Memo

RMF Engineering
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To: Mike Herman / Erik Backus

From: Corey Gray, P.E.

Date: December 2013

Re: **Study for the Expansion of the Central Utility Plant**

In 2009, RMF Engineering issued an update of the George Mason University (GMU) Utility Master Plan. Since the 2009 Update, the University has constructed several which are served heating and cooling from the Central Heating and Cooling Plant. The following is a list of buildings connected since the 2009 Update:

- Art and Design
- University Hall
- Nguyen Engineering
- Performing Arts Addition
- Science and Tech II Addition
- Housing VIIIA (Rogers/Whitetop)

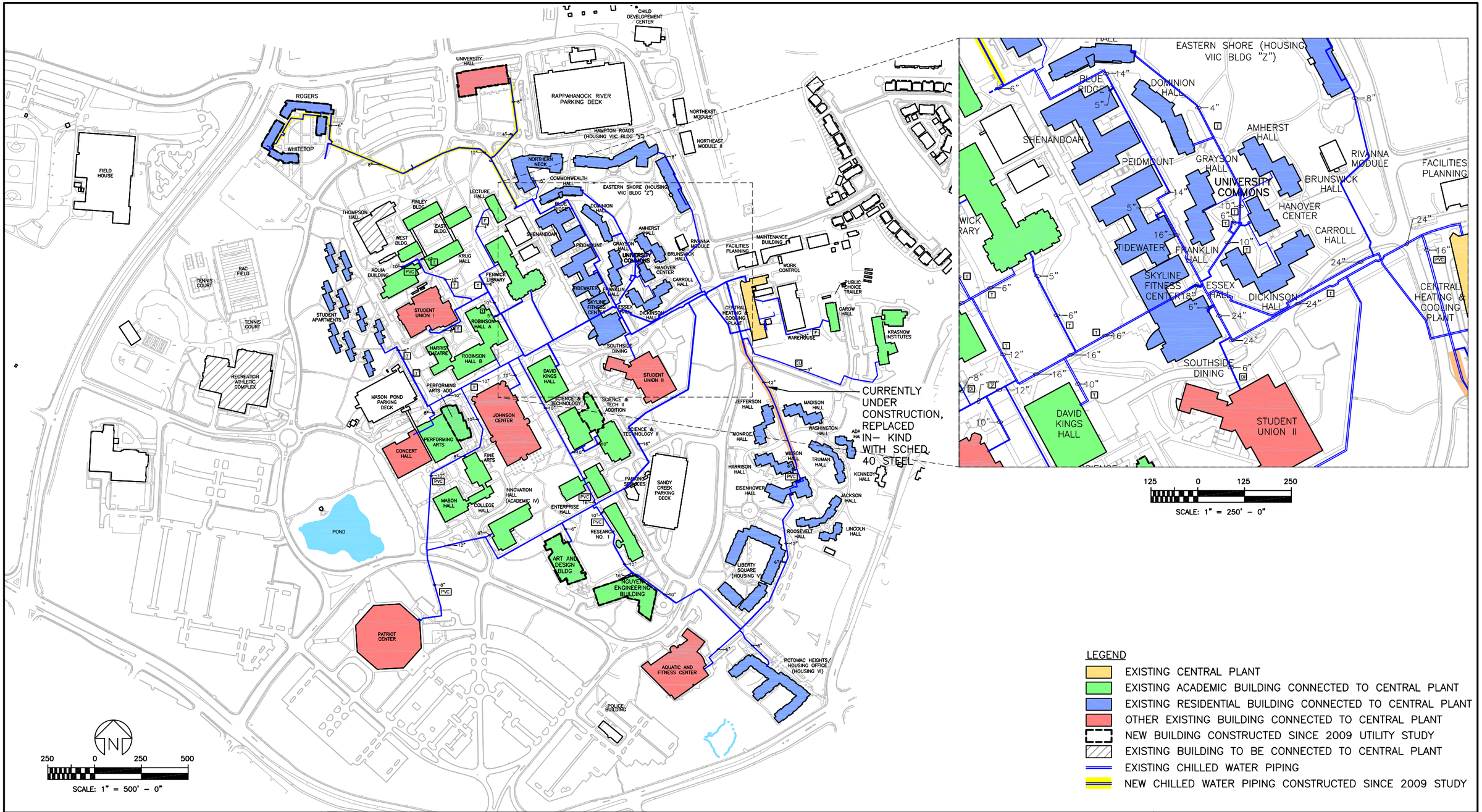
Existing Chilled Water System

A site plan of the existing (2013) chilled water distribution system is presented in Figure No. 1. Buildings that have been connected to the chilled water system since the 2009 study and the associated distribution piping are indicated on the site plan.

The existing plant operation was determined by reviewing the plant logs and discussions with the operating personnel. The plant logs include chilled water flow and temperature difference as well as the chiller percentage output and design capacity at four-hour intervals. Also included in the plant logs is the percentage of ice remaining in both ice tanks. According to the log data, the peak cooling load of the system is approximately 7,500 tons which occurred in June 2012.

The connected load represents the total cooling capacity of all terminal equipment installed within the building. It is unlikely for all campus cooling equipment to be operated at full capacity simultaneously. To account for variances in operation, a system diversity is applied to the connected load to represent the peak system operation. By comparing the peak output of the Central Plant (7,500 tons) to the total connected load of the system (14,629 tons), a diversity factor of 0.51 was estimated. This diversity was utilized to estimate the individual peak loads of each building, which are summarized in Table No. 1.

Also noted on this table are two other load scenarios in which either all residential buildings or all academic buildings on campus peak at similar times. These buildings are denoted on the previous site plan (Figure No. 1) in blue and green shading, respectively. Under each of these scenarios, the diversity factor of these buildings was increased from 0.51 to 0.80 and the



LEGEND

- EXISTING CENTRAL PLANT
- EXISTING ACADEMIC BUILDING CONNECTED TO CENTRAL PLANT
- EXISTING RESIDENTIAL BUILDING CONNECTED TO CENTRAL PLANT
- OTHER EXISTING BUILDING CONNECTED TO CENTRAL PLANT
- NEW BUILDING CONSTRUCTED SINCE 2009 UTILITY STUDY
- EXISTING BUILDING TO BE CONNECTED TO CENTRAL PLANT
- EXISTING CHILLED WATER PIPING
- NEW CHILLED WATER PIPING CONSTRUCTED SINCE 2009 STUDY

GEORGE MASON EXISTING CHILLED WATER SITE PLAN

SCALE: 1" = 500'

PHYSICAL PLANT ADDITION AND RENOVATION

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FIGURE NO. 1

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TABLE NO. 1: EXISTING CAMPUS COOLING LOAD SUMMARY

GEORGE MASON UNIVERSITY

BUILDING NAME	CENTRAL PLANT COOLING AREA (GSF)	SPACE UTILIZATION	UNITARY LOAD (GSF/TON)	CONNECTED COOLING LOAD (TONS)	ALL BUILDINGS AT 0.51		RESIDENTIAL 0.80 REST OF CAMPUS 0.41		ACADEMIC 0.80 REST OF CAMPUS 0.3	
					PEAK COOLING LOAD (TONS)	PEAK COOLING FLOW (GPM)	PEAK COOLING LOAD (TONS)	PEAK COOLING FLOW (GPM)	PEAK COOLING LOAD (TONS)	PEAK COOLING FLOW (GPM)
ACADEMIC IIIA (KING HALL)	83,600	ACADEMIC	258	324	166	285	131	225	259	444
AQUATIC CENTER & EXPANSION	90,740	EVENT	202	450	231	396	182	313	137	235
AQUIA BUILDING	60,000	ACADEMIC	200	300	154	264	122	208	240	411
ART & VISUAL TECH BLDG	90,000	ACADEMIC	250	360	185	316	146	250	288	494
BLUE RIDGE \ SHENANDOAH (H-VII)	121,270	RESIDENTIAL	404	300	154	264	240	411	91	157
CAROW HALL	7,500	ACADEMIC	170	44	23	39	18	31	35	60
COMMONWEALTH HALL	51,200	RESIDENTIAL	582	88	45	77	70	121	27	46
DOMINION HALL	48,800	RESIDENTIAL	555	88	45	77	70	121	27	46
EAST BLDG.	13,100	ACADEMIC	211	62	32	55	25	43	50	85
EASTERN SHORE	97,400	RESIDENTIAL	453	215	110	189	172	295	66	112
ENGINEERING BUILDING	180,000	ACADEMIC	250	720	369	633	292	500	576	987
ENTERPRISE HALL	100,000	ACADEMIC	346	289	148	254	117	201	231	396
FINLEY BLDG.	20,500	ACADEMIC	280	73	38	65	30	51	59	101
HAMPTON ROADS	97,400	RESIDENTIAL	453	215	110	189	172	295	66	112
HOUSING VIII (ROGERS)	127,049	RESIDENTIAL	442	288	147	253	230	394	88	150
HOUSING VIII (WHITETOP)	104,036	RESIDENTIAL	366	284	146	250	228	390	87	149
HUMANITIES I	81,900	ACADEMIC	266	308	158	271	125	214	246	422
HUMANITIES II	101,300	ACADEMIC	237	427	219	375	173	296	342	586
HUMANITIES III (CONCERT HALL)	59,400	EVENT	156	380	195	334	154	264	116	199
INNOVATION HALL (ACADEMIC IV)	99,560	ACADEMIC	249	400	205	351	162	278	320	549
JOHNSON CENTER	317,850	STUDENT CNTR	289	1,100	564	967	446	764	335	575
KRASNOW INSTITUES	22,695	ACADEMIC	454	50	26	44	20	35	40	69
KRUG HALL	32,000	ACADEMIC	273	117	60	103	47	81	94	161
LECTURE HALL	8,000	ACADEMIC	174	46	24	41	19	32	37	63
LIBERTY SQUARE (HOUSING V)	183,040	RESIDENTIAL	446	410	210	360	328	562	125	214
LIBRARY I	32,600	ACADEMIC	296	110	56	97	45	77	88	151
LIBRARY II	58,000	ACADEMIC	263	221	113	194	89	153	177	303
LIBRARY III	50,000	ACADEMIC	541	92	47	81	37	64	74	127
NORTHERN NECK (H-VII)	123,140	RESIDENTIAL	410	300	154	264	240	411	91	157
PATRIOT CENTER	162,200	EVENT	189	860	441	756	348	597	262	449
PEIDMOUNT \ TIDEWATER (H-VII)	117,550	RESIDENTIAL	446	263	135	231	211	361	80	138
PERFORMING ARTS ADDITION	15,000	ACADEMIC	250	60	31	53	24	42	48	82
POTOMAC HEIGHTS (HOUSING VI)	192,470	RESIDENTIAL	448	430	220	378	344	590	131	225
PRESIDENTS PARK II	101,700	RESIDENTIAL	480	212	109	186	170	291	65	111
PRESIDENTS PARKS I	113,880	RESIDENTIAL	330	345	177	303	276	473	105	180
RESEARCH NO. 1	98,840	ACADEMIC	247	400	205	351	162	278	320	549
ROBINSON A	100,000	ACADEMIC	348	287	147	252	116	199	230	394
ROBINSON B	110,500	ACADEMIC	318	348	178	306	141	242	278	477
SCIENCE & TECH II ADDITION	50,000	ACADEMIC	250	200	103	176	81	139	160	274
SCIENCE &TECHNOLOGY I	95,100	ACADEMIC	226	421	216	370	171	292	337	577
SCIENCE &TECHNOLOGY II	100,000	ACADEMIC	238	420	215	369	170	292	336	576
SKYLINE FIT CTR \ SOUTHSIDE DIN. (H-VII)	54,480	RESIDENTIAL	374	146	75	128	117	200	44	76
STUDENT APARTMENTS	109,100	RESIDENTIAL	559	195	100	171	156	267	59	102
STUDENT UNION ADDITION	60,000	STUDENT CNTR	200	300	154	264	122	208	91	157
STUDENT UNION I, PHASES I & II	83,100	STUDENT CNTR	188	442	227	389	179	307	135	231
STUDENT UNION II	91,000	STUDENT CNTR	337	270	138	237	109	188	82	141
UNIVERSITY COMMONS	101,900	RESIDENTIAL	495	206	106	181	165	283	63	108
UNIVERSITY HALL	140,000	ADMIN	200	700	359	615	284	486	213	366
WEST BLDG.	18,400	ACADEMIC	296	62	32	55	25	43	50	85
EXISTING CAMPUS	4,377,300	---	299	14,629	7,499	12,856	7,499	12,855	7,499	12,856

NOTES: 1. ☐ BUILDING ADDED SINCE 2009 STUDY

2. PEAK LOAD BASED ON LOG DATA FOR JUNE 20, 2012

3. FLOW BASED UPON A 14° DELTA-T

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diversity factor for the remainder of the buildings connected to the chilled water system was reduced in order to maintain a peak load of 7,500 tons.

