2009 UTILITY MASTER PLAN UPDATE

FINAL SUBMISSION

George Mason University

JULY 2009

RMF ENGINEERING, INC.
CONSULTING ENGINEERS
5520 RESEARCH PARK DRIVE
BALTIMORE, MARYLAND 21228
(410) 576-0505 Fax: (410) 385-0327

TABLE OF CONTENTS

DIVISION NO. 4 - APPENDIX

DIVISION NO. 1 - EXECUTIVE SUMMARY

1.1 BACKGROUND

A comprehensive Utility Master Plan was developed for George Mason University in 2002. That report established a series of utility projects needed to reliably and efficiently support the future campus development. Since 2002, the University has requested updates to ensure the proposed utility plan provides adequate capacity to support the site, as the campus planning has been further developed, modified, and implemented. In 2006, a Utility Master Plan update was requested which confirmed the capacity and timing requirements of the utility projects that are currently in construction.

Since the 2006 Utility Master Plan Update, over 600,000 gross square feet (gsf) of facilities have been added to the central heating and cooling systems. In addition, significant changes to the initial campus planning have occurred. The most notable difference is the shift of development to the Southwest Sector of campus. Previously, this portion of campus encompassed approximately 15% of the future development of the campus. In the 2009 Campus Plan, approximately 36% of the future development is planned within the Southwest Sector. These issues have prompted the University to initiate this 2009 Utility Master Plan Update.

1.2 OBJECTIVE

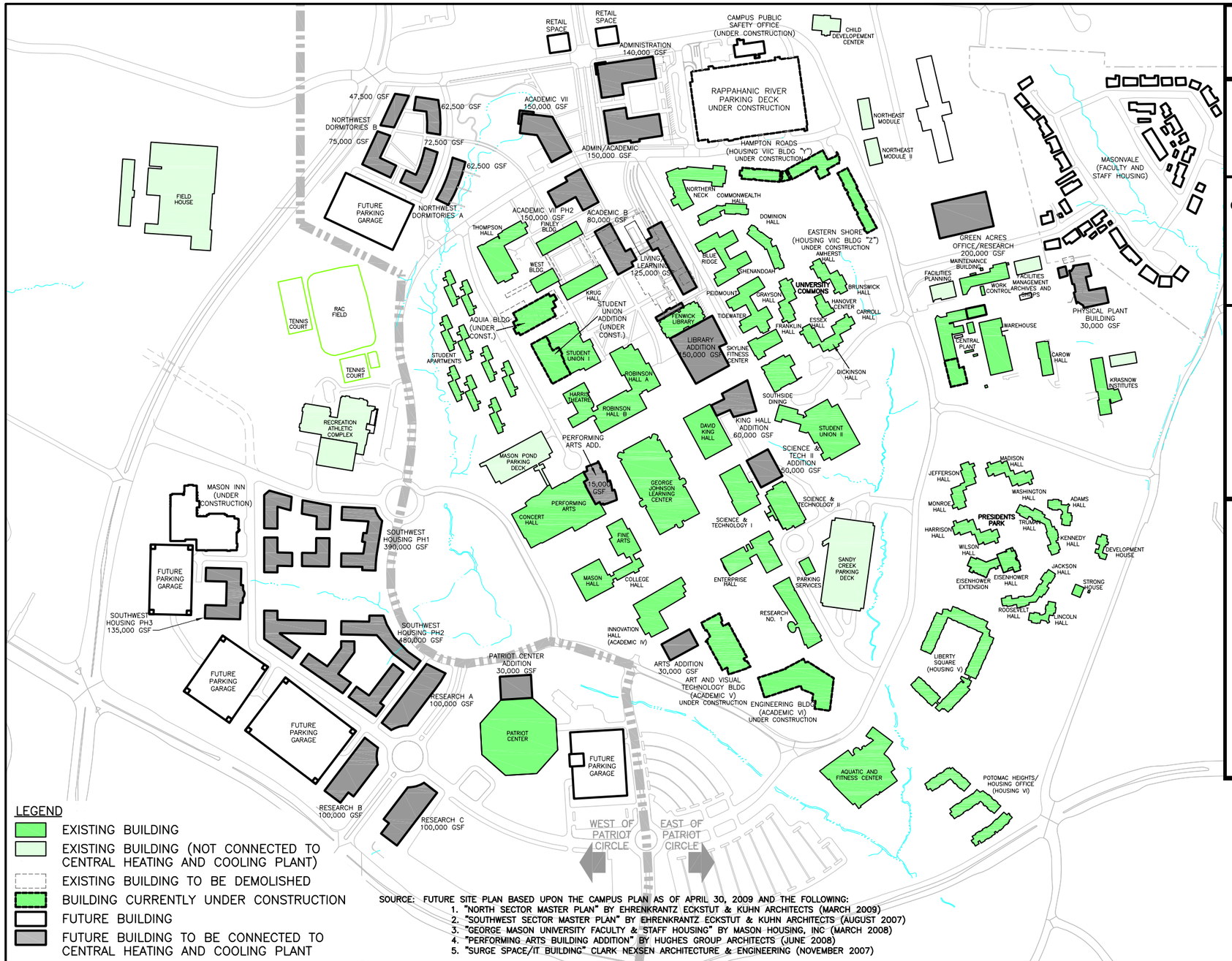
This study is intended to synchronize the Utility Master Plan with the current (2009) campus plan. Specifically, the report addressed the timing and implementation of the previously recommended utility projects to ensure adequate capacity to meet the need for the existing and future campus facilities.

1.3 UTILITY UPGRADES SINCE 2006

The 2006 Update was the initial phase of a utility project that included the expansion of the existing Central Plant and the installation of a set of high temperature hot water distribution (HTHW) and chilled water mains from the Central Plant to the campus distribution loops. The expansion of the Central Plant was intended include an additional 25 million Btu's per hour (MMBH) hot water boiler and a 1,500 ton chiller (Chiller No. 9). Subsequently, the boiler addition was deferred due to cost limitations. The chiller and distribution upgrades are in progress and scheduled to be complete by 2010. A separate project to replace Boiler No. 2 with a 25 MMBH unit is planned for completion by the end of 2010.

1.4 2009 UTILITY MASTER PLAN UPDATE

The current 2009 campus plan is presented in Figure No. 1-1. The estimated areas and space utilization of the future buildings were utilized to project the future heating and cooling loads.



LEGEND

- EXISTING BUILDING
- EXISTING BUILDING (NOT CONNECTED TO CENTRAL HEATING AND COOLING PLANT)
- EXISTING BUILDING TO BE DEMOLISHED
- BUILDING CURRENTLY UNDER CONSTRUCTION
- FUTURE BUILDING
- FUTURE BUILDING TO BE CONNECTED TO CENTRAL HEATING AND COOLING PLANT

SOURCE: FUTURE SITE PLAN BASED UPON THE CAMPUS PLAN AS OF APRIL 30, 2009 AND THE FOLLOWING:

1. "NORTH SECTOR MASTER PLAN" BY EHRENKRANTZ ECKSTUT & KUHN ARCHITECTS (MARCH 2009)
2. "SOUTHWEST SECTOR MASTER PLAN" BY EHRENKRANTZ ECKSTUT & KUHN ARCHITECTS (AUGUST 2007)
3. "GEORGE MASON UNIVERSITY FACULTY & STAFF HOUSING" BY MASON HOUSING, INC (MARCH 2008)
4. "PERFORMING ARTS BUILDING ADDITION" BY HUGHES GROUP ARCHITECTS (JUNE 2008)
5. "SURGE SPACE/IT BUILDING" CLARK NEXSEN ARCHITECTURE & ENGINEERING (NOVEMBER 2007)

