

Munition Storage Magazines (MSMs)

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INTRODUCTION

Hill Air Force Base (HAFB) currently has two aging Munition Storage Magazines (MSMs) and is planning to replace these with modern MSMs. HAFB's new project will implement five new MSMs to increase their capacity, see Fig 1. HHI Corporation, the client, has acquired the project and has decided to include QM² Engineering as a subcontractor.

QM² Engineering has worked on the site layout of the five MSMs, foundation design, retention pond, and access road. Portions of the MSMs are pre-designed by the US Army Corps of Engineers, but require a site specific foundation, see Fig 2. QM² Engineering has incorporated the MSMs' designs and has designed a site specific foundation. Alternatives were developed, and the most suitable option was chosen.

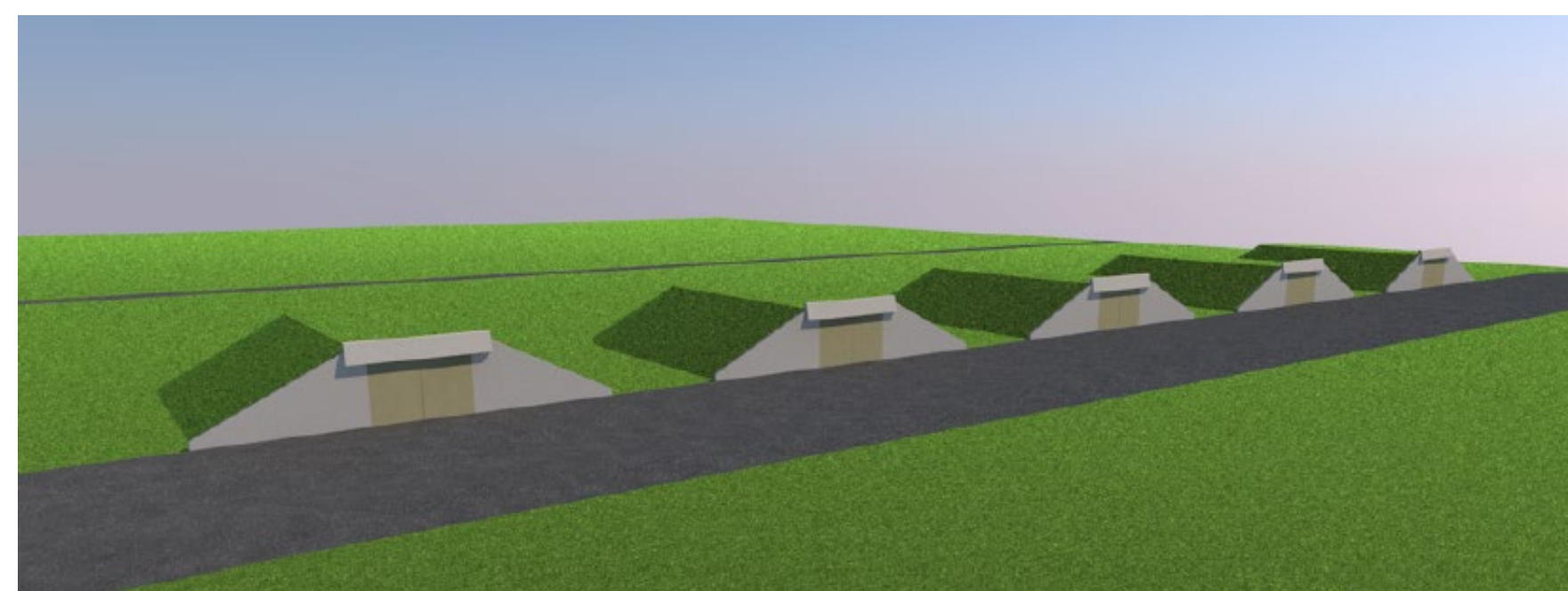
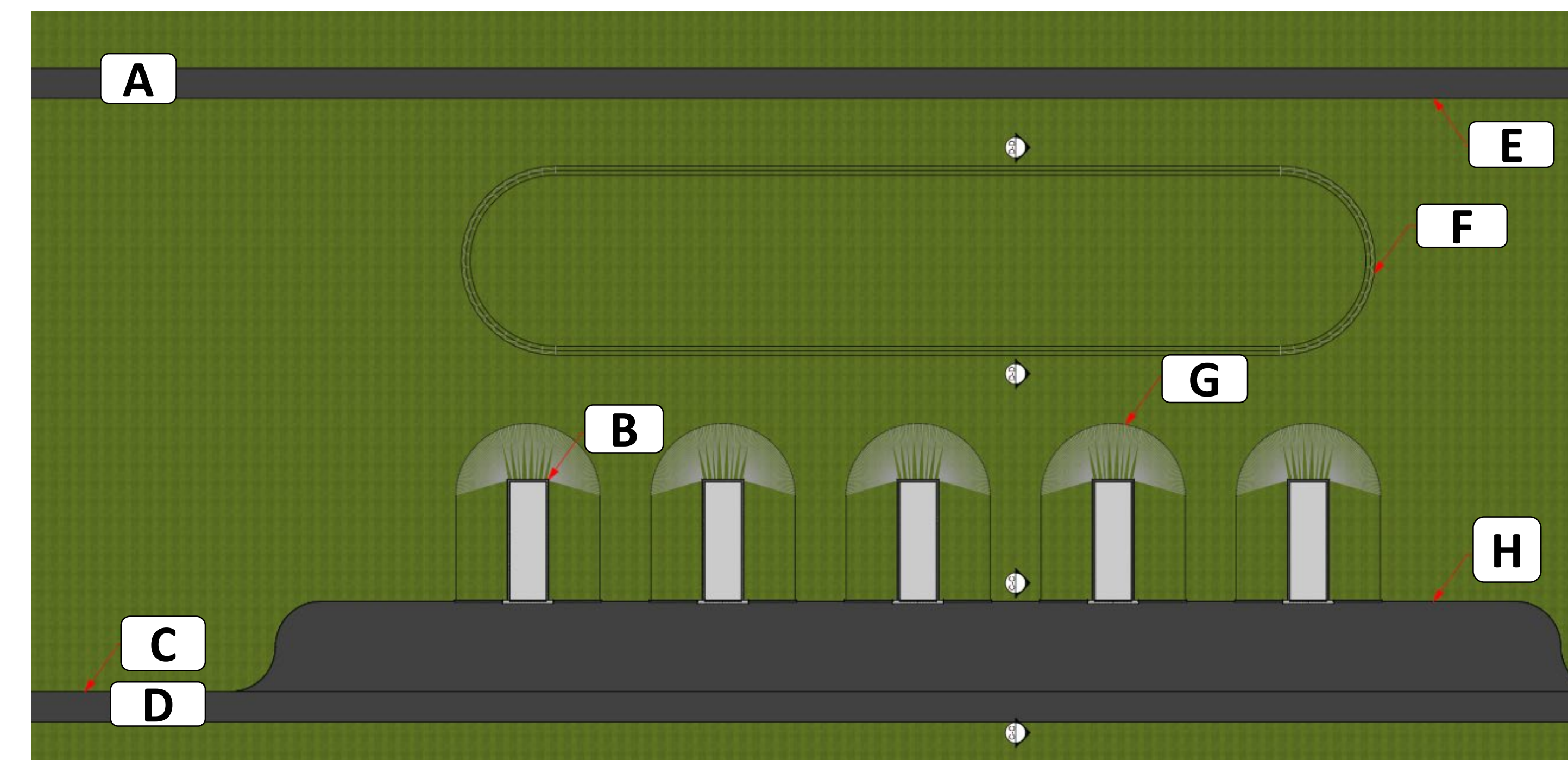