A computerized hydraulic model was utilized to simulate the piping network and determine the pressure loss in the existing piping system. The software utilized was developed by the University of Kentucky and is called KYPIPE 2000. Friction losses are calculated in the program using the Hazen Williams formula as follows:

$h_f = 0.002083 \times L \times (100 / C)^{1.85} \times (gpm^{1.85} / D^{4.8655})$, where

h_f = head loss due to friction (feet) L = length of pipe (feet)

C = roughness factor gpm = flow (gallons per minute)

D = pipe inside diameter (inches)

The results of the pumping requirements from the hydraulics for each of the three scenarios are presented in Figure No. 2. Based upon a previous study of the Academic VII building project, it was recommended to install chilled water building pumps within Rogers, Whitetop and Academic VII as well as the installation of 6-inch supply and return piping to directly feed Whitetop. Once these pumps are installed, the distribution pumps located at the Central Plant would be able to support the peak load of the system.

Future Chilled Water System

The projected increase in the peak campus cooling is based upon the George Mason University Master Plan (2009), which identifies the construction of several new facilities as well as additions to existing buildings. The locations of the proposed future projects on the GMU campus in relation to the chilled water system are indicated in Figure No. 3.

Based upon current planning, the future peak cooling load is expected to increase to approximately 12,400 tons. This future loading was applied at different load scenarios for the purposes of the hydraulic modeling and the loads are presented in Table No. 2.

A hydraulic model was developed to include the future loads. Similar to the existing model, three operating scenarios were considered to determine the ability of the distribution pumps at the Central Plant to support the future load growth. For all three scenarios (Even Diversity Factor = 0.51, Academic = 0.80 and Residential = 0.80), the head requirement of the system is beyond the capabilities of the distribution pumps. The system curves for each of the three load scenarios are presented in Figure Nos. 4 through 6, respectively.

Based upon near term load development in the northern portion of campus, there is a need to complete the North Loop. When the North Loop piping is complete, the head requirements are reduced, but will still be beyond the capabilities of the distribution pumps. Only with the addition of the Satellite Plant (2,400 tons) in the southwest portion of campus are the distribution pumps at the Central Plant able to support the future load. The timing of Satellite Plant is based upon the development of the Southwest Sector of campus.

FIGURE NO. 2: OPERATING CURVES FOR CENTRAL PLANT CHILLED WATER DISTRIBUTION PUMPS (EXISTING)

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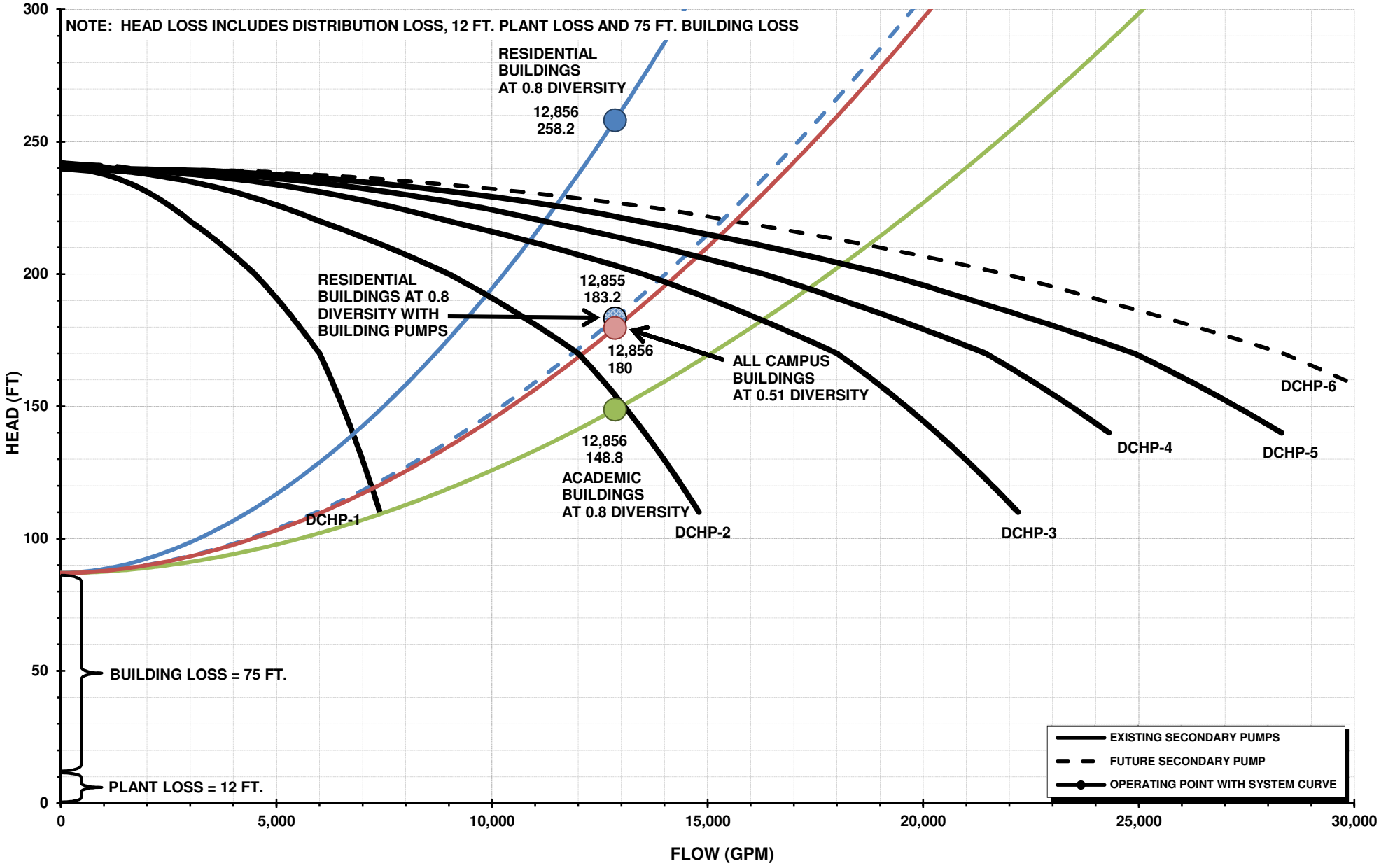
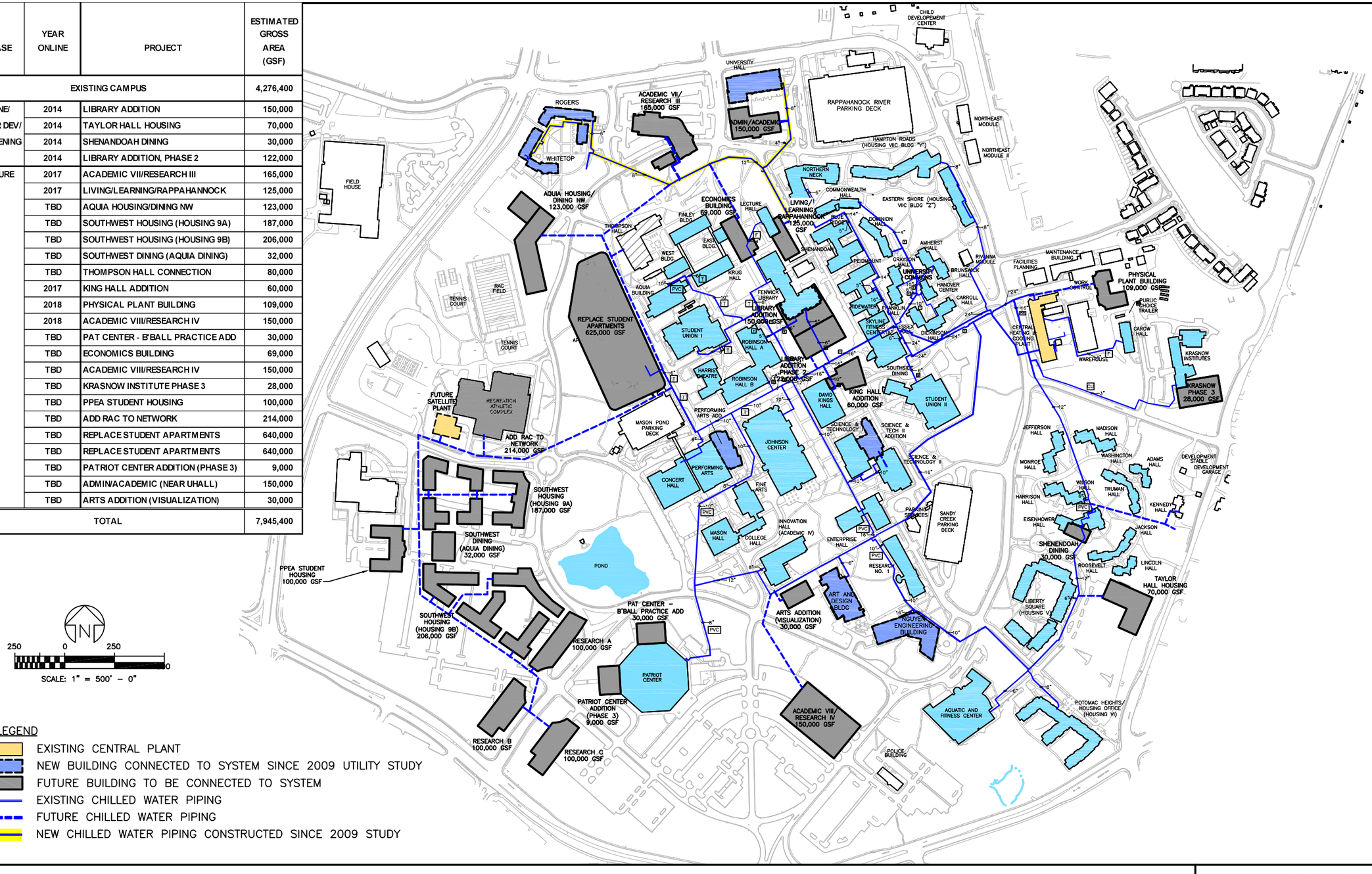


PHASE	YEAR ONLINE	PROJECT	ESTIMATED GROSS AREA (GSF)
EXISTING CAMPUS			4,276,400
DONE/ UNDER DEV/ HAPPENING	2014	LIBRARY ADDITION	150,000
	2014	TAYLOR HALL HOUSING	70,000
	2014	SHENANDOAH DINING	30,000
	2014	LIBRARY ADDITION, PHASE 2	122,000
FUTURE	2017	ACADEMIC VII/RESEARCH III	165,000
	2017	LIVING/LEARNING/RAPPAHANNOCK	125,000
	TBD	AQUIA HOUSING/DINING NW	123,000
	TBD	SOUTHWEST HOUSING (HOUSING 9A)	187,000
	TBD	SOUTHWEST HOUSING (HOUSING 9B)	206,000
	TBD	SOUTHWEST DINING (AQUIA DINING)	32,000
	TBD	THOMPSON HALL CONNECTION	80,000
	2017	KING HALL ADDITION	60,000
	2018	PHYSICAL PLANT BUILDING	109,000
	2018	ACADEMIC VIII/RESEARCH IV	150,000
	TBD	PAT CENTER - B'BALL PRACTICE ADD	30,000
	TBD	ECONOMICS BUILDING	69,000
	TBD	ACADEMIC VIII/RESEARCH IV	150,000
	TBD	KRASNOW INSTITUTE PHASE 3	28,000
	TBD	PPEA STUDENT HOUSING	100,000
	TBD	ADD RAC TO NETWORK	214,000
	TBD	REPLACE STUDENT APARTMENTS	640,000
	TBD	REPLACE STUDENT APARTMENTS	640,000
	TBD	PATRIOT CENTER ADDITION (PHASE 3)	9,000
	TBD	ADMIN/ACADEMIC (NEAR UHALL)	150,000
	TBD	ARTS ADDITION (VISUALIZATION)	30,000
TOTAL			7,945,400



