radius. The crest vertical curve is proposed at a K value of 4.4, greater than the minimum of 3. The sag vertical curve is proposed at a K value of 7.5, which is less than the minimum of 10 for 15 MPH, but will be mitigated with an additional street light near this part of the connector roadway so drivers will have sufficient sight distance when it is dark.

INTERSECTIONS

An intersection has been designed to provide access to NE 232nd south of the new road. Vehicles travelling south on NE 232nd will turn right onto the new connector road and continue south without stop or yield control. Vehicles approaching the site from the south on 232nd will be diverted onto the new connector road with a tee intersection at the new road. The south leg of the tee (new connector road) will be stop controlled. The connector road is designed for Phase 1, and may be reconfigured in final build-out. Northbound drivers on the new road can access the southern leg of 232nd via the new connector road.

One variation considered for this intersection is allowing southbound drivers to remain on the existing 232nd Avenue pavement and bypass the connector road. However, this seems to create several unsafe conditions. First, it causes the southbound driver to make a decision to go left along the new curving road or straight. A driver that ends up in between would result in an accident. Second, it forces the southbound movement on either the connector road or the existing 232nd Avenue lane to stop or yield for the other lane prior to merging. Additionally, the angle at which one would have to look back at merging traffic is small and would likely make it difficult to make safe decisions. If a yield or stop control were to be on the southbound movement of the connector road prior to the merge, the connector road may back up into the intersection with the new half-street arterial, causing additional interruptions to the flow of traffic. For these reasons, the connector road is the only proposed way to travel north or south along 232nd Avenue in the interim condition. Drivers may continue south through the connector road without stopping and just slowing for a right-turn. When traveling north, drivers will need to stop before taking a left turn.

The new elementary school will have a commercial driveway intersection with the new Phase 1 roadway. The driveway will be completely constructed during Phase 1, including curb returns. The Phase 1 new road will dead-end immediately after the commercial driveway intersection. Existing properties south of 9th Street will continue to access their lots off 9th Street until the arterial is further developed in the future.

Both of these new intersections were designed with radii and lane widths that support a school bus, SU-40, and fire engine truck with no conflicts. If additional vehicles are required, additional analysis can be performed.

SIGHT DISTANCE - Alignment

The preferred alignment is designed to provide a safe stopping distance for vehicles, as calculated using the AASHTO Green Book. AASHTO Table 3-1 specifies a stopping sight distance of 250' on level roadways for 35 mph. For a downgrade of 6.5%, the maximum grade used for the new roadway design, the stopping sight distance is 274 ft. (inferred from AASHTO Table 3-2). Sight distance was evaluated at the single horizontal curve in the new roadway and considered the cut slope on the inside of the curve. The horizontal geometry of both the Phase 1 and final build-out condition provide sight distances greater than 274 ft., unobstructed by roadway geometry or the side slope. The 274 ft. sight line will cross the planter strip (where installed), where street trees and appurtenances will be located. These obstacles, however, will be managed by tree location, selection, and maintenance (limbing).

The Phase 1 preferred alignment has a single sag vertical curve. The sight distance for sag vertical curves is typically determined by the visibility provided by a vehicle's headlights, projecting 1-degree upward from a height of 2 ft. Calculated in this manner, the vertical curve has a sight distance of 250 ft. Vehicles entering the vertical curve from the SE begin on a downgrade of 6.5% and require a stopping sight distance of 274 ft. During the day, the sight distance will not be controlled by headlights and will exceed 274 ft. Street lights are being installed as part of the project, and will illuminate objects in the roadway. This will effectively extend the sight distance beyond the headlight distance at night. Therefore, the current vertical curve length of 615' is adequate to provide the required stopping sight distance with installation of street lights.

SIGHT DISTANCE - Intersections

At intersections, greater sight distance than stopping sight distance is required so that drivers entering traffic can evaluate an appropriately sized gap in traffic. There are two stop controlled intersections on the new road: at the new connector road to NE 232nd Ave., and at the school access road driveway. Recommended sight distances were determined using the AASHTO Green Book, Chapter 9 - Intersections.

The new connector road intersects perpendicularly with the new road to create a tee intersection, with a stop sign and stop bar on the connector road. Sight distances were evaluated for a passenger car stopped at the stop sign for the Phase 1 condition. The minimum recommended sight distance to the right is controlled by making a left-hand turn onto the new road (AASHTO Case B1). The minimum sight distance to the left is controlled by making a right-hand turn onto the new road (AASHTO Case B2). Recommended sight distances for this intersection were calculated, using AASHTO Equation 9-1, to be 460 ft. to the right and 370 ft. to the left. The 370 ft. sight-line to the left is an unobstructed view across roadway pavement. The 460 ft. sight-line to the right crosses the inside of the horizontal curve of the new road. A profile of the sight-line confirmed that the view is unobstructed by cut slopes or natural topography.