Fig 1. Orthographic View of MSMs



- A. Pine Street
- B. MSM
80 ft x 27 ft
- C. Existing Road
- D. Madrona LN.

- E. Existing Road
- F. Retention Pond
- G. Cover Fill
- H. Access Road

Fig 2. Site Layout – MSMs are set back from road with a new access road placed between. The retention pond is placed behind the MSMs, all site runoff will flow to it.

ALTERNATIVES

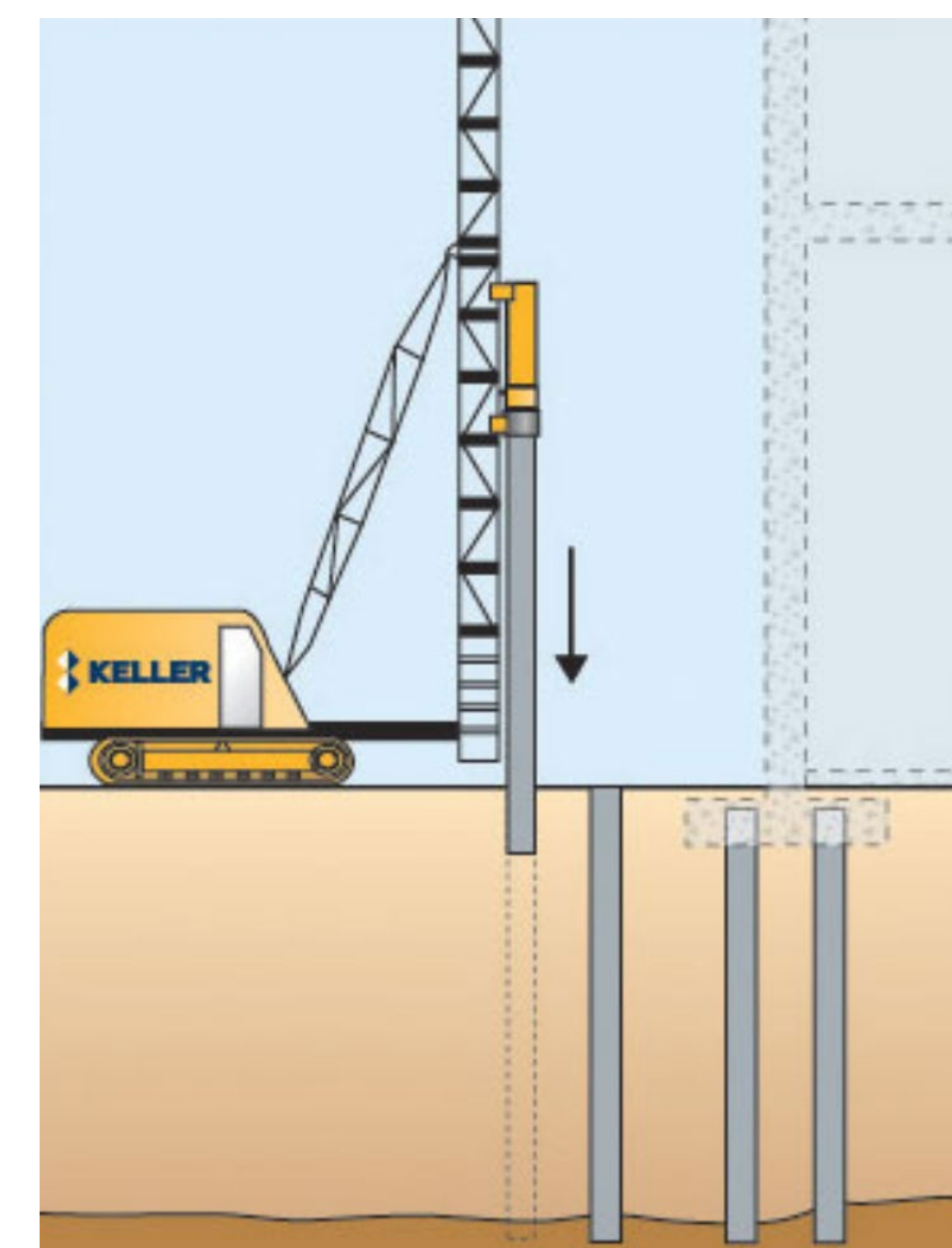


Fig 3. Driven Piles – generally steel H - sections, or pipes pounded into the soil.