GEORGE MASON FUTURE CHILLED WATER SITE PLAN– FULL BUILD OUT

SCALE: 1" = 500'

PHYSICAL PLANT ADDITION AND RENOVATION

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FIGURE NO. 3

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TABLE NO. 2: FULL BUILD-OUT CAMPUS COOLING LOAD SUMMARY
GEORGE MASON UNIVERSITY

BLDG NO.	BUILDING NAME	CENTRAL PLANT COOLING AREA (GSF)	SPACE UTILIZATION	UNITARY LOAD (GSF/TON)	CONNECTED COOLING LOAD (TONS)	ALL BUILDINGS AT 0.51		RESIDENTIAL 0.80 REST OF CAMPUS 0.39		ACADEMIC 0.80 REST OF CAMPUS 0.2	
						PEAK COOLING LOAD (TONS)	PEAK COOLING FLOW (GPM)	PEAK COOLING LOAD (TONS)	PEAK COOLING FLOW (GPM)	PEAK COOLING LOAD (TONS)	PEAK COOLING FLOW (GPM)
EXISTING CAMPUS		4,377,300	---	---	14,629	7,499	12,855	7,361	12,619	6,639	11,380
2014	LIBRARY ADDITION	150,000	ACADEMIC	275	545	280	479	214	367	436	748
2014	TAYLOR HALL HOUSING	70,000	RESIDENTIAL	450	156	80	137	124	213	32	54
2014	SHENANDOAH DINING	30,000	RESIDENTIAL	450	67	34	59	53	91	14	23
2014	LIBRARY ADDITION, PHASE 2	122,000	ACADEMIC	275	444	227	390	174	298	355	608
2017	ACADEMIC VII/RESEARCH III	165,000	ACADEMIC	233	867	444	762	340	583	693	1,189
2017	LIVING/LEARNING/RAPPAHANNOCK	125,000	RESIDENTIAL	450	278	142	244	222	381	57	97
TBD	AQUIA HOUSING/DINING NW	123,000	RESIDENTIAL	450	273	140	240	219	375	56	95
TBD	SOUTHWEST HOUSING (HOUSING 9A)	187,000	RESIDENTIAL	450	416	213	365	332	570	85	145
TBD	SOUTHWEST HOUSING (HOUSING 9B)	206,000	RESIDENTIAL	450	458	235	402	366	628	93	160
TBD	SOUTHWEST DINING (AQUIA DINING)	32,000	RESIDENTIAL	450	71	36	62	57	98	15	25
TBD	THOMPSON HALL CONNECTION	80,000	ACADEMIC	275	291	149	256	114	196	233	399
2017	KING HALL ADDITION	60,000	ACADEMIC	258	233	119	204	91	156	186	319
2018	PHYSICAL PLANT BUILDING	109,000	ACADEMIC	275	396	203	348	155	266	317	544
TBD	PAT CENTER - B'BALL PRACTICE ADD	30,000	ACADEMIC	189	159	81	139	62	107	127	218
TBD	ECONOMICS BUILDING	69,000	ACADEMIC	275	251	129	220	98	169	201	344
TBD	ACADEMIC VIII/RESEARCH IV	150,000	ACADEMIC	275	545	280	479	214	367	436	748
TBD	KRASNOW INSTITUTE PHASE 3	28,000	ACADEMIC	275	102	52	89	40	68	82	140
TBD	PPEA STUDENT HOUSING	100,000	RESIDENTIAL	450	222	114	195	178	305	45	77
TBD	ADD RAC TO NETWORK	214,000	ACADEMIC	275	778	399	684	305	523	623	1,067
TBD	STUDENT APARTMENTS (DEMO)	(109,100)	RESIDENTIAL	559	(195)	(100)	(171)	(156)	(267)	(40)	(68)
TBD	REPLACE STUDENT APARTMENTS	640,000	RESIDENTIAL	450	1,422	729	1,250	1,138	1,951	289	496
TBD	PATRIOT CENTER ADDITION (PHASE 3)	9,000	ACADEMIC	189	48	24	42	19	32	38	65
TBD	ADMIN/ACADEMIC (NEAR UHALL)	150,000	ACADEMIC	275	545	280	479	214	367	436	748
TBD	ARTS ADDITION (VISUALIZATION)	30,000	ACADEMIC	275	109	56	96	43	73	87	150
TBD	RESEARCH A	100,000	ACADEMIC	275	364	186	320	143	244	291	499
TBD	RESEARCH B	100,000	ACADEMIC	275	364	186	320	143	244	291	499
TBD	RESEARCH C	100,000	ACADEMIC	275	364	186	320	143	244	291	499
TOTAL FUTURE		2,769,900	---	---	9,571	4,906	8,411	5,044	8,648	5,767	9,886
FULL BUILD-OUT		7,147,200	---	---	24,200	12,405	21,266	12,405	21,266	12,406	21,267

NOTES: 1. ACADEMIC VII CONNECTED LOAD BASED ON BUILDING DESIGN DRAWINGS

2. UNITARY LOADS FOR PATRIOT CENTER ADDITIONS AND KING HALL ADDITION BASED UPON EXISTING UNITARY LOADS

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FIGURE NO. 4: OPERATING CURVES FOR CENTRAL PLANT CHILLED WATER DISTRIBUTION PUMPS (FULL BUILDOUT)

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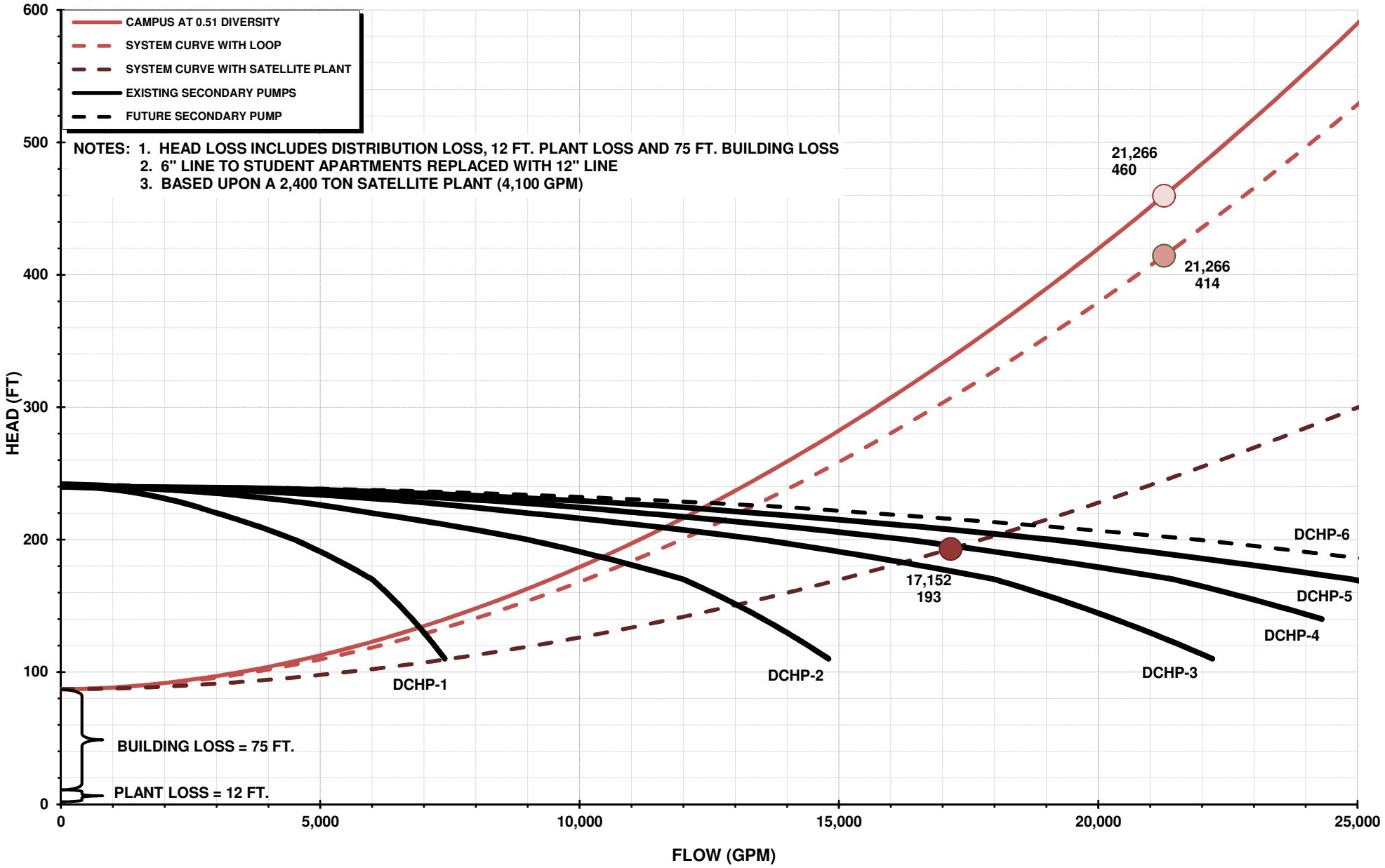

FIGURE NO. 5: CENTRAL PLANT CHILLED WATER DISTRIBUTION PUMP OPERATING CURVES - RES. BLDGS AT .80 DIVERSITY (FULL BUILDOUT)

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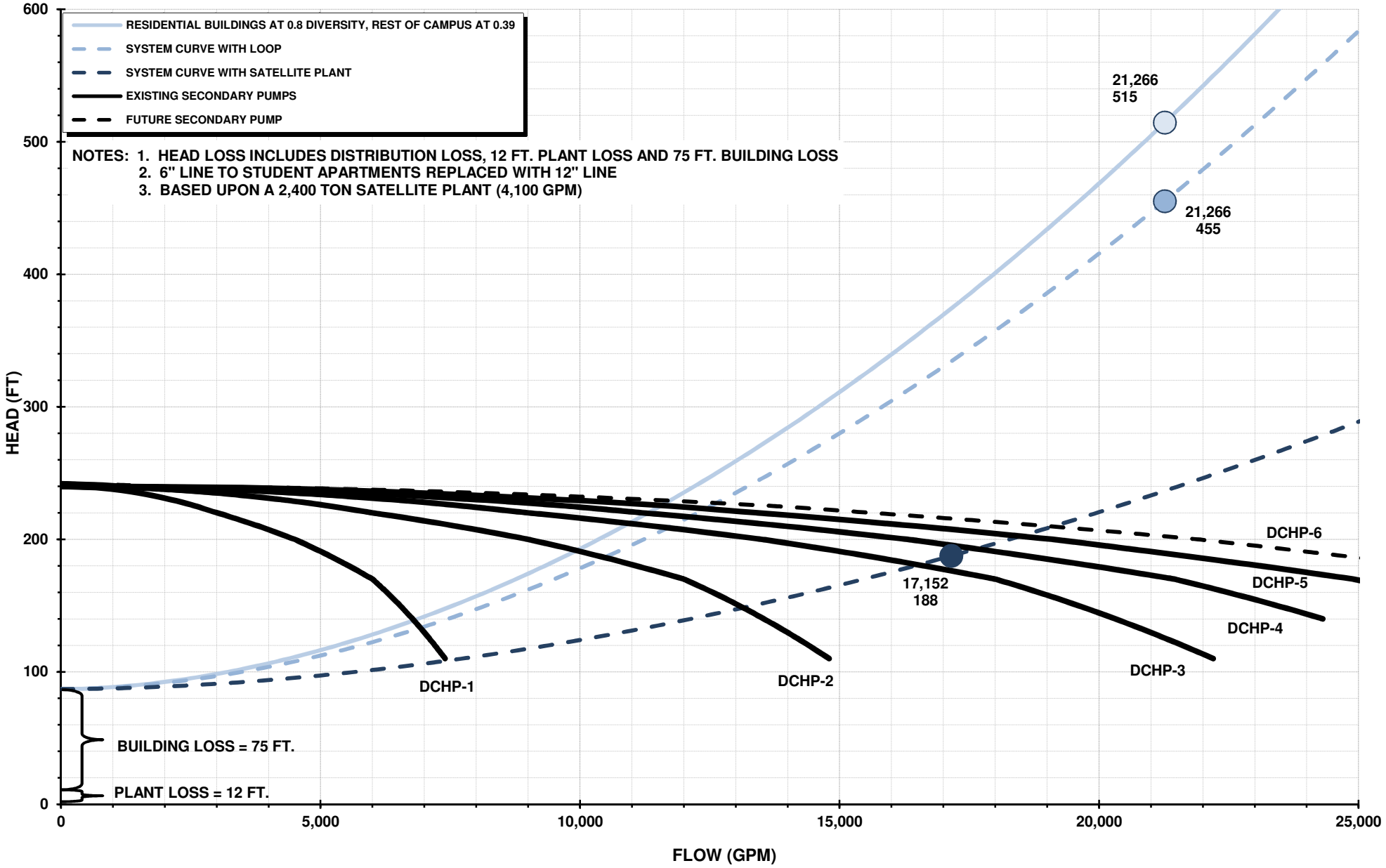