FUTURE BUILDING SUMMARY

GEORGE MASON UNIVERSITY

PHASE	YEAR ONLINE	PROJECT	ESTIMATED GROSS AREA (GSF)
UNDER CONSTRUCTION	JUN '09	ART & VISUAL TECH BLDG (ACADEMIC V)	90,000
	JUN '09	ENGINEERING BUILDING (ACADEMIC VI)	180,000
	SEP '09	HAMPTON ROADS (HOUSING VIIC BLDG "Y")	97,400
	DEC '09	AQUIA BUILDING	60,000
	JUN '10	EASTERN SHORE (HOUSING VIIC BLDG "Z")	97,400
	SEP '10	STUDENT UNION ADDITION	60,000
FUTURE (2010-2014)	SEP '10	PERFORMING ARTS ADDITION	15,000
	2011	ADMINISTRATION	140,000
	2011	SCIENCE & TECH II ADDITION	50,000
	2012	LIBRARY ADDITION	150,000
	2012	NORTHWEST DORMITORIES A	135,000
	2012	PATRIOT CENTER ADDITION	30,000
	2012	PHYSICAL PLANT BUILDING	30,000
	2013	ACADEMIC VII	150,000
	2013	LIVING/LEARNING	125,000
(>2014)	2015	RESEARCH A	100,000
	2015	SOUTHWEST HOUSING PH1	390,000
	2015	KING HALL ADDITION	60,000
	2017	RESEARCH B	100,000
	2017	ACADEMIC VII PH2	150,000
	2017	SOUTHWEST HOUSING PH2	480,000
	2019	RESEARCH C	100,000
	2019	ADMIN/ACADEMIC	150,000
	2019	SOUTHWEST HOUSING PH3	135,000
	2019	ARTS ADDITION	30,000
	2020	ACADEMIC B	80,000
	2020	NORTHWEST DORMITORIES B	185,000
	2020	GREEN ACRES RESEARCH/OFFICE	200,000

BUILDIINGS WEST OF PATRIOT CIRCLE

250 0 250 500

SCALE: 1" = 500' – 0"

GEORGE MASON UNIVERSITY
FUTURE SITE PLAN – THROUGH 2020

SCALE: 1" = 500'

GMU UPDATE TO UTILITY MASTER PLAN

RMF ENGINEERING, INC. BALTIMORE, MD

GEORGE MASON UNIV. FAIRFAX, VA

28 JULY 2009

FIGURE NO. 1–1

FILE: H:\Proj\100836A0\MP\DWG\100836-11-CHN-mTHK.dwg

Graphs representing the existing central plant capacity versus the future load requirements for high temperature hot water and chilled water systems are presented in Figure Nos. 1-2 and 1-3, respectively. The firm capacity, noted in each graph, is the total capacity of the respective system without the operation of the largest single unit. For the high temperature hot water system, the future projected load will exceed the firm capacity of the plant (with the Boiler No. 2 replacement) once the current building projects under construction are complete. Therefore, there is an immediate need for additional boiler capacity.

For chilled water, the future projected load will exceed the firm capacity (including Chiller No. 9) of the plant within next five years. This includes consideration for Chiller No. 9 which is currently under construction.

To establish the funding and implement a project to expand the Central Heating Plant will require several years during which the existing plant would operate without standby capacity. As an alternative, the Satellite Utility Plant programmed for the Southwest Sector could be utilized to provide the needed standby capacity for the Central Heating system. The Satellite Plant was originally proposed in the 2002 Utility Master Plan to serve the facilities west of Patriot Circle. As the planning for future development has shifted to the southwest, the Satellite Plant has developed a more prominent role in the future utility planning. While initially planned as a low temperature hot water (LTHW) plant, modifying the utility plan to develop a high temperature hot water plant, connected to the central distribution system, will provide the campus with the additional capacity needed. The Satellite Plant would provide LTHW to the Southwest Sector via heat exchangers that would be installed within the plant. In the future, the University will have the flexibility to add capacity to either the Central Plant or the Satellite Plant to support the future load beyond 2014. While the need for chilled water is not as critical, the Satellite Utility Plant would provide similar flexibility in regards to future chiller capacity.

The sanitary sewer system was also reviewed to determine if the existing mains can accommodate the future sanitary sewer requirements. At full buildout, the two sanitary mains that service the majority of the campus will be at a combined 98% of capacity. Because of the projected load is essentially equal to the capacity threshold of the existing mains, the connection of the future buildings will need to be carefully balanced among the two mains in order to avoid exceeding the individual piping capacity. Furthermore, since this global analysis resulted in identifying a 2% capacity margin, a more detailed sanitary analysis is recommended prior to the year 2014.

The revised costs and schedule of the utility infrastructure upgrades for the campus are presented in Table No. 1-1. The proposed site plan and plant layout is presented in Figure No. 1-4. The budgetary capital costs are based upon the following unitary cost factors:

1. Heating Equipment - $100 / thousand Btu's per hour (MBH)
2. Cooling Equipment - $2,000 / ton

FIGURE NO. 1-2: EXISTING HOT WATER CAPACITY VS. FUTURE LOAD

GEORGE MASON UNIVERSITY

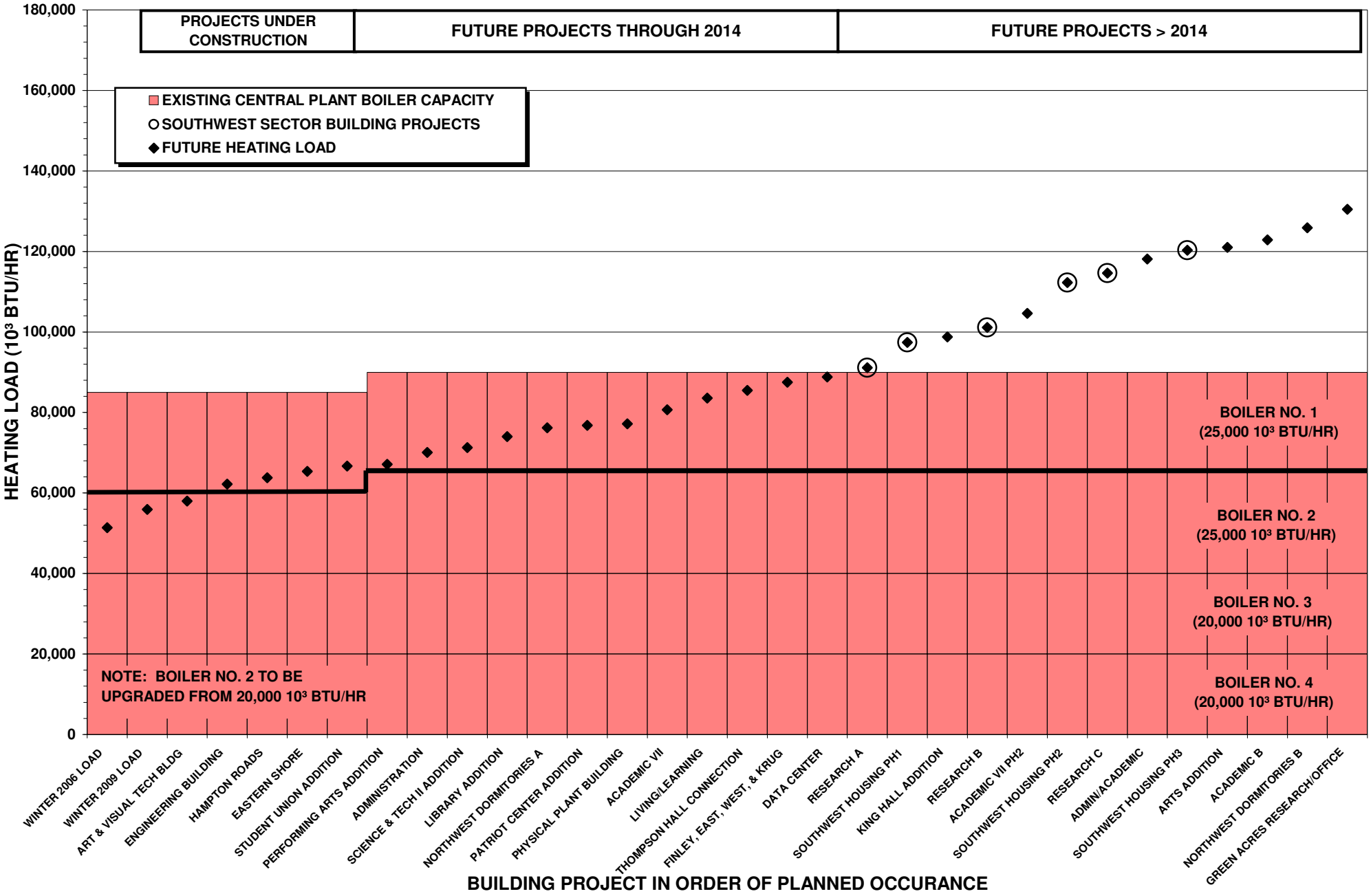


FIGURE NO. 1-3: EXISTING CHILLED WATER CAPACITY VS. FUTURE LOAD

GEORGE MASON UNIVERSITY

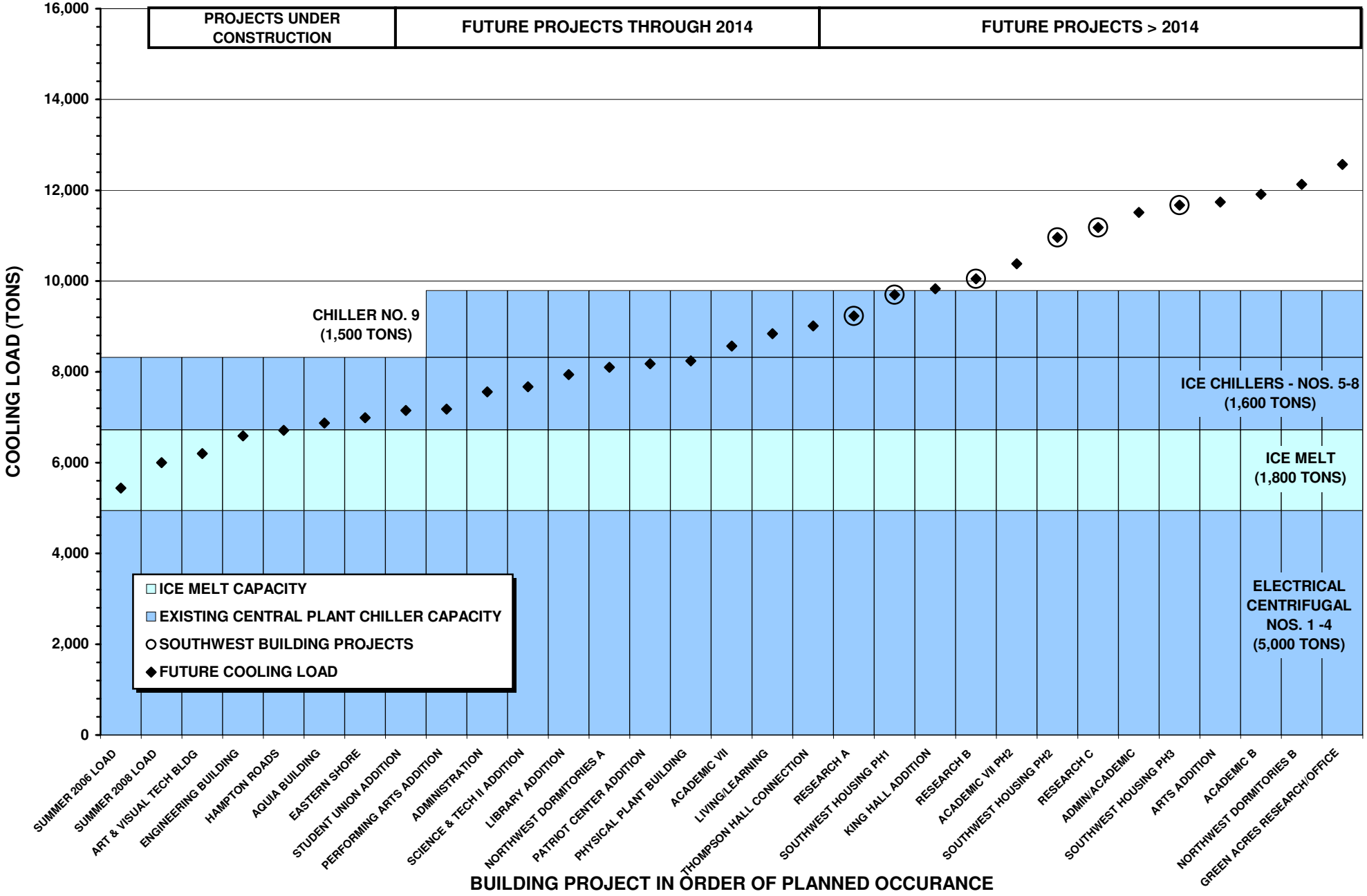


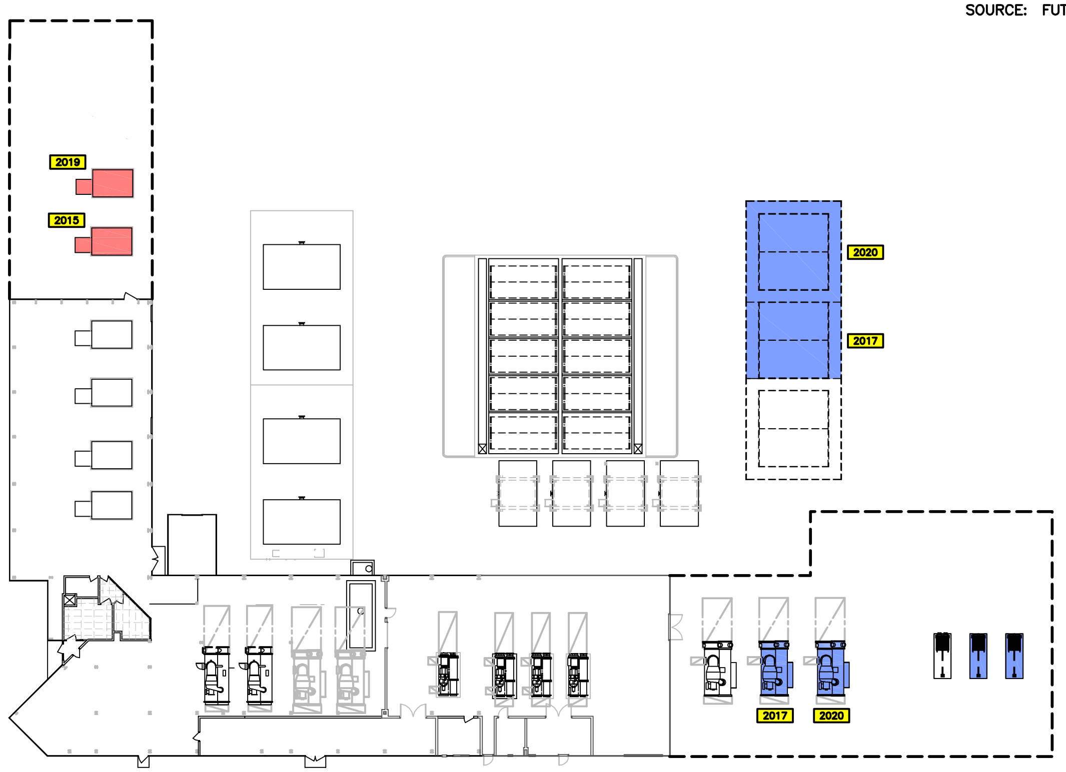
TABLE NO. 1-1: SUMMARY OF INFRASTRUCTURE UPGRADES - 2009 COSTS (PRELIMINARY)