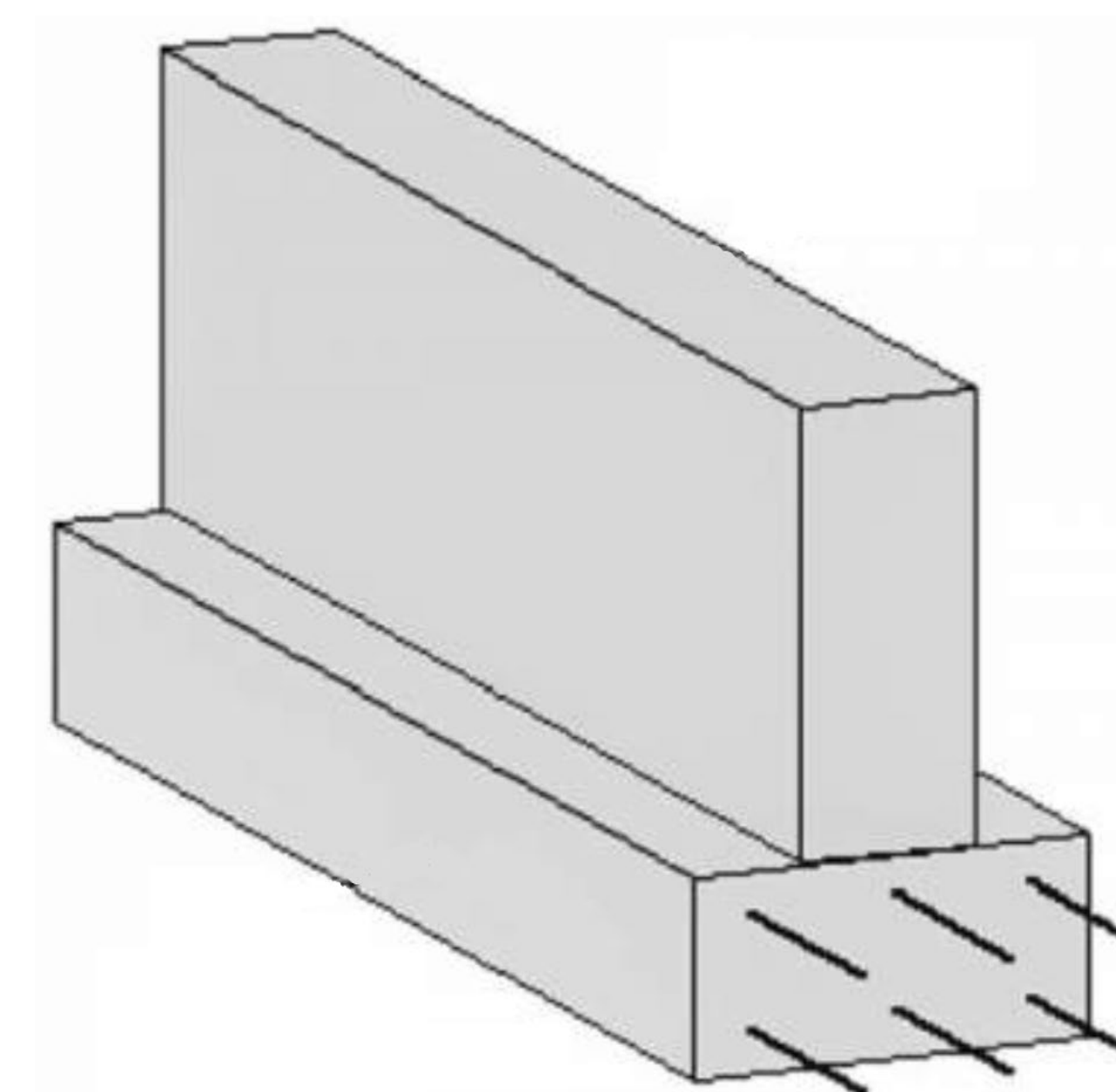


Fig 4. Shallow Footing – called for in the standard drawings. Very common cast in place concrete footing.