FIGURE NO. 6: CENTRAL PLANT CHILLED WATER DISTRIBUTION PUMP OPERATING CURVES - ACAD. BLDGS AT .80 DIVERSITY (FULL BUILDOUT)

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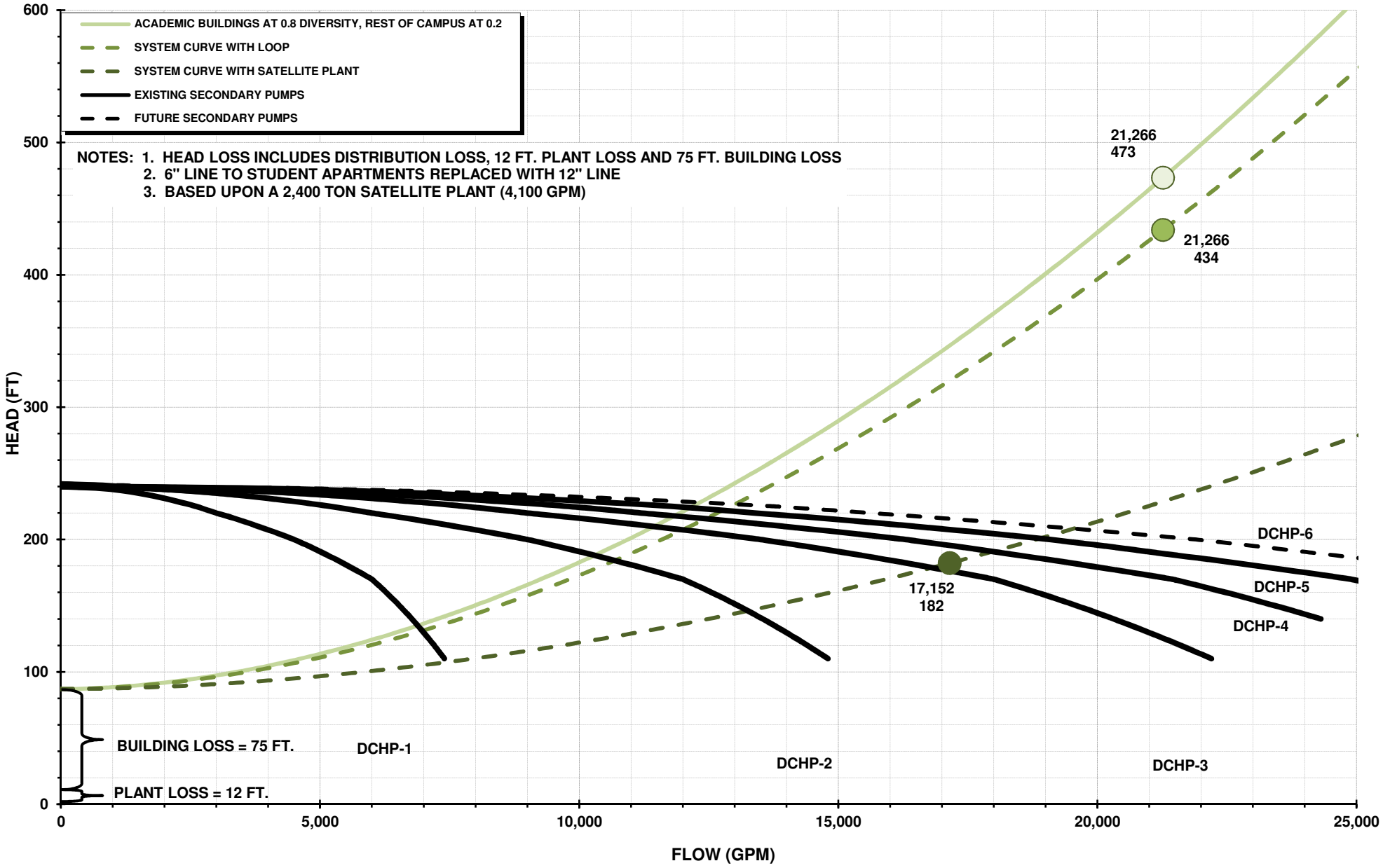

Based upon current planning, there is a need for the additional two chillers at the Central Plant (Chiller Nos. 10 and 11) and two additional units at the Satellite Plant. The current load development versus future chiller capacity is presented in Figure No. 7. It was assumed that the timing of when the Satellite Plant comes online is based on the timing of the load development in the Southwest Sector.

Existing High Temperature Hot Water System

Similar to the chilled water system, an analysis of the high temperature hot water (HTHW) system was performed. A site plan of the existing HTHW distribution system is presented in Figure No. 8. Buildings that have been connected to the chilled water system since the 2009 study and the associated distribution piping are indicated on the site plan.

The existing plant operation was determined by reviewing the plant logs and discussions with the operating personnel. The plant logs include HTHW flow and temperature difference at four-hour intervals. According to the log data, the peak heating load of the system is approximately 72,200,000 BTU's per hour (72,200 MBH) which occurred in January 2012.

The connected load represents the total cooling capacity of all terminal equipment installed within the building. It is unlikely for all campus heating equipment to be operated at full capacity simultaneously. To account for variances in operation, a system diversity is applied to the connected load to represent the peak system operation. By comparing the peak output of the Central Plant (72,200 MBH) to the total connected load of the system (206,400 MBH), a diversity factor of 0.35 was estimated. This diversity was utilized to estimate the individual peak loads of each building, which are summarized in Table No. 3.

Also noted on this table are two other alternative load scenarios in which either all residential buildings or all academic buildings on campus peak at similar times. These buildings are denoted on the previous site plan (Figure No. 1) in blue and green shading, respectively. Under each of these scenarios, the diversity factor of these buildings was increased from 0.35 to 0.60 and the diversity factor for the remainder of the buildings connected to the HTHW system was reduced in order to maintain a peak load of 72,200 MBH.

A computerized hydraulic model was utilized to simulate the piping network and determine the pressure loss in the existing piping system. The results of the pumping requirements from the hydraulics for each of the three scenarios for the HTHW system are presented in Figure No. 9. The distribution pumps located at the Central Plant would be able to support the peak hot water load of the system.

Future High Temperature Hot Water System

Similar to the chilled water system, the locations of the future building projects in relation to the existing high temperature hot water system is presented in Figure No. 10.

FIGURE NO. 7: CENTRAL PLANT CHILLED WATER CAPACITY VS. FUTURE LOAD
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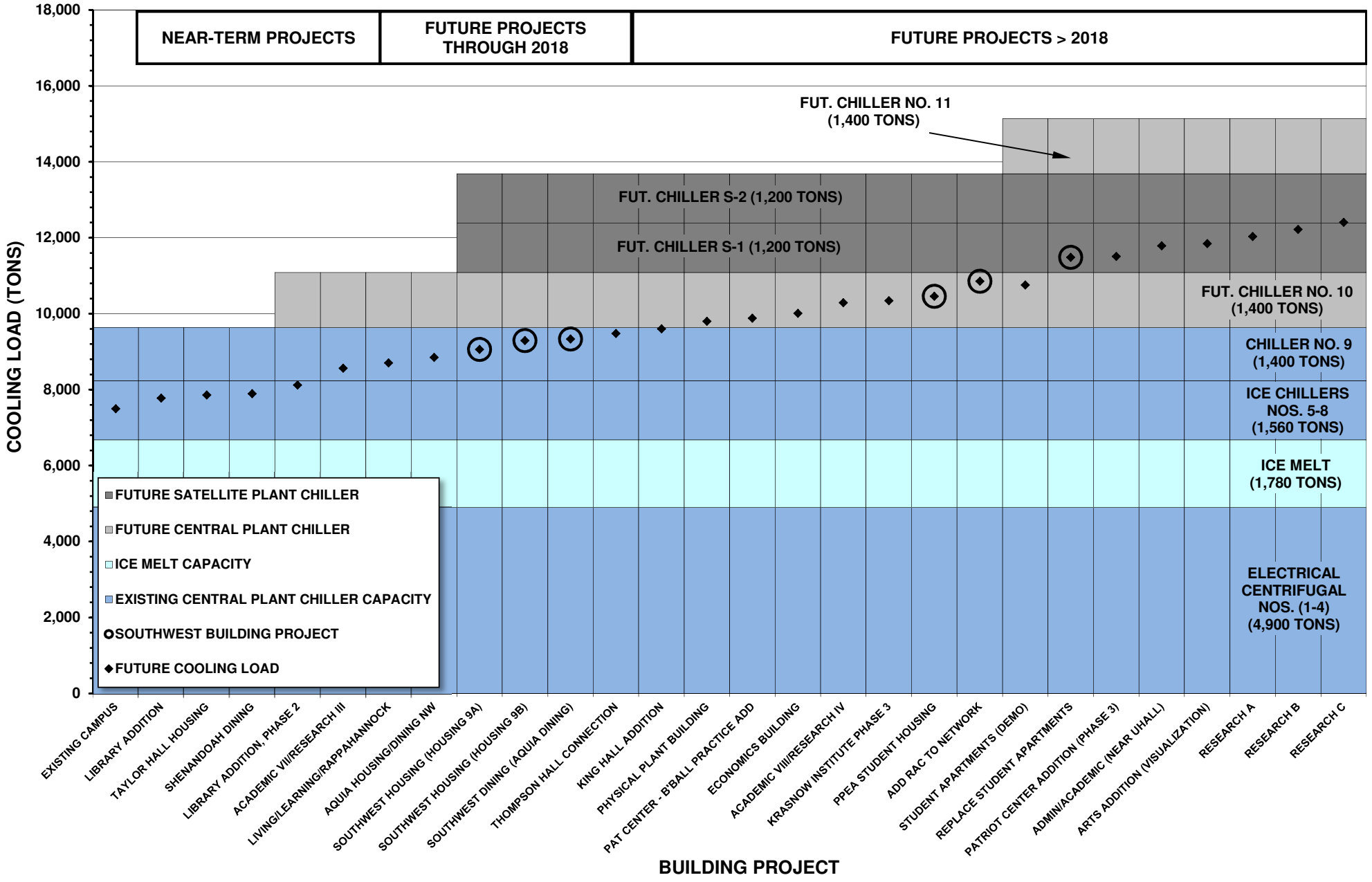

