PHOSPHORUS REMOVAL TECHNOLOGIES SUMMARY

TABLE 2.1

Process/ Technology # Name	Process/Tech Description	Facilities/Chemicals Required	Effluent Phos. Limits achievable	Performance History/ Number of Installations	Process/ Biosolids Impacts	Estimated Construction Costs [1]	Ability to PO_4 Limits of: 1.0	.36	.2
1. EBPR (AO)	Enhanced Biological Phosphorus Removal (EBPR)	• Construction/Creation of Anaerobic zone at beginning of the activated sludge process • no chemicals required	0.8 – 1.2 mg/l	Established technology, growing number of installations	Slight increase in sludge production	$2,500,000	X		
2. Primary Chemical Precipitation	Metal Salt addition upstream of Primary Clarifiers	• Chemical Storage and Feeding Equipment • Building Addition • Primary clarifier improvements • Sludge pumping improvements	0.6 – 1.0 mg/l	Well established technology, numerous installations	Moderate increase in sludge production	$655,000	X		
3. Secondary Chemical Precipitation	Metal Salt addition upstream of Secondary Clarifiers	• Chemical Storage and Feeding Equipment Required	0.5 – 0.9 mg/l	Well established technology, numerous installations	Small increase in sludge production	$1,130,000	X		
4. Multi Point Chemical Addition	Metal Salt addition upstream of both Primary Clarifiers and Secondary Clarifiers	• Chemical Storage and Feeding Equipment Required • Building Addition • Primary clarifier improvements • Sludge pumping improvements	0.4 – 0.8 mg/l	Well established technology, numerous installations	Larger increase in sludge production	$1,600,000	X		
5. EBPR w/ Chemical Addition	EBPR with secondary Chemical Addition	• Construction/Creation of Anaerobic zone at beginning of the activated sludge process • Chemical Storage and Feed Equipment • Sludge pumping improvements	0.3 – 0.6 mg/l	Established technology, many installations	Larger increase in sludge production	$3,630,000	X		
6. EBPR w/ Chemical Addition & Filtration	EBPR with secondary Chemical Addition and Tertiary disc Filtration	• Construction/Creation of Anaerobic zone • Chemical Storage and Feed Equipment • Effluent Disc Filters required • New Building	0.1 – 0.3 mg/l	Established technology, many installations	Larger increase in sludge production	$6,630,000		X	
7. Multi Point Chemical Addition w/ Filtration	Multi Point Chemical Addition and Tertiary Filtration	• Chemical Storage and Feed Equipment • Effluent disc Filters required • New Building	0.1 – 0.3 mg/l	Established technology, many installations	Large increase in sludge production	$4,600,000		X	
8. Tertiary Clarification w/ two stage Filtration	Tertiary Solids Contact Clarifiers for Chemical Precipitation, followed by two stage Filtration	• Construction of Tertiary Solids Contact Clarifiers • Effluent Filters required • New Building	0.03 – 0.1 mg/l	Established wastewater treatment technology, with many wastewater installations	Moderate increase in sludge production	$7,455,000			X
9. MBR w/ Chemical Addition	Membrane Biological Reactor w/ Multi Point Chemical Addition	• Construction of Membrane Biological Reactor • Chemical Storage and Feeding Equipment	0.01 – 0.1 mg/l	Emerging technology, many installations	Large increase in sludge production	$10,500,000			X
10. Tertiary Ballasted Floc	Ballasted Clarification Process	• CoMag® (Magnetite Weighted) or Actiflo® (Sand Weighted) proprietary process equipment • Chemical Feed Systems	0.01 – 0.1 mg/l	New and Emerging technology being piloted, no installations for CoMag, few for Actiflo	Potentially small increase in sludge production	$6,530,000			X
11. Tertiary Membrane w/ Chemical Addition	Multi Point Chemical Addition followed by Tertiary Membrane Microfiltration	• Construction of in-tank Membrane Microfiltration equip. • Chemical Storage and Feed Equipment • Sludge pumping improvements	0.01 – 0.05 mg/l	New and Emerging technology being piloted, few installations	Potentially large increase in sludge production	$8,855,000			X

Notes:
1) Capital Costs are for PO_4 Unit process equipment and appurtenant tankage and equipment only for similar sized facilities. Costs have not been adapted to the Keene WWTP.

Stantec

EXHIBIT 4C