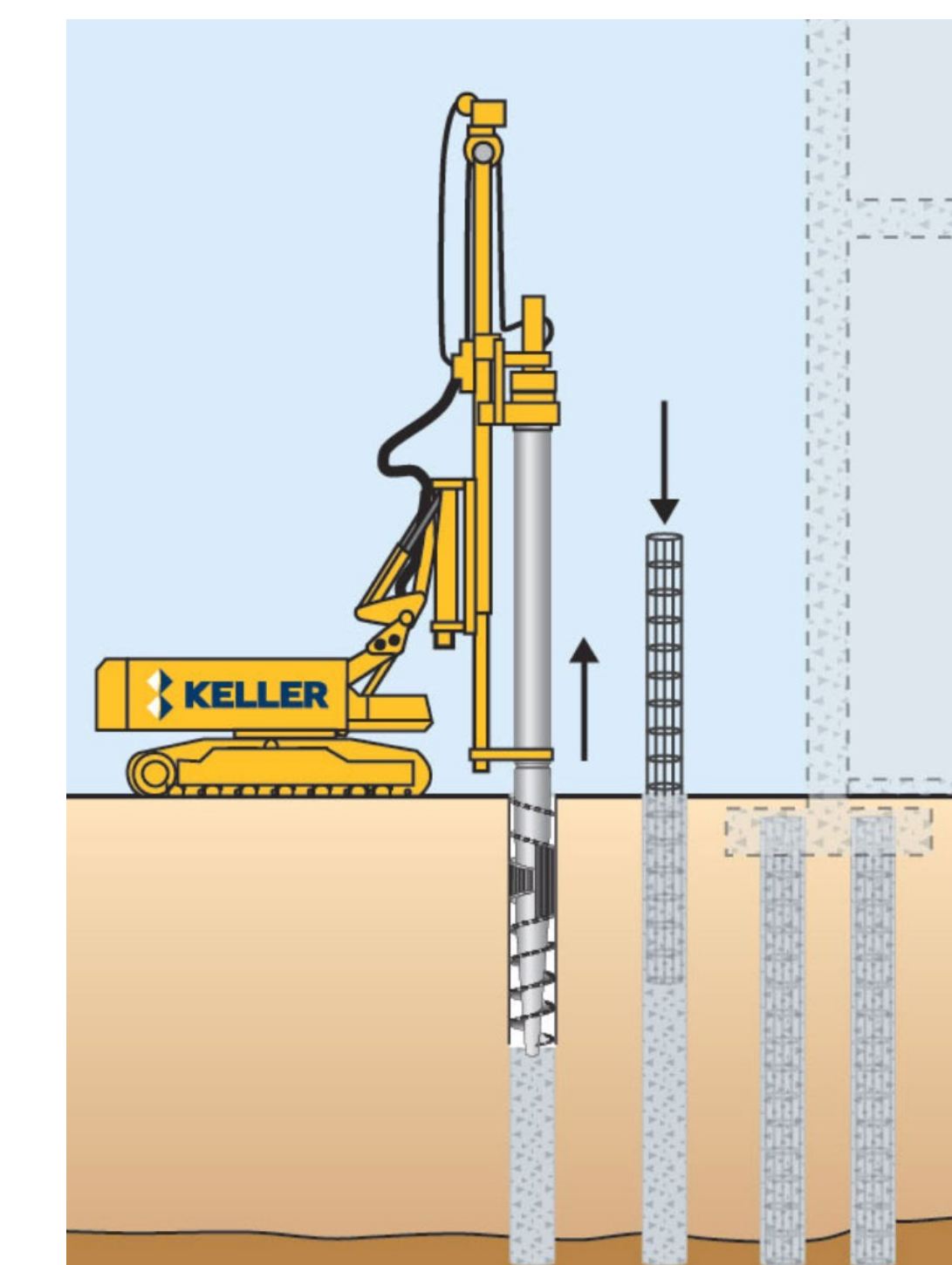


Fig 5. Drilled Shafts – soil is removed with an auger and filled with concrete and reinforcing steel.

PREFERRED ALTERNATIVE

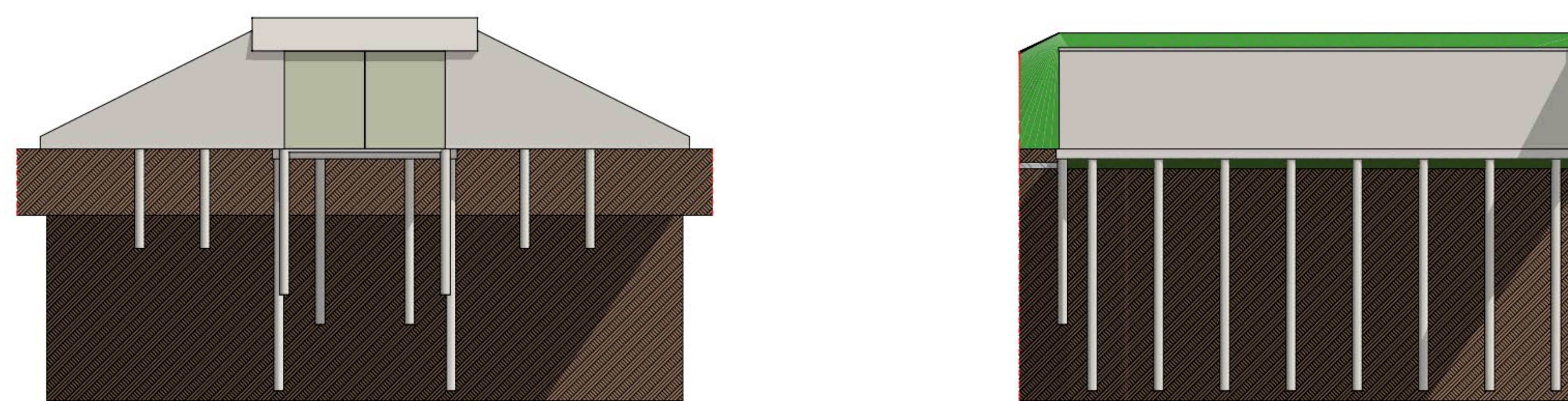


Fig 6. Drilled Shafts from Front and Side View

The preferred alternative is drilled shafts, see Fig 6. The type of drilled shaft is a continuous flight auger (CFA). A CFA is installed using an auger that drills into the soil. Concrete is pumped through the auger as it is drawn out. Once the auger is removed and the hole filled, reinforcing steel is placed in the hole.