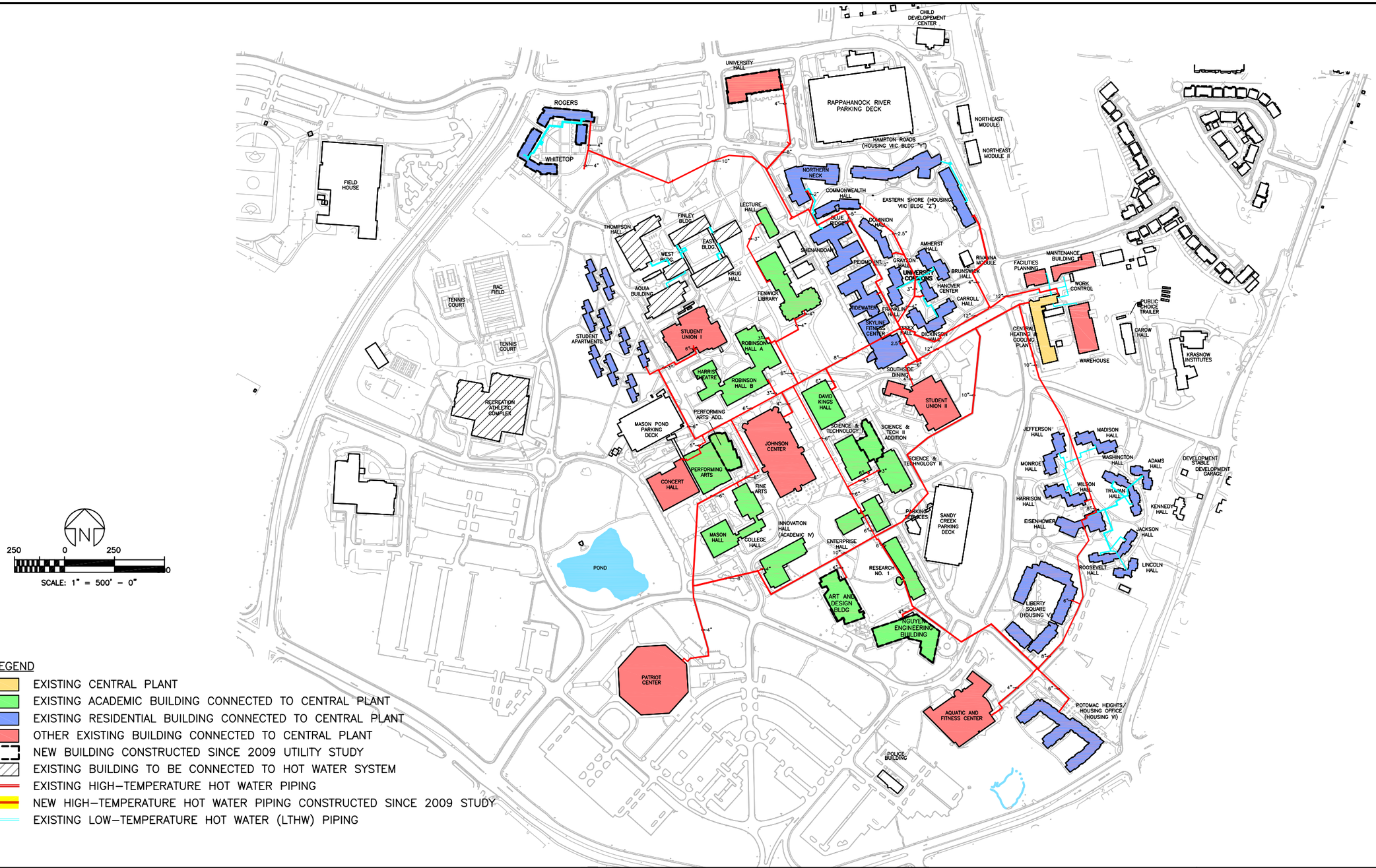

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SCALE: 1" = 500' – 0"

LEGEND

- EXISTING CENTRAL PLANT
- EXISTING ACADEMIC BUILDING CONNECTED TO CENTRAL PLANT
- EXISTING RESIDENTIAL BUILDING CONNECTED TO CENTRAL PLANT
- OTHER EXISTING BUILDING CONNECTED TO CENTRAL PLANT
- NEW BUILDING CONSTRUCTED SINCE 2009 UTILITY STUDY
- EXISTING BUILDING TO BE CONNECTED TO HOT WATER SYSTEM
- EXISTING HIGH–TEMPERATURE HOT WATER PIPING
- NEW HIGH–TEMPERATURE HOT WATER PIPING CONSTRUCTED SINCE 2009 STUDY
- EXISTING LOW–TEMPERATURE HOT WATER (LTHW) PIPING

GEORGE MASON EXISTING HOT WATER SITE PLAN

SCALE: 1" = 500'

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FIGURE NO. 8

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TABLE NO. 3: EXISTING CAMPUS HEATING LOAD SUMMARY
GEORGE MASON UNIVERSITY

BLDG NO.	BUILDING NAME	HEATING AREA (GSF)	SPACE UTILIZATION	CONNECTED HEATING LOAD (MBTU/HR)	ALL BUILDINGS AT 0.35		RESIDENTIAL 0.60 REST OF CAMPUS AT 0.2		ACADEMIC 0.60 REST OF CAMPUS 0.2	
					PEAK HEATING LOAD (MBTU/HR)	PEAK HEATING LOAD (GPM)	PEAK HEATING LOAD (MBTU/HR)	PEAK HEATING LOAD (GPM)	PEAK HEATING LOAD (MBTU/HR)	PEAK HEATING LOAD (GPM)
38	ACADEMIC IIIA (KING HALL)	83,600	ACADEMIC	8,425	2,946	75	1,661.83	42	5,055	129
40	CAROW HALL	7,500	ACADEMIC	375	131	3	74	2	225	6
26	CENTRAL WAREHOUSE	23,600	ADMIN	1,200	420	11	237	6	242	6
69	ENTERPRISE HALL	100,000	ACADEMIC	4,000	1,399	36	789	20	2,400	61
27	FACILITIES PLANNING	11,570	ADMIN	600	210	5	118	3	121	3
74	HUMANITIES I	81,900	ACADEMIC	600	210	5	118	3	360	9
75	HUMANITIES II	101,300	ACADEMIC	3,265	1,142	29	644	16	1,959	50
76	HUMANITIES III (CONCERT HALL)	59,400	EVENT	2,129	744	19	420	11	430	11
77	JOHNSON CENTER	317,850	STUDENT CNTR	12,000	4,196	107	2,367	60	2,425	62
5B	LIBRARY II	58,000	ACADEMIC	3,270	1,143	29	645	17	1,962	50
5C	LIBRARY III	50,000	ACADEMIC	869	304	8	171	4	521	13
36	MAINTENANCE	12,000	ADMIN	600	210	5	118	3	121	3
58	PATRIOT CENTER	162,200	EVENT	10,166	3,554	91	2,005	51	2,054	52
41-49	STUDENT APARTMENTS	109,100	RESIDENTIAL	2,500	874	22	1,500	38	505	13
60-67	UNIVERSITY COMMONS	101,900	RESIDENTIAL	3,597	1,258	32	2,158	55	727	19
80-85	PRESIDENTS PARKS I	97,000	RESIDENTIAL	4,435	1,551	40	2,661	68	896	23
86-92	PRESIDENTS PARK II	101,700	RESIDENTIAL	3,936	1,376	35	2,362	60	795	20
51	COMMONWEALTH HALL	51,200	RESIDENTIAL	1,220	427	11	732	19	247	6
52	DOMINION HALL	48,800	RESIDENTIAL	1,220	427	11	732	19	247	6
34A	ROBINSON A	100,000	ACADEMIC	2,350	822	21	464	12	1,410	36
34B	ROBINSON B	110,500	ACADEMIC	4,029	1,409	36	795	20	2,417	62
70	SCIENCE &TECHNOLOGY I	95,100	ACADEMIC	7,399	2,587	66	1,459	37	4,439	113
71	SCIENCE &TECHNOLOGY II	100,000	ACADEMIC	6,763	2,365	60	1,334	34	4,058	104
33	STUDENT UNION I, PHASES I & II	83,100	STUDENT CNTR	2,921	1,021	26	576	15	590	15
53	STUDENT UNION II	91,000	STUDENT CNTR	4,000	1,399	36	789	20	808	21
78	INNOVATION HALL (ACADEMIC IV)	99,561	ACADEMIC	6,471	2,263	58	1,276	33	3,883	99
94-98	LIBERTY SQUARE (HOUSING V)	183,037	RESIDENTIAL	8,237	2,880	74	4,942	126	1,664	43
99	POTOMAC HEIGHTS (HOUSING VI)	192,470	RESIDENTIAL	8,661	3,028	77	5,197	133	1,750	45
31	AQUATIC CENTER & EXPANSION	90,736	EVENT	5,440	1,902	49	1,073	27	1,099	28
102	RESEARCH NO. 1	98,844	ACADEMIC	6,420	2,245	57	1,266	32	3,852	98
92A	EISENHOWER EXPANSION	114,577	RESIDENTIAL	6,870	2,402	61	4,122	105	1,388	35
106-107	BLUE RIDGE \ SHENANDOAH (H-VII)	121,270	RESIDENTIAL	16,600	5,804	148	9,960	254	3,354	86
108-109	PEIDMOUNT \ TIDEWATER (H-VII)	117,550	RESIDENTIAL	1,950	682	17	1,170	30	394	10
110	NORTHERN NECK (H-VII)	123,140	RESIDENTIAL	1,790	626	16	1,074	27	362	9
112-113	SKYLINE FIT CTR \ SOUTHSIDE DIN. (H-VII)	54,480	RESIDENTIAL	2,270	794	20	1,362	35	459	12
2009	UNIVERSITY HALL	140,000	ADMIN	9,100	3,182	81	1,795	46	1,839	47
JUN '09	ART & VISUAL TECH BLDG	90,000	ACADEMIC	5,900	2,063	53	1,164	30	3,540	90
JUN '09	ENGINEERING BUILDING	180,000	ACADEMIC	11,700	4,091	104	2,308	59	7,020	179
SEP '09	HAMPTON ROADS	97,400	RESIDENTIAL	4,400	1,538	39	2,640	67	889	23
JUN '10	EASTERN SHORE	97,400	RESIDENTIAL	4,400	1,538	39	2,640	67	889	23
SEP '10	STUDENT UNION ADDITION	60,000	STUDENT CNTR	3,600	1,259	32	710	18	727	19
	PERFORMING ARTS ADDITION	15,000	ACADEMIC	1,000	350	9	197	5	600	15
	ROGERS	127,049	RESIDENTIAL	6,004	2,099	54	3,602	92	1,213	31
	WHITETOP	104,036	RESIDENTIAL							
	SCIENCE & TECH II ADDITION	50,000	ACADEMIC	3,300	1,154	30	651	17	1,980	51
	LECTURE HALL	8,000	ACADEMIC	400	140	4	79	2	240	6
EXISTING CAMPUS		4,322,870	---	206,400	72,200	1,842	72,200	1,842	72,200	1,842

NOTES: 1. BUILDINGS ADDED SINCE 2009

2. UNITARY LOAD OF 50 BTU/HR/GSF APPLIED

FIGURE NO. 9: OPERATING CURVES FOR CENTRAL PLANT HOT WATER DISTRIBUTION PUMPS (EXISTING)

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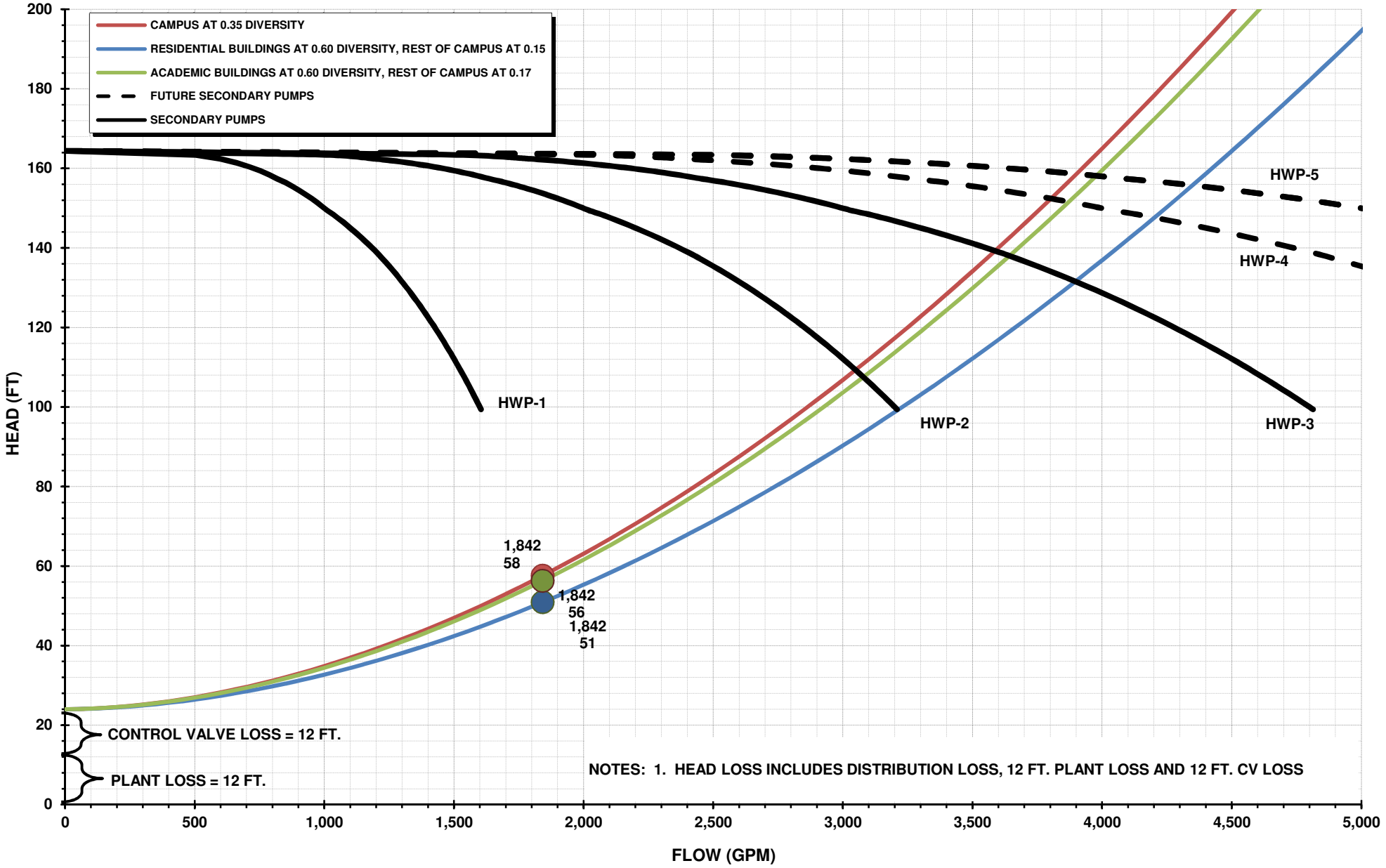