GEORGE MASON UNIVERSITY - FAIRFAX CAMPUS

PHASE NO.	ONLINE TIME FRAME	PROJECT	INFRASTRUCTURE UPGRADES						
			HEATING AND COOLING		DISTRIBUTION LOOP		RADIAL DISTRIBUTION		TOTAL COST ($)
			DESCRIPTION	CONSTRUCT. COST ($)	DESCRIPTION	CONSTRUCT. COST ($)	DESCRIPTION	CONSTRUCT. COST ($)	
UNDER CONST.	JUN '09	ART & VISUAL TECH BLDG (ACADEMIC V)	CURRENTLY UNDER DESIGN OR IN CONSTRUCTION						
	JUN '09	ENGINEERING BUILDING (ACADEMIC VI)							
	SEP '09	HAMPTON ROADS (HOUSING VIIC BLDG "Y")							
	DEC '09	AQUIA BUILDING							
	JUN '10	EASTERN SHORE (HOUSING VIIC BLDG "Z")							
	SEP '10	STUDENT UNION ADDITION							
FUTURE	SEP '10	PERFORMING ARTS ADDITION	---	---	---	---	100 LF CHW & HTHW	160,000	160,000
	2011	ADMINISTRATION	---	---	---	---	480 LF CHW & HTHW	768,000	770,000
	2011	SCIENCE & TECH II ADDITION	---	---	---	---	130 LF CHW & HTHW	208,000	210,000
	2012	LIBRARY ADDITION	SAT. PLANT (2) 1,100 TONS CHW	6,000,000	SAT. PLANT BACKFEED (1,300 LF)	4,600,000	100 LF CHW & HTHW	160,000	14,200,000
			SAT. PLANT (1) 25 MMBH HTHW	3,400,000					
	2012	NORTHWEST DORMITORIES A	---	---	NORTH LOOP PHASE II (810 LF)	2,800,000	200 LF CHW & HTHW	320,000	3,120,000
	2012	PATRIOT CENTER ADDITION	---	---	---	---	100 LF CHW & HTHW	160,000	160,000
	2012	PHYSICAL PLANT BUILDING	---	---	---	---	600 LF CHW & HTHW	960,000	960,000
	2013	ACADEMIC VII	---	---	---	---	100 LF CHW & HTHW	160,000	160,000
	2013	LIVING/LEARNING	---	---	---	---	100 LF CHW & HTHW	160,000	160,000
	2014	THOMPSON HALL CONNECTION	---	---	SANITARY SYSTEM HYDRAULIC ANALYSIS	40,000	100 LF CHW & HTHW	160,000	200,000
	2014	FINLEY, EAST, WEST, & KRUG							
	2014	DATA CENTER							
	2015	SOUTHWEST HOUSING PH1	---	---	SOUTHWEST CHW & LTHW (460 LF)	920,000	470 LF CHW & LTHW	752,000	1,670,000
	2015	KING HALL ADDITION	---	---	---	---	100 LF CHW & HTHW	160,000	160,000
	2015	RESEARCH A	ADD BOILER NO. 5 (25 MMBH)	2,500,000	SOUTHWEST CHW & LTHW (1,200 LF)	2,400,000	100 LF CHW & LTHW	160,000	5,060,000
	2017	ACADEMIC VII PH2	---	---	---	---	100 LF CHW & HTHW	160,000	160,000
	2017	RESEARCH B	ADD CHILLER NO. 10 (1,500 TONS)	3,000,000	SOUTHWEST CHW & LTHW (200 LF)	400,000	100 LF CHW & LTHW	160,000	3,560,000
	2017	SOUTHWEST HOUSING PH2	---	---	---	---	300 LF CHW & LTHW	480,000	480,000
	2019	ADMIN/ACADEMIC	---	---	---	---	100 LF CHW & HTHW	160,000	160,000
	2019	ARTS ADDITION	---	---		---	100 LF CHW & HTHW	160,000	160,000
	2019	RESEARCH C	ADD BOILER NO. 6 (25 MMBH)	2,500,000	---	---	100 LF CHW & LTHW	160,000	2,660,000
	2019	SOUTHWEST HOUSING PH3	---	---	---	---	100 LF CHW & LTHW	160,000	160,000
	2020	ACADEMIC B	ADD CHILLER NO. 11 (1,500 TONS)	3,000,000	---	---	100 LF CHW & HTHW	160,000	3,160,000
	2020	NORTHWEST DORMITORIES B	---	---	---	---	250 LF CHW & HTHW	400,000	400,000
	2020	GREEN ACRES RESEARCH/OFFICE	---	---	---	---	300 LF CHW & HTHW	480,000	480,000
	---	COMPLETION OF NORTH LOOP	---	---	NORTH LOOP COMPLETION (700 LF)	2,500,000	---	---	2,500,000
	---	ADDITIONAL LOOP PIPING	---	---	ADDITIONAL LOOP PIPING (900 LF)	3,200,000	---	---	3,200,000
TOTAL			---	20,400,000	---	16,860,000	---	6,768,000	44,100,000

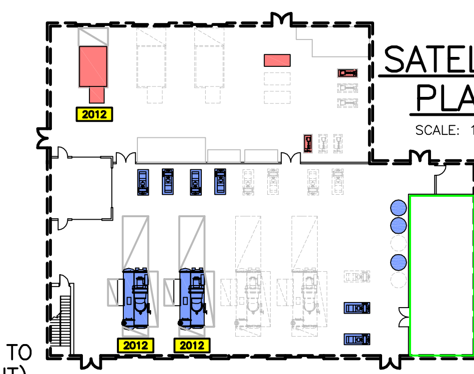
RMF 29 JULY 2009

SOURCE: FUTURE SITE PLAN BASED UPON THE CAMPUS PLAN AS OF APRIL 30, 2009 AND THE FOLLOWING:
1. "NORTH SECTOR MASTER PLAN" BY EHRENKRANTZ ECKSTUT & KUHN ARCHITECTS (MARCH 2009)
2. "SOUTHWEST SECTOR MASTER PLAN" BY EHRENKRANTZ ECKSTUT & KUHN ARCHITECTS (AUGUST 2007)
3. "GEORGE MASON UNIVERSITY FACULTY & STAFF HOUSING" BY MASON HOUSING, INC (MARCH 2008)
4. "PERFORMING ARTS BUILDING ADDITION" BY HUGHES GROUP ARCHITECTS (JUNE 2008)
5. "SURGE SPACE/IT BUILDING" CLARK NEXSEN ARCHITECTURE & ENGINEERING (NOVEMBER 2007)



CENTRAL PLANT

SCALE: 1"=60'



SATELLITE PLANT

SCALE: 1"=60'

LEGEND

- EXISTING BUILDING
- EXISTING BUILDING (NOT CONNECTED TO CENTRAL HEATING AND COOLING PLANT)
- EXISTING BUILDING TO BE DEMOLISHED
- BUILDING CURRENTLY UNDER CONSTRUCTION
- FUTURE BUILDING
- FUTURE BUILDING – PHASE I (2010 – 2015)
- FUTURE BUILDING – PHASE II (2016 – 2020)
- FUTURE COOLING EQUIPMENT
- FUTURE HEATING EQUIPMENT
- EXISTING CHILLED WATER AND HOT WATER PIPING
- CHILLED AND HOT WATER PIPING UNDER CONSTRUCTION
- FUTURE CHILLED WATER AND HIGH TEMPERATURE HOT WATER PIPING
- FUTURE CHILLED WATER AND LOW TEMPERATURE HOT WATER PIPING
- ADDITIONAL CHILLED WATER LOOP PIPING

125 0 125 250

SCALE: 1" = 250' – 0"

FUTURE GEORGE MASON UNIVERSITY SITE PLAN AND PLANT FLOOR PLANS – FULL BUILDOUT

SCALE: 1" = 500'

GMU UPDATE TO UTILITY MASTER PLAN

RMF ENGINEERING, INC.
BALTIMORE, MD

GEORGE MASON UNIV.
FAIRFAX, VA

28 JULY 2009

FIGURE NO. 1–4

3. Building Costs - $200 / gsf
4. HTHW and Chilled Water Mains - $3,500 / linear foot
5. LTHW and Chilled Water Mains - $2,000 / linear foot
6. HTHW and Chilled Water Radial Feeds - $1,600 / linear foot

Note: These costs are 2009 **construction costs only** and do not include escalation or project costs (i.e. project design fees, project contingencies, etc.)