COST ESTIMATE

Table 2. Cost Estimate Breakdown

General	Quantity	Unit	Amount	Total Amount
Mobilization	1	LS	\$ 62,000.00	\$ 62,000.00
Site Clean-up	1	LS	\$ 10,402.47	\$ 10,402.47
Operational Costs	52	WK	\$ 12,000.00	\$ 624,000.00
Removal of Previous Structures	1	LS	\$ 93,839.14	\$ 93,839.14
SUBTOTAL GENERAL				\$ 790,241.61
Access Road				
Remove Asphalt Pavement	50	SY	\$ 15.02	\$ 751.00
Roadway Excavation	2230	CY	\$ 5.00	\$ 11,150.00
Fill	955	CY	\$ 70.00	\$ 66,850.00
Compaction	1000	CY	\$ 6.21	\$ 6,210.00
Reinforcing Steel	51500	LB	\$ 4.00	\$ 206,000.00
Pavement	1275	CY	\$ 200.00	\$ 255,000.00
SUBTOTAL ACCESS ROAD				\$ 545,961.00
Retaining Wall				
Retaining Wall Excavation (Class A)	160	CY	\$ 38.14	\$ 6,102.40
Concrete (Class 400)	100	CY	\$ 825.00	\$ 82,500.00
Reinforcing Steel	20000	LB	\$ 4.00	\$ 80,000.00
SUBTOTAL RETAINING WALL				\$ 168,602.40
Head Wall				
Concrete (Class 400)	60	CY	\$ 1,000.00	\$ 60,000.00
Reinforcing Steel	14000	LB	\$ 4.00	\$ 56,000.00
SUBTOTAL HEAD WALL				\$ 116,000.00
MSMs				
Structure excavation (Class A)	6500	CY	\$ 5.00	\$ 32,500.00
Granular Backfill	200	CY	\$ 70.00	\$ 14,000.00
Structural Concrete Precast Panels	1000	CY	\$ 200.00	\$ 200,000.00
Reinforcing Steel Precast Panels	260000	LB	\$ 10.00	\$ 2,600,000.00
Concrete Grade Beam	100	CY	\$ 500.00	\$ 50,000.00
Reinforcing Steel Grade Beam	27000	LB	\$ 4.00	\$ 108,000.00
Cover Fill	15334	CY	\$ 5.00	\$ 76,670.00
SUBTOTAL MSMs				\$ 3,081,170.00
Drilled Shafts				
Drilling	3570	LF	\$ 185.00	\$ 660,450.00
Concrete	234	CY	\$ 400.00	\$ 93,462.36
Reinforcing Steel	63087	LB	\$ 4.00	\$ 252,348.43
SUBTOTAL DRILLED SHAFTS				\$ 1,006,260.81
GRAND TOTAL				\$ 5,592,235.82

The project cost was estimated using WSDOT's construction cost database. All general, access road, retaining wall, head wall, and MSM costs are consistent for all alternatives. Shown in Table 2 is the cost estimate for the preferred alternative, drilled shafts.

DESIGN CRITERIA

- Site specific foundation
 - Cost efficiency
 - Ease of installation
 - Client preference
 - Availability of contractor
- Access road
 - Suitable for heavy equipment
- Retention pond
 - Storage capacity for 95th percentile storm
 - Provide fill needed for MSM cover

Three alternative footings were driven piles, shallow footings, and drilled shafts. See figures 3 - 5 for a brief description of each alternative.

The criteria for the foundation were compared using a Pugh Matrix, see table 1. Each alternative was ranked for each criteria. The highest scoring option was the drilled shafts.

Table 1. Pugh Matrix Comparing Alternatives

Criteria	Alternatives		
	Driven Piles	Shallow Footing	Drilled Shafts
Cost	1	2	3
Installation	3	1	2
Client Preference	2	1	3
Availability of Contractor	1	3	2
Total:	7	7	10

SPECIAL THANKS

- Austin Ball, SE - USU
For being a great professor and resource.
- Robert Campbell, PE – HHI Corporation
For his guidance, reviews, and providing this project.
- Joseph Caliendo, PE, PhD - USU
For his expertise in deep foundations.
- Families and support
For their patience and understanding.
- USU CEE faculty and staff
For many years of instruction and advice.



REFERENCES

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