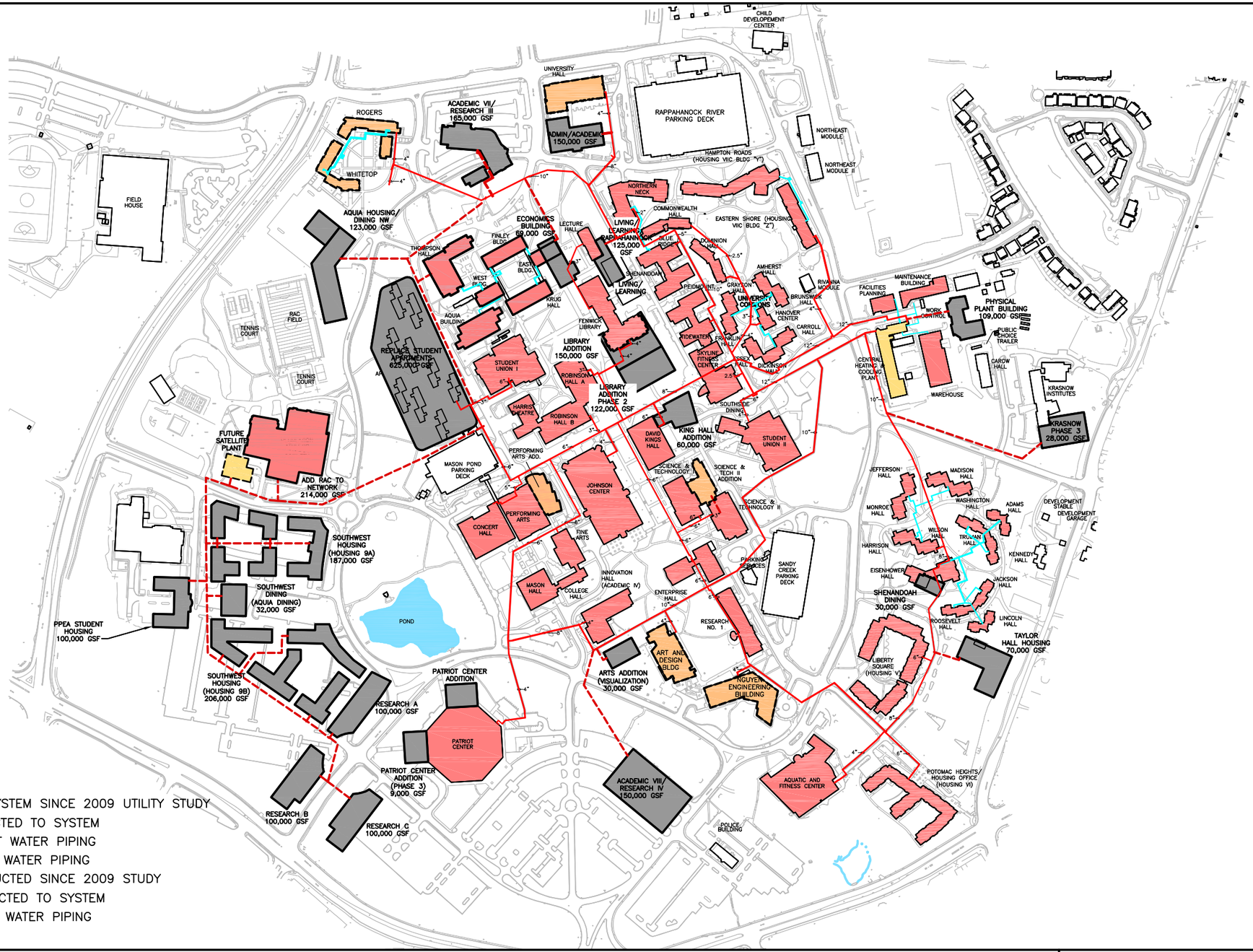

250 0 250

SCALE: 1" = 500' – 0"

LEGEND

- EXISTING CENTRAL PLANT
- NEW BUILDING CONNECTED TO SYSTEM SINCE 2009 UTILITY STUDY
- FUTURE BUILDING TO BE CONNECTED TO SYSTEM
- EXISTING HIGH–TEMPERATURE HOT WATER PIPING
- FUTURE HIGH–TEMPERATURE HOT WATER PIPING
- NEW HOT WATER PIPING CONSTRUCTED SINCE 2009 STUDY
- EXISTING BUILDING TO BE CONNECTED TO SYSTEM
- EXISTING LOW–TEMPERATURE HOT WATER PIPING

GEORGE MASON FUTURE HOT WATER SITE PLAN– FULL BUILD OUT

SCALE: 1" = 500'

PHYSICAL PLANT ADDITION AND RENOVATION

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FAIRFAX, VA

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FIGURE NO. 10

FILE: H:\Proj\113150A\MP\DWGS\3150A-HW.dwg

Memo

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Re: Study of Capacity of GMU North Chilled Water Loop

Based upon current planning, the future peak heating load is expected to increase to approximately 139,430 MBH. This future loading was applied at different load scenarios for the purposes of the hydraulic modeling and the loads are presented in Table No. 4.

A hydraulic model was developed to include the future loads. Similar to the existing model, three operating scenarios were considered to determine the ability of the distribution pumps at the Central Plant to support the future load growth. For all three scenarios (Even Diversity Factor = 0.35, Academic = 0.60 and Residential = 0.60), the head requirement of the system is beyond the capabilities of the distribution pumps. The system curves for each of the three load scenarios are presented in Figure Nos. 11 through 13, respectively.

When the North Loop piping is complete, the head requirements are reduced, but will still be beyond the capabilities of the distribution pumps for two of the three scenarios. Only with the addition of the Satellite Plant (25,000 MBH) in the southwest portion of campus are the distribution pumps at the Central Plant able to support the future load. The timing of the satellite plant is based upon the development of the Southwest Sector of campus

Based upon current planning, there is a need for the additional two boilers at the Central Plant (Boilers Nos. 5 and 6) and a single additional unit at the Satellite Plant. The current load development versus future boiler capacity is presented in Figure No. 14. It was assumed that the timing of when the Satellite Plant comes online is based on the timing of the load development in the Southwest Sector.

The proposed heating and cooling site plan and plant layouts is presented in Figure No. 19.

TABLE NO. 4: FULL BUILD-OUT CAMPUS HEATING LOAD SUMMARY
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BLDG NO.	BUILDING NAME	HEATING AREA (GSF)	SPACE UTILIZATION	UNITARY LOAD (BTU/HR/GSF)	CONNECTED HEATING LOAD (MBTU/HR)	ALL BUILDINGS AT 0.35		RESIDENTIAL 0.60 REST OF CAMPUS AT 0.16		ACADEMIC 0.60 REST OF CAMPUS 0.16	
						PEAK HEATING LOAD (MBTU/HR)	PEAK HEATING LOAD (GPM)	PEAK HEATING LOAD (MBTU/HR)	PEAK HEATING LOAD (GPM)	PEAK HEATING LOAD (MBTU/HR)	PEAK HEATING LOAD (GPM)
EXISTING CAMPUS		4,322,870	---	---	206,382	72,157	1,866	66,866	1,729	66,381	1,717
2014	LIBRARY ADDITION	150,000	ACADEMIC	45	6,750	2,360	61	1,053	27	4,050	105
2014	TAYLOR HALL HOUSING	70,000	RESIDENTIAL	65	4,550	1,591	41	2,730	71	717	19
2014	SHENANDOAH DINING	30,000	RESIDENTIAL	65	1,950	682	18	1,170	30	307	8
2014	LIBRARY ADDITION, PHASE 2	122,000	ACADEMIC	45	5,490	1,920	50	856	22	3,294	85
2017	ACADEMIC VII/RESEARCH III	165,000	ACADEMIC	45	7,425	2,596	67	1,158	30	4,455	115
2017	LIVING/LEARNING/RAPPAHANNOCK	125,000	RESIDENTIAL	65	8,125	2,841	73	4,875	126	1,280	33
TBD	AQUIA HOUSING/DINING NW	123,000	RESIDENTIAL	65	7,995	2,795	72	4,797	124	1,260	33
TBD	SOUTHWEST HOUSING (HOUSING 9A)	187,000	RESIDENTIAL	65	12,155	4,250	110	7,293	189	1,915	50
TBD	SOUTHWEST HOUSING (HOUSING 9B)	206,000	RESIDENTIAL	65	13,390	4,682	121	8,034	208	2,110	55
TBD	SOUTHWEST DINING (AQUIA DINING)	32,000	RESIDENTIAL	65	2,080	727	19	1,248	32	328	8
TBD	THOMPSON, AQUIA, AND FINLEY COMPLEX	482,235	ACADEMIC	45	21,701	7,587	196	3,385	88	13,020	337
2017	KING HALL ADDITION	60,000	ACADEMIC	101	6,060	2,119	55	945	24	3,636	94
2018	PHYSICAL PLANT BUILDING	109,000	ACADEMIC	40	4,360	1,524	39	680	18	2,616	68
2018	ACADEMIC VIII/RESEARCH IV	150,000	ACADEMIC	45	6,750	2,360	61	1,053	27	4,050	105
TBD	PAT CENTER - B'BALL PRACTICE ADD	30,000	ACADEMIC	63	1,890	661	17	295	8	1,134	29
TBD	ECONOMICS BUILDING	69,000	ACADEMIC	45	3,105	1,086	28	484	13	1,863	48
TBD	KRASNOW INSTITUTE PHASE 3	28,000	ACADEMIC	45	1,260	441	11	197	5	756	20
TBD	PPEA STUDENT HOUSING	100,000	RESIDENTIAL	65	6,500	2,273	59	3,900	101	1,024	26
TBD	ADD RAC TO NETWORK	214,000	ACADEMIC	45	9,630	3,367	87	1,502	39	5,778	149
TBD	STUDENT APARTMENTS (DEMO)	(109,100)	RESIDENTIAL	23	(2,509)	(877)	(23)	(1,506)	(39)	(395)	(10)
TBD	REPLACE STUDENT APARTMENTS	640,000	RESIDENTIAL	65	41,600	14,545	376	24,960	645	6,555	170
TBD	PATRIOT CENTER ADDITION (PHASE 3)	9,000	ACADEMIC	63	567	198	5	88	2	340	9
TBD	ADMIN/ACADEMIC (NEAR UHALL)	150,000	ACADEMIC	45	6,750	2,360	61	1,053	27	4,050	105
TBD	ARTS ADDITION (VISUALIZATION)	30,000	ACADEMIC	45	1,350	472	12	211	5	810	21
TBD	RESEARCH A	100,000	ACADEMIC	45	4,500	1,573	41	702	18	2,700	70
TBD	RESEARCH B	100,000	ACADEMIC	45	4,500	1,573	41	702	18	2,700	70
TBD	RESEARCH C	100,000	ACADEMIC	45	4,500	1,573	41	702	18	2,700	70
TOTAL FUTURE		3,472,135	---	---	192,423	67,276	1,740	72,568	1,877	73,053	1,889
FULL BUILDOUT		7,795,005	---	---	398,806	139,433	3,606	139,433	3,606	139,433	3,606