DIVISION NO. 2 - 2009 UPDATED SYSTEM CONDITIONS

2.1 2009 UPDATED SUMMARY OF EXISTING UTILITY SYSTEMS

The George Mason University (GMU) Fairfax campus is comprised of various educational facilities including academic classrooms, libraries, assembly areas, and student and faculty housing. The majority of the campus is provided heating and cooling by the Central Plant located in the northeast quadrant of campus as shown in Figure No. 2-1. The existing Central Plant currently distributes chilled water and high temperature hot water (HTHW) to approximately 3,250,000 gross square feet (GSF) of facility area. In 2006, a Utility Master Plan update was requested which confirmed the capacity and timing requirements of the utility projects that are currently in construction.

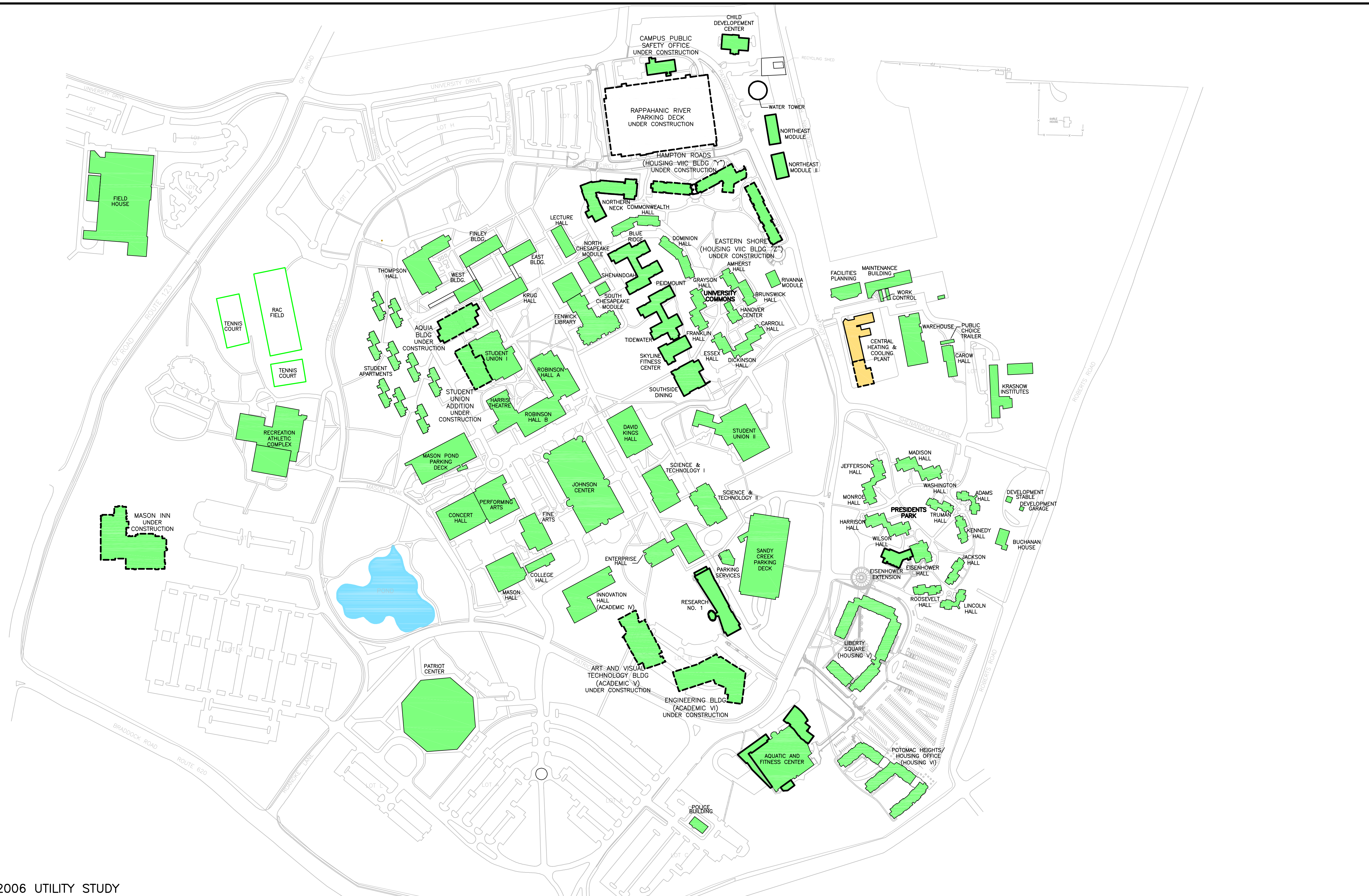
Since the 2006 Utility Master Plan Update the following buildings have been constructed and connected to the Central Plant:

Building Name	Area (gsf)
Aquatic Center Expansion	90,740
Research No. 1	98,840
Eisenhower Expansion	16,880
Blue Ridge / Shenandoah (H-VII)	121,270
Peidmount / Tidewater (H-VII)	117,550
Northern Neck (H-VII)	123,140
Skyline Fitness / Southside Dining (H-VII)	54,480
Total	622,900

The following is a summary of the 2009 existing utility system configuration and the current peak chilled water and heating loads.

2.2 HIGH TEMPERATURE HOT WATER GENERATION

The existing Central Plant consists of four HTHW generators with a total capacity of 85 million Btu's per hour (MMBH). A summary of the individual units is presented in Table No. 2-1. Generator No. 2 is approximately 36 years in age. Typically HTHW generators may require an overhaul or replacement beyond 30 years in age depending upon the water treatment and maintenance program. Boiler No. 2 has been identified by GMU for replacement by the end of 2010.



LEGEND

- EXISTING CENTRAL PLANT
- EXISTING BUILDING
- NEW BUILDING CONSTRUCTED SINCE 2006 UTILITY STUDY
- BUILDING CURRENTLY UNDER CONSTRUCTION

NOTE: 2009 CAMPUS SITE PLAN IS CURRENT AS OF APRIL 30, 2009

N

250 0 250 500

SCALE: 1" = 500' – 0"

GEORGE MASON UNIVERSITY
2009 CAMPUS SITE PLAN

SCALE: 1" = 500'

GMU UPDATE TO UTILITY MASTER PLAN

RMF ENGINEERING, INC.
BALTIMORE, MD

GEORGE MASON UNIV.
FAIRFAX, VA

28 JULY 2009

FIGURE NO. 2–1

TABLE NO. 2-1: EXISTING HTHW GENERATOR DESIGN CAPACITIES
GEORGE MASON UNIVERSITY

HTHW GEN. NO.	DATE INST.	MANUFACT.	TYPE/ MODEL NO.	SERIAL NO.	DESIGN CAP. (10^3 BTU/HR)	DIFF. PRESS. (PSIG)
1	2005	ENGLISH	FK 25 350	24 065	25,000	---
2	1973	FLO / KRONTOLD	219-20A	20259	20,000	6.5
3	1988	IBW	TJH C20	L296	20,000	6.5
4	1994	ENGLISH	N/A	94-149	20,000	6.5
TOTAL EXISTING CAPACITY					85,000	---
EXISTING FIRM CAPACITY (WITHOUT LARGEST UNIT)					60,000	---

NOTES:
1. NO NEW EQUIPMENT HAS BEEN INSTALLED SINCE THE 2006 MASTER PLAN UPDATE.
2. BOILER NO. 4 HAS BEEN DE-RATED FROM 24 MILLION BTU/HR SINCE THE 2006 MASTER PLAN UPDATE.