The new school access road intersects perpendicularly with the new road at a commercial driveway, with a stop sign and stop bar on the access road. In the Phase 1 configuration the intersection will be a 90-degree turn, with no conflicting vehicular movements requiring sight

distance evaluation. The final build-out of the arterial will result in a tee intersection, stop controlled on the access road. Sight distances were evaluated for a school bus stopped at the stop sign. Recommended sight distances for this intersection were calculated, using AASHTO Equation 9-1, to be 490 ft. to the right and 440 ft. to the left. The 490 ft. sight-line to the right is unobstructed by roadway geometry or slopes. The 440 ft. sight-line to the left will cross the inside of a future horizontal curve (based on our assumption of the future alignment). Design of the future roadway will need to accommodate the recommended sight distance from the access road for safe and smooth operation. No inherent sight distance problems are predicted with our current assumptions regarding the future alignment.

STORMWATER

The project area currently drains to a wetland at the southwest corner of the property. Stormwater flows out of the wetland southerly through a 30" culvert under NE 9th Street. The Phase 1 roadway adds greater than 5,000 square feet of impervious surface, making the project subject to all Minimum Requirements for stormwater management.

Minimum Requirement #7 is flow control. A geotechnical investigation was performed throughout the project property. The borehole closest to the proposed roadway was tested for infiltration, revealing an infiltration rate of 0.2 inches/hour (5' depth). An infiltration facility is deemed infeasible as a means of stormwater disposal and flow control. Because the entire roadway project drains to one low point and the relatively steep grades, an end-of-line detention facility (underground) is proposed between the roadway and the wetland south of the roadway. The proposed location of the facility is under the southbound lane of the future built-out arterial. The facility can be maintained and expanded in the future to accommodate detention of stormwater run-off from the future condition.

Washington State Department of Ecology (DOE) requires that wetlands receive the same flow from the developed condition as the existing condition. Therefore, the existing condition is modeled as the land lies today (pasture and forest), as opposed to all pre-European settlement (forested). Additionally, a french drain at the back of sidewalk will intercept water from north of the roadway (off-site flow) and convey it under the road to the wetland, bypassing the new road's stormwater system.

Curb inlets will collect runoff from asphalt pavement, landscape planter, and sidewalk. Collected roadway stormwater will be conveyed to the underground detention facility. A stormwater control manhole within the detention facility will dispense water from the facility to the wetland at a controlled rate. The detention facility be designed to accommodate flows from the Phase 1 condition only. Full build-out of the roadway will require expansion of the facility or creation of a secondary facility.

Minimum Requirement #6 requires the treatment of stormwater runoff from pollution generating surfaces (and from other runoff that is collected in combination with polluted runoff). Runoff from the roadway will need to be treated to the Basic Treatment level. The project is also located within the area above the dam at Round Lake, which requires treatment for phosphorous. Bio-retention facilities with an increased bioretention soil media depth of 24" are proposed to provide basic and phosphorous runoff treatment for the new school project. Roadways with flat grades can utilize bio-retention facilities in the planter strip. However, since the bottom of bio-filtration facilities must be flat, the moderately steep grades of the new road make use of these facilities infeasible.

Other treatment options were considered. A large wetpond would meet the treatment criteria, but would likely include direct wetland impacts. Mechanical treatment approved for both basic and phosphorus control is another option. However, these would require ongoing filter replacements.

The proposed design utilizes the first option, a bio-retention facility downstream of the underground detention facility. The treatment facility is proposed to be located between the new road and the wetland to the south, outside of the footprint of the future arterial. The facility will be designed to accommodate Phase 1 water quality flows. The fully built-out arterial will require expansion of the bio-retention facility or additional measures to treat the additional run-off.

The stormwater collection and conveyance system will be designed for the 10-year, 24-hour storm event, as prescribed in the City's stormwater manual (for contributing drainage areas less than 40 acres). The collection system will be designed to accommodate future expansion of the roadway to logical limits determined by geography. The assumed northern limit is the creek located 230' north of the Phase 1 limit of construction. The roadway north of the creek continues uphill, and will drain to the creek (separate point-of-compliance than the on-site wetland). The eastern boundary is assumed to be a high point in the geography located at the eastern boundary of the project property (see sheet R2.1).

MILESTONES

Since these improvements will be dedicated to the City as public improvements within newly dedicated right-of-way, it is our intent to design these improvements in coordination with City staff. This memo and supporting drawings represent a 30% design. Additional milestones where City review and input is anticipated are at 60%, 90%, and 100%.