NOTES: 1. UNITARY LOADS FOR PATRIOT CENTER ADDITIONS AND KING HALL ADDITION BASED UPON EXISTING UNITARY LOADS

FIGURE NO. 11: OPERATING CURVES FOR CENTRAL PLANT HOT WATER DISTRIBUTION PUMPS (FULL BUILDOUT)

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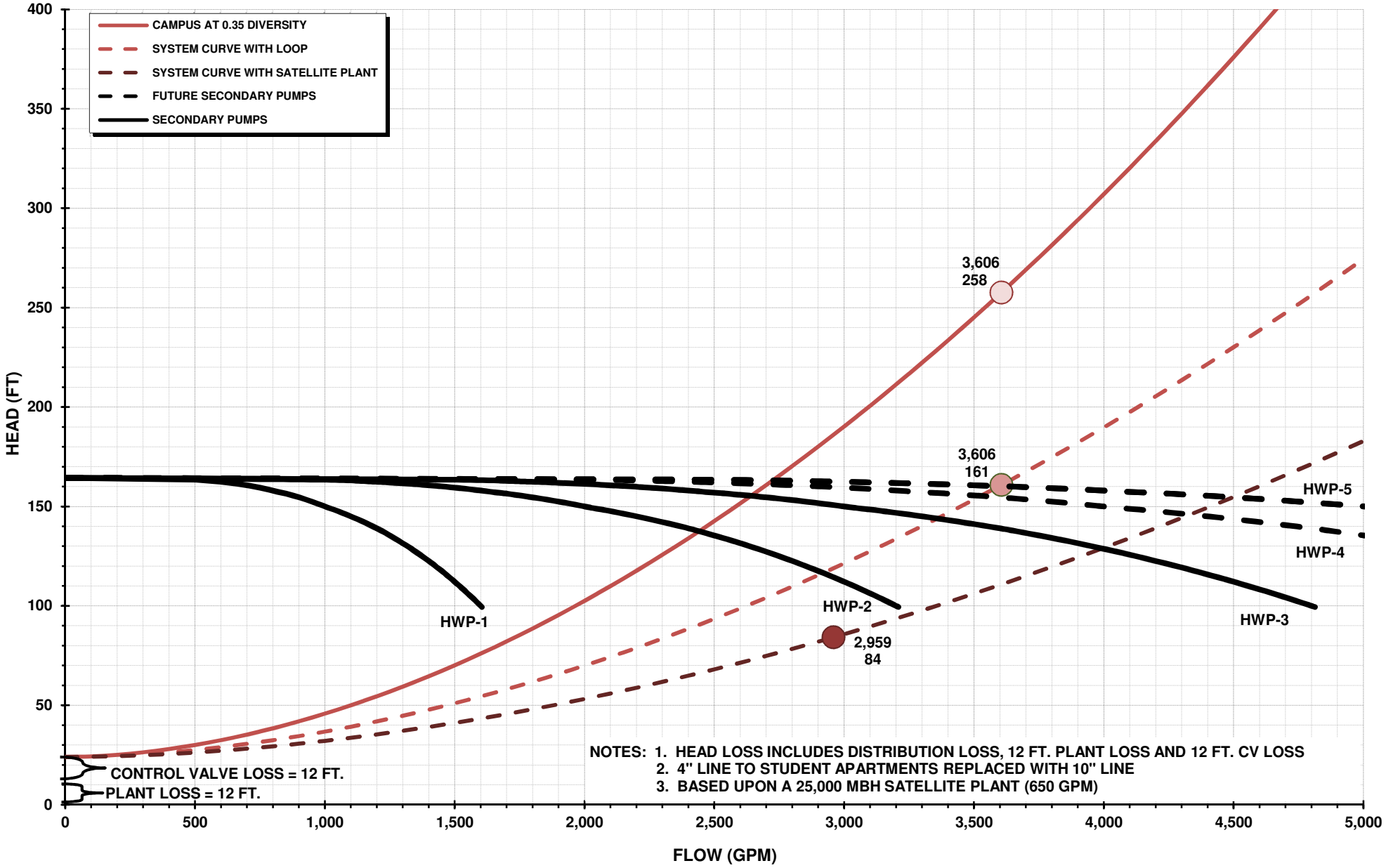

FIGURE NO. 12: CENTRAL PLANT HOT WATER DISTRIBUTION PUMP OPERATING CURVES - RES. BLDGS AT .60 DIVERSITY (FULL BUILDOUT)

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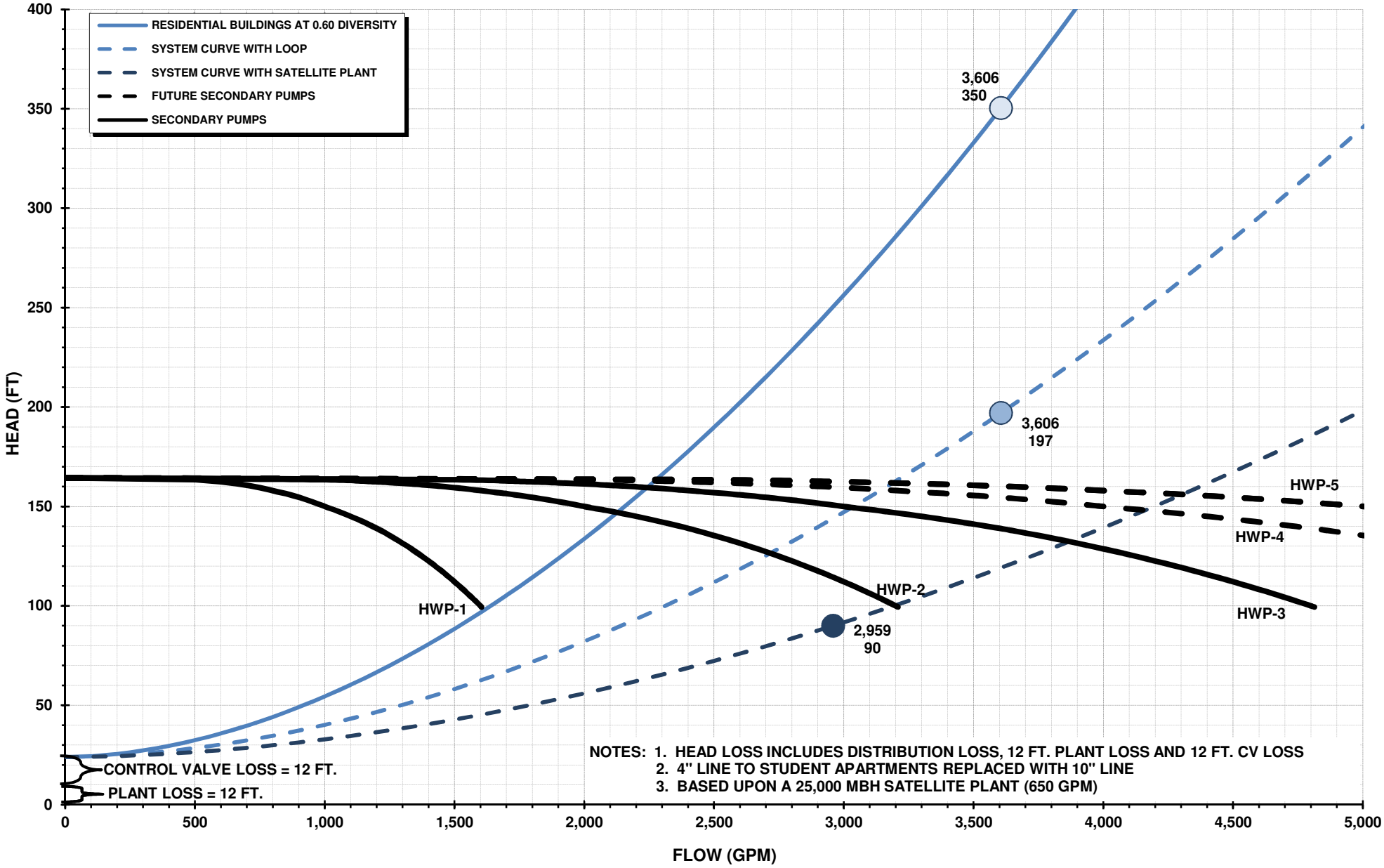

FIGURE NO. 13: CENTRAL PLANT HOT WATER DISTRIBUTION PUMP OPERATING CURVES - ACAD. BLDGS AT .60 DIVERSITY (FULL BUILDOUT)

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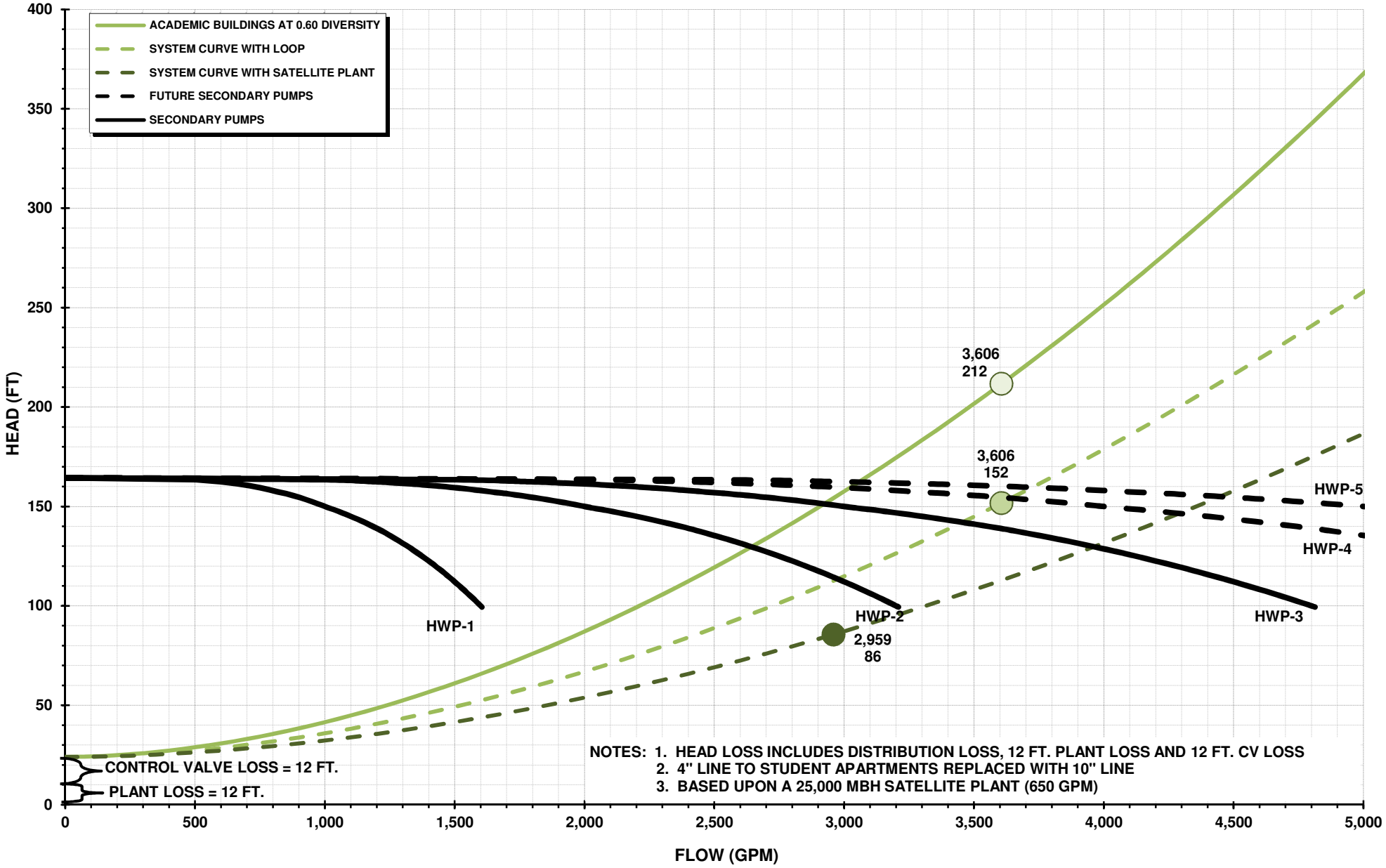