RMF 12 JUNE 2009

2.3 2009 HIGH TEMPERATURE HOT WATER LOAD

2.3.1 Peak Load

The HTHW flow and the temperature difference between the supply and return water that are recorded in the plant boiler logs were used to estimate the peak plant HTHW operation for the months of January and February 2009, which is summarized in Table No. 2-2. According to the plant boiler logs, the peak heating load in February 2009 was approximately 56 MMBH. This load is considered to represent the peak heating load, since the outdoor air temperature during this period was 10°F, which is within one degree of the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) design temperature of 9°F. The current peak load is within 4% of the load projections established in the 2006 Utility Master Plan Update.

The estimated design heating load for each building is presented in Table No. 2-3. These loads are based upon building area and unitary load factors from previous studies. The total connected (design) load of the campus is approximately 157 MMBH, which compared to the peak plant output of 56 MMBH, results in a diversity of approximately 36%. This diversity factor is lower than the typical diversity factor for a central heating system. This is most likely because the original connected load estimates of the campus buildings may be higher than the actual design. The University could invest to a study to calculate the design loads of all the existing facilities; however, since the utility planning is based on peak loads derived from the documented log data, revisions to the connected load would have negligible impact on the future utility recommendations.

2.4 2009 HTHW DISTRIBUTION

The HTHW distribution system supplies HTHW to the individual campus facilities by a supply and return system. The main HTHW pipe is a 12-inch diameter distribution line extending west from the Central Plant. The HTHW distribution piping is installed within utility trenches parallel to the direct buried chilled water distribution piping. All the pipes within the HTHW distribution system are welded steel construction. A site plan indicating the campus HTHW distribution is presented in Figure No. 2-2.

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)

TABLE NO. 2-2: ESTIMATED MONTHLY HEATING LOAD SUMMARY
GEORGE MASON UNIVERSITY

MONTH	2006 UTILITY MASTER PLAN						UPDATED UTILITY MP (2009 BOILER LOGS)	
	2005		2006		TOTAL			
	PEAK HEATING LOAD (MBTU/HR)	TOTAL PRODUCTION (MMBTU)	PEAK HEATING LOAD (MBTU/HR)	TOTAL PRODUCTION (MMBTU)	TOTAL HEATING LOAD (MBTU/HR)	TOTAL PRODUCTION (MMBTU)	PEAK HEATING LOAD (MBTU/HR)	TOTAL PRODUCTION (MMBTU)
JAN	---	---	43,850	20,039	43,850	20,039	55,010	22,145
FEB	---	---	51,435	21,404	51,435	21,404	55,939	19,088
MAR	---	---	46,916	19,140	46,916	19,140	---	---
APR	---	---	33,000	8,711	33,000	8,711	---	---
MAY	---	---	13,326	1,895	13,326	1,895	---	---
JUN	---	---	18,096	3,229	18,096	3,229	---	---
JUL	---	---	8,316	2,572	8,316	2,572	---	---
AUG	---	---	8,112	164	8,112	164	---	---
SEP	5,967	2,337	---	---	5,967	2,337	---	---
OCT	25,650	6,533	---	---	25,650	6,533	---	---
NOV	46,380	15,618	---	---	46,380	15,618	---	---
DEC	48,982	22,621	---	---	48,982	22,621	---	---
TOTAL	---	47,108	---	77,154	---	124,262	---	41,233

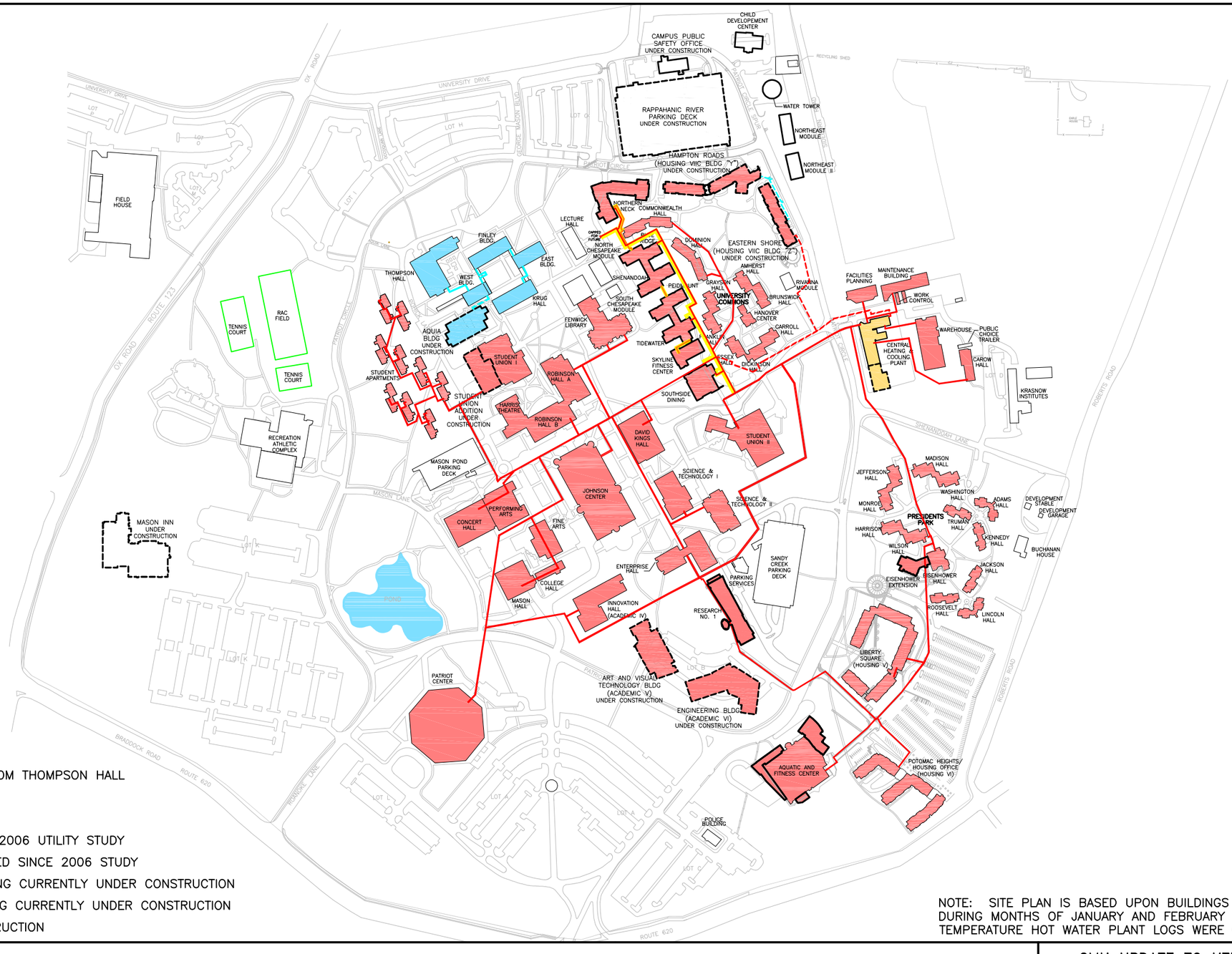
TABLE NO. 2-3: EXISTING BUILDING HEATING SUMMARY
GEORGE MASON UNIVERSITY

BLDG NO.	BUILDING NAME	GROSS AREA (GSF)	2009 MASTER PLAN UPDATE			CENTRAL PLANT HEATING LOAD 2006 MASTERPLAN			
			HEATING AREA (GSF)	CONNECTED HEATING LOAD (MBTU/HR)	PEAK HEATING LOAD (MBTU/HR)	HEATING AREA (GSF)	UNITARY LOAD (BTU/HR/GSF)	CONNECTED HEATING LOAD (MBTU/HR)	PEAK HEATING LOAD (MBTU/HR)
38	ACADEMIC IIIA (KING HALL)	83,600	83,600	8,425	3,010	83,600	101	8,425	3,977
40	CAROW HALL	7,500	7,500	375	134	7,500	50	375	177
26	CENTRAL WAREHOUSE	23,600	23,600	1,200	429	23,600	51	1,200	566
69	ENTERPRISE HALL	100,000	100,000	4,000	1,429	100,000	40	4,000	1,888
27	FACILITIES PLANNING	11,570	11,570	600	214	11,570	52	600	283
74	HUMANITIES I	81,900	81,900	600	214	81,900	7	600	283
75	HUMANITIES II	101,300	101,300	3,265	1,166	101,300	32	3,265	1,541
76	HUMANITIES III (CONCERT HALL)	59,400	59,400	2,129	761	59,400	36	2,129	1,005
77	JOHNSON CENTER	317,850	317,850	12,000	4,287	317,850	38	12,000	5,664
5B	LIBRARY II	58,000	58,000	3,270	1,168	58,000	56	3,270	1,543
5C	LIBRARY III	50,000	50,000	869	310	50,000	17	869	410
36	MAINTENANCE	12,000	12,000	600	214	12,000	50	600	283
58	PATRIOT CENTER	162,200	162,200	10,166	3,632	162,200	63	10,166	4,798
41-49	STUDENT APARTMENTS	109,100	109,100	2,500	893	109,100	23	2,500	1,180
60-67	UNIVERSITY COMMONS	101,900	101,900	3,597	1,285	101,900	35	3,597	1,698
80-85	PRESIDENTS PARKS I	97,000	97,000	4,435	1,584	97,000	46	4,435	2,093
86-92	PRESIDENTS PARK II	101,700	101,700	3,936	1,406	101,700	39	3,936	1,858
51	COMMONWEALTH HALL	51,200	51,200	1,220	436	51,200	24	1,220	576
52	DOMINION HALL	48,800	48,800	1,220	436	48,800	25	1,220	576
34A	ROBINSON A	100,000	100,000	2,350	840	100,000	24	2,350	1,109
34B	ROBINSON B	110,500	110,500	4,029	1,439	110,500	36	4,029	1,902
70	SCIENCE &TECHNOLOGY I	95,100	95,100	7,399	2,643	95,100	78	7,399	3,492
71	SCIENCE &TECHNOLOGY II	100,000	100,000	6,763	2,416	100,000	68	6,763	3,192
33	STUDENT UNION I, PHASES I & II	83,100	83,100	2,921	1,044	83,100	35	2,921	1,379
53	STUDENT UNION II	91,000	91,000	4,000	1,429	91,000	44	4,000	1,888
78	INNOVATION HALL (ACADEMIC IV)	105,584	99,561 [3]	6,471	2,312	105,584	65	6,863	3,239
94-98	LIBERTY SQUARE (HOUSING V)	166,535	183,037 [3]	8,237	2,943	166,535	45	7,494	3,537
99	POTOMAC HEIGHTS (HOUSING VI)	171,166	192,470 [3]	8,661	3,094	171,166	45	7,702	3,636
31	AQUATIC CENTER & EXPANSION	81,410	90,736 [3]	5,440	1,943	81,410	60	4,880	2,303
102	RESEARCH NO. 1	104,897	98,844 [3]	6,420	2,294	104,897	65	6,820	3,219
92A	EISENHOWER EXPANSION	6,513	114,577 [3]	6,870	2,454	6,513	60	390	184
106-107	BLUE RIDGE \ SHENANDOAH (H-VII)	355,050	121,270 [3]	16,600	5,930	355,050	45	15,980	7,543
108-109	PEIDMOUNT \ TIDEWATER (H-VII)		117,550 [3]	1,950	697				
110	NORTHERN NECK (H-VII)		123,140 [3]	1,790	639				
112-113	SKYLINE FIT CTR \ SOUTHSIDE DIN. (H-VII)		54,480 [3]	2,270	811				
TOTAL		3,149,475	2,633,390	156,580	55,940	2,601,605	---	113,930	53,770

NOTES:
1. CONNECTED LOADS BASED UPON MINI MASTER UTILITY PLAN UPDATE 1997.
2. PEAK HEATING LOAD BASED UPON PLANT LOG DATA AND CORRESPONDS TO A 36% DIVERSITY.
3. BUILDING AREAS UPDATED SINCE 2006 STUDY BASED UPON *MAIN CAMPUS BUILDING SUMMARY* FROM GMU's WEBSITE.
4. [ ] - BUILDINGS CONNECTED SINCE 2006 STUDY

FILE: H:\PROJ\109083A0\MP\CALC\9083A-BLDG-LOAD-EX.XLS

RMF 28 JULY 2009



LEGEND

- EXISTING CENTRAL PLANT
- EXISTING BUILDING SERVED HTHW
- EXISTING BUILDING SERVED LTHW FROM THOMPSON HALL
- HTHW SUPPLY AND RETURN PIPING
- LTHW SUPPLY AND RETURN PIPING
- NEW BUILDING CONSTRUCTED SINCE 2006 UTILITY STUDY
- NEW HOT WATER PIPING CONSTRUCTED SINCE 2006 STUDY
- HIGH TEMPERATURE HOT WATER PIPING CURRENTLY UNDER CONSTRUCTION
- LOW TEMPERATURE HOT WATER PIPING CURRENTLY UNDER CONSTRUCTION
- BUILDING CURRENTLY UNDER CONSTRUCTION

NOTE: SITE PLAN IS BASED UPON BUILDINGS THAT WERE CONNECTED DURING MONTHS OF JANUARY AND FEBRUARY 2009 FOR WHICH HIGH TEMPERATURE HOT WATER PLANT LOGS WERE COLLECTED.

250 0 250 500

SCALE: 1" = 500' – 0"

GEORGE MASON UNIVERSITY – WINTER 2009 HIGH AND LOW TEMPERATURE HOT WATER SITE PLAN

SCALE: 1" = 500'

GMU UPDATE TO UTILITY MASTER PLAN

RMF ENGINEERING, INC. BALTIMORE, MD

GEORGE MASON UNIV. FAIRFAX, VA

28 JULY 2009

FIGURE NO. 2–2

FILE: H:\Proj\109083A0\MP\DWGS\90834-ex-siteplan.dwg

Each pipe segment was evaluated based upon the flow velocity and pressure loss. The limiting velocity criteria for peak flow conditions is between 12 and 16 feet per second (FPS) for welded-steel piping ranging from 8 to 20 inches in diameter. This velocity limitation is based upon potential water hammer occurring within the distribution system. The larger pipe diameters can sustain higher velocities (16 FPS), while the relatively smaller pipes are limited to 12 FPS.