FIGURE NO. 14: CENTRAL PLANT HW CAPACITY VS. FUTURE LOAD

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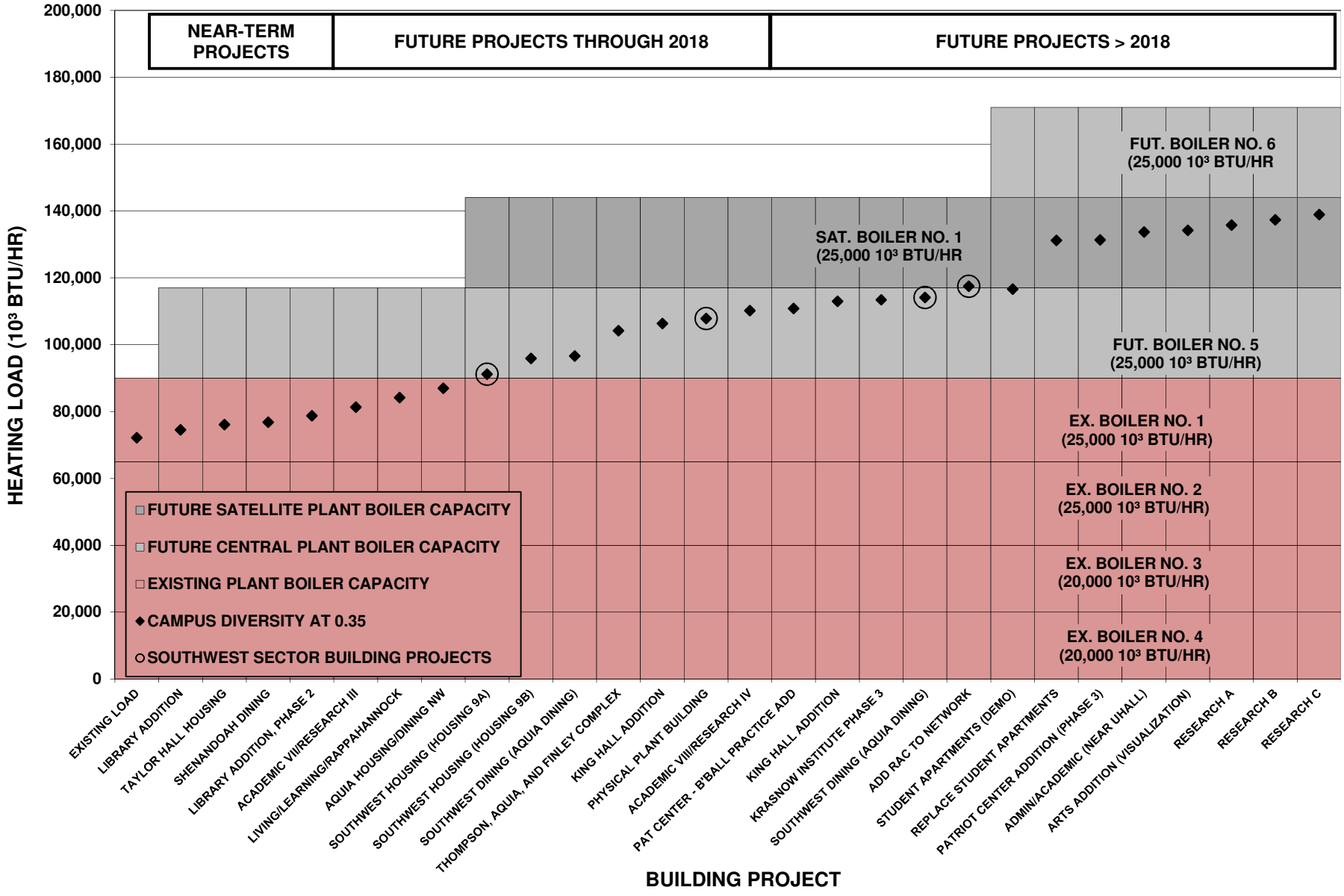
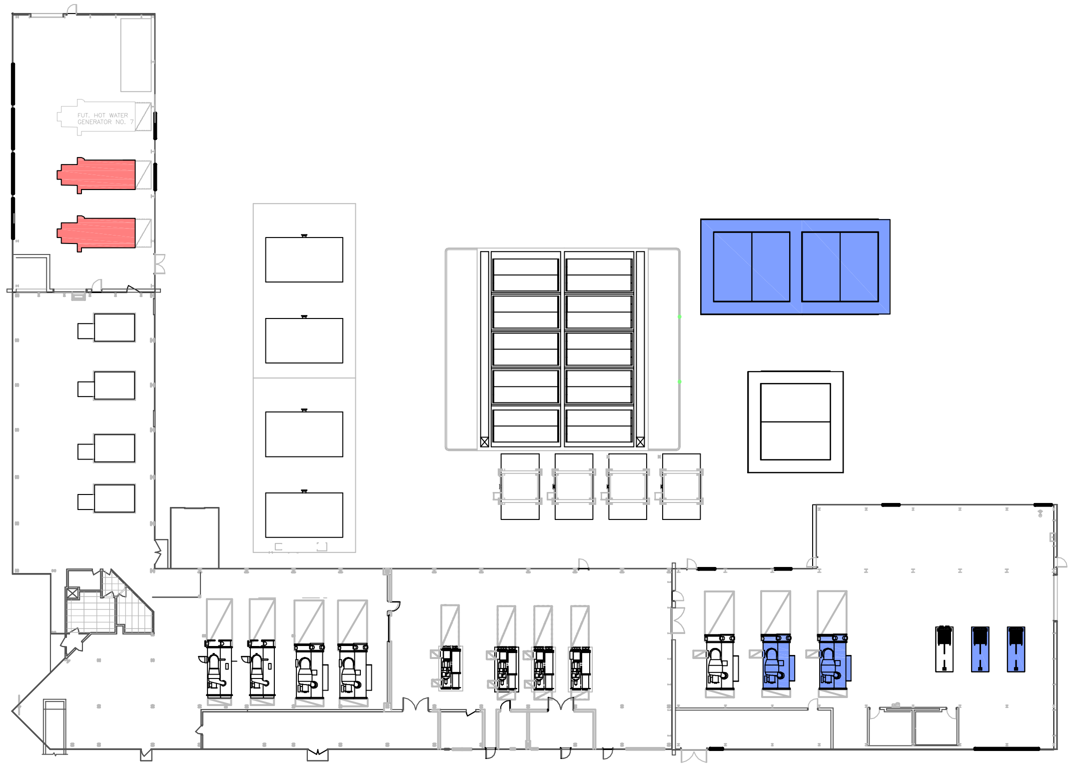


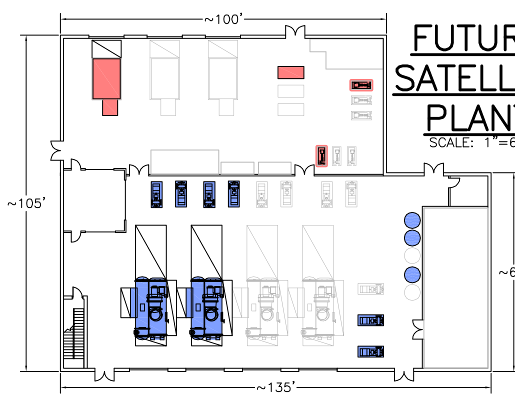


CENTRAL PLANT

SCALE: 1"=60'

30 0 30 60

SCALE: 1" = 60' – 0"

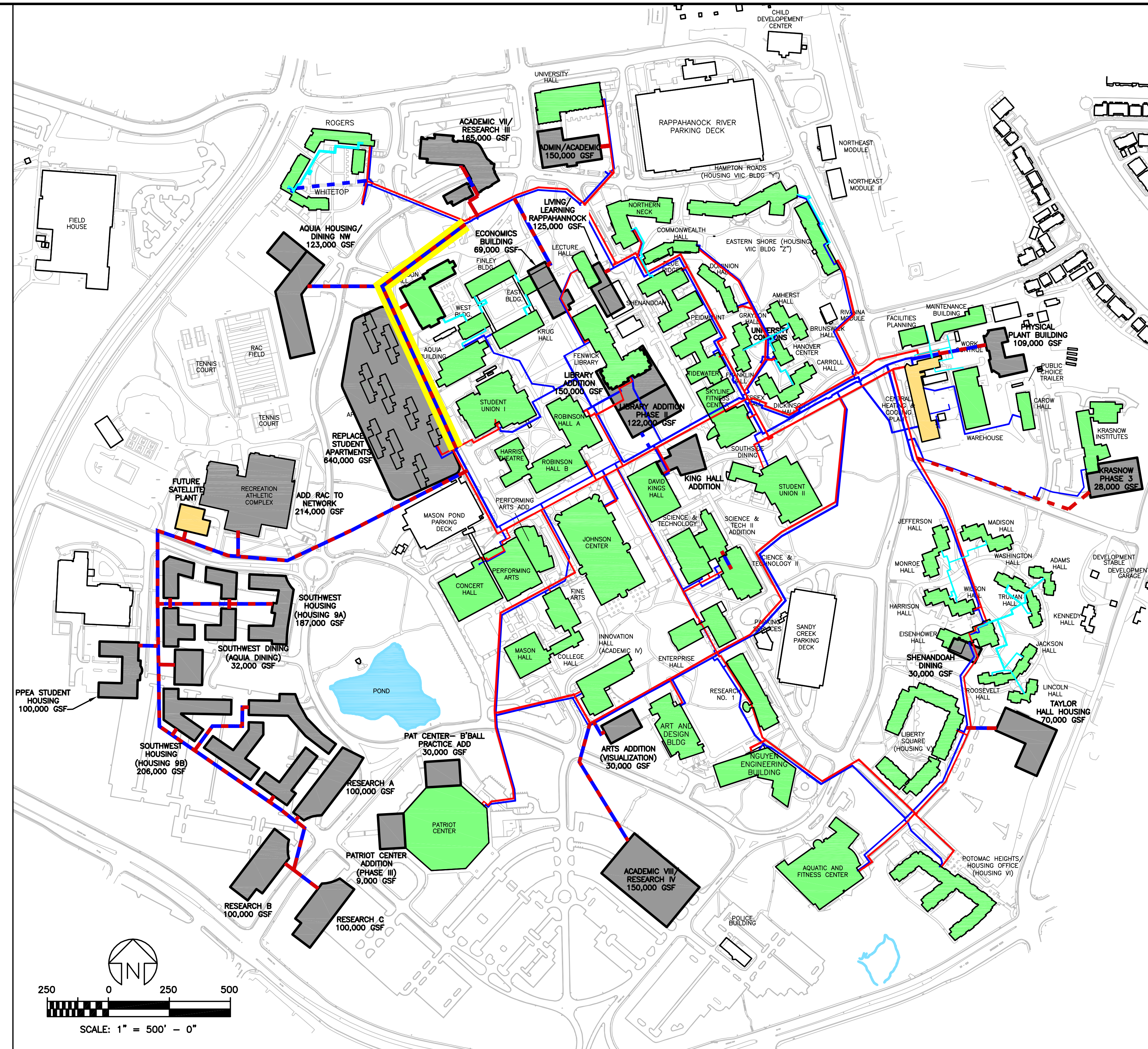


FUTURE SATELLITE PLANT

SCALE: 1"=60'

LEGEND

- EXISTING PLANT EQUIPMENT
- CHILLED WATER EQUIPMENT TO BE ADDED IN NEAR TERM
- HOT WATER EQUIPMENT TO BE ADDED IN NEAR TERM
- FUTURE PLANT EQUIPMENT
- EXISTING BUILDING CONNECTED TO CENTRAL PLANT
- EXISTING BUILDING TO BE CONNECTED TO CENTRAL PLANT
- FUTURE BUILDING CONNECTED TO CENTRAL PLANT
- EXISTING CHILLED WATER AND HOT WATER PIPING
- EXISTING LOW TEMPERATURE HOT WATER PIPING
- FUTURE CHILLED WATER AND HTHW PIPING
- FUTURE CHILLED WATER PIPING
- FUTURE HOT WATER PIPING
- FUTURE LOOP PIPING



GEORGE MASON FULL–BUILDOUT SITE PLAN

SCALE: 1" = 500'

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FIGURE NO. 15