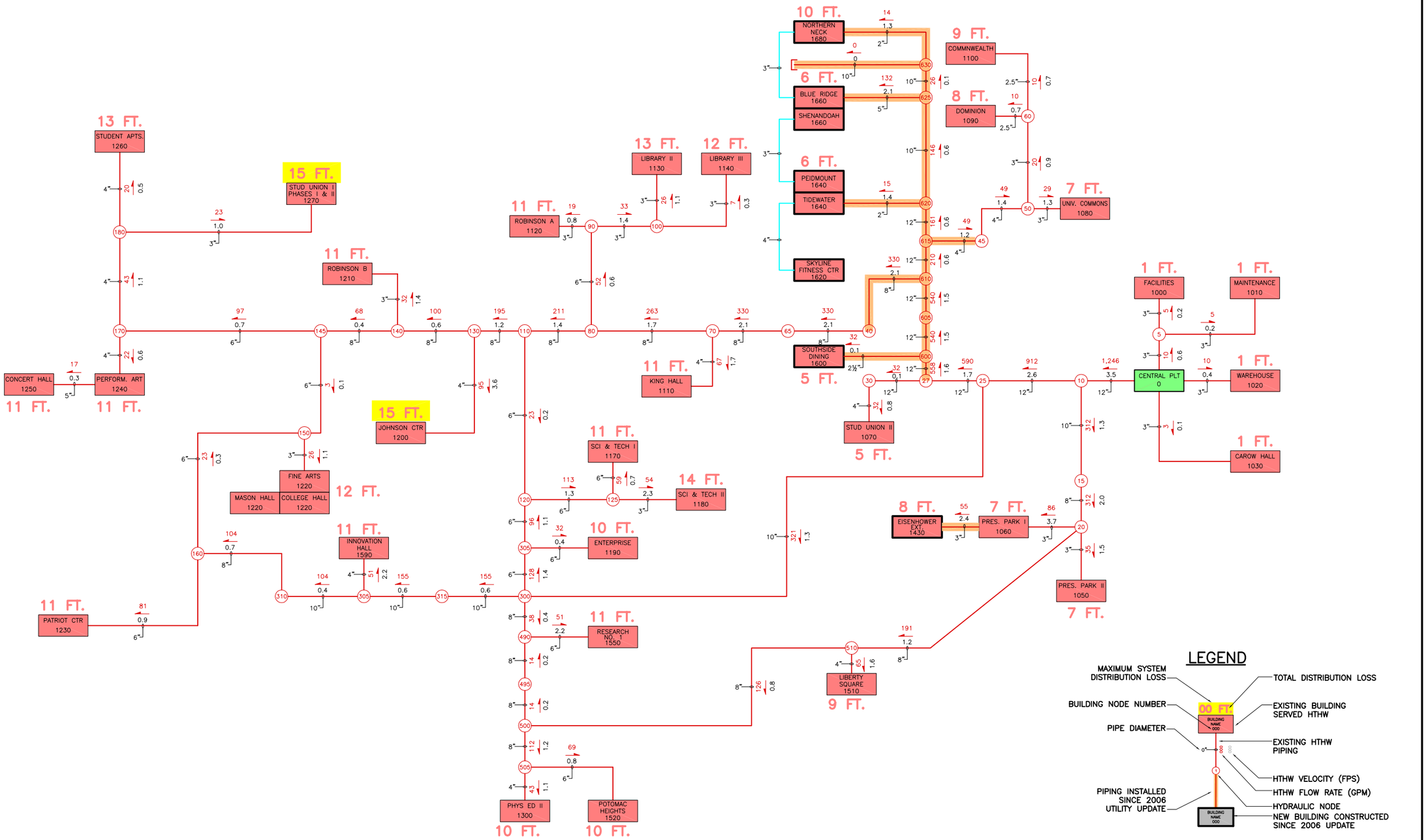
The pipe diameter, segment length and roughness factor for each pipe as well as the peak flow demand for each building were entered into the computer model. The peak flow for each building was estimated based upon the approximate design load, system diversity factor and an 90°F system temperature differential that corresponds to peak load conditions recorded in the plant operating logs. The system is designed to operate at a 100°F temperature differential.

A HTHW distribution schematic representing the current (2009) peak operating conditions is presented in Figure No. 2-3. The schematic indicates the HTHW flow and velocity in each pipe and the distribution loss for each building. According to this data, the maximum distribution loss of 15 feet occurs at the Johnson Learning Center and Student Union I, which is within the operating conditions of the existing distribution pumps. There are no pipe segments within the distribution system that exceed the recommended velocity limitations of 12 feet per second.

2.5 CHILLED WATER GENERATION

The chilled water generation system in the Central Plant currently includes four electrical centrifugal chillers and four positive displacement screw chillers capable of low temperature operation for ice generation and subsequent storage. The four centrifugal chillers (Chiller Nos. 1 through 4) consist of two 1,000 ton machines installed in 1999, and two 1,470 ton chillers added in 2006. Chiller No. 5 is a screw chiller and has a nominal refrigeration capacity of 435 tons which is reduced to 304 tons when generating ice. Chiller Nos. 6 through 8 are also screw chillers, with a nominal refrigeration capacity of 388 tons, which is reduced to 260 tons when generating ice. The design conditions of the existing chillers are summarized in Table No. 2-4. Currently there are two ice storage tanks, each having the capacity to store approximately 7,200 ton-hours (ton-hrs) of cooling.

The existing plant operation was determined by reviewing the plant logs and discussions with the operating personnel. A summary of the chiller operation for a two month period during August and September 2008 is presented in Table No. 2-5. This data was developed based upon daily operating logs recorded at the Central Plant. 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 5,900 tons which occurred in September with a wet bulb temperature of 79°F (ASHRAE design is 77.7°F)



WINTER 2009 HIGH TEMPERATURE HOT WATER SYSTEM SCHEMATIC

SCALE: NONE

GMU UPDATE TO UTILITY MASTER PLAN

RMF ENGINEERING, INC. BALTIMORE, MD

GEORGE MASON UNIV. FAIRFAX, VA

28 JULY 2009

FIGURE NO. 2-3

FILE: H:\Proj\10908340\MP\DWGS\908340-npp-hw.dwg

TABLE NO. 2-4: EXISTING CHILLER DESIGN CAPACITIES
GEORGE MASON UNIVERSITY

CHILLER NO.	DATE INST.	MANUFACT.	TYPE/ MODEL NO.	REFRIG.	CAPACITY (TONS)	CHILLED WATER			CONDENSER WATER			EFF. (KW/TON)
						FLOW (GPM)	TEMP. IN (°F)	TEMP. OUT (°F)	FLOW (GPM)	TEMP. IN (°F)	TEMP. OUT (°F)	
1	1999	TRANE	CVHF1060	R-123	1,000	2,000	54.00	42.00	3,000	85.00	95.00	0.600
2	1999	TRANE	CVHF1060	R-123	1,000	2,000	54.00	42.00	3,000	85.00	95.00	0.600
3	2006	TRANE	CVHF1470	R-123	1,470	3,000	53.54	42.00	3,000	85.00	98.70	0.590
4	2006	TRANE	CVHF1470	R-123	1,470	3,000	53.54	42.00	3,000	85.00	98.70	0.590
5	1994	YORK	YSECEBS4-CRAO	R-22	435	1,000	51.40	40.00	1,350	85.00	94.30	0.740
6	1999	TRANE	RTHC-1	R-134A	388	1,000	50.20	40.00	1,350	85.00	93.00	0.800
7	1999	TRANE	RTHC-1	R-134A	388	1,000	50.20	40.00	1,350	85.00	93.00	0.800
8	1999	TRANE	RTHC-1	R-134A	388	1,000	50.20	40.00	1,350	85.00	93.00	0.800
ICE MELT NO. 1		---	---	---	890	---	---	---	---	---	---	---
ICE MELT NO. 2		---	---	---	890	---	---	---	---	---	---	---

NOTE: NO NEW EQUIPMENT HAS BEEN INSTALLED SINCE THE 2006 MASTER PLAN UPDATE.

TABLE NO. 2-5: ESTIMATED MONTHLY COOLING LOAD SUMMARY
GEORGE MASON UNIVERSITY

MONTH	2006 UTILITY MASTER PLAN							UPDATED UTILITY MP (2008 CHILLER LOGS)		
	2005 - CHILLER LOGS		2006 - CHILLER LOGS		TOTAL					
	PEAK COOLING LOAD (TONS)	TOTAL USAGE (TON-HR)	PEAK COOLING LOAD (TONS)	TOTAL USAGE (TON-HR)	PEAK COOLING LOAD (TONS)	TOTAL USAGE (TON-HR)	PEAK WET-BULB TEMP (°F)	PEAK COOLING LOAD (TONS)	TOTAL USAGE (TON-HR)	PEAK WET-BULB TEMP (°F)
JAN	---	---	990	440,460	990	440,460	61	---	---	---
FEB	---	---	980	407,880	980	407,880	58	---	---	---
MAR	---	---	2,110	546,680	2,110	546,680	65	---	---	---
APR	---	---	3,373	885,066	3,373	885,066	66	---	---	---
MAY	---	---	4,293	1,219,523	4,293	1,219,523	75	---	---	---
JUN	---	---	4,840	1,711,527	4,840	1,711,527	74	---	---	---
JUL	---	---	4,542	2,100,649	4,542	2,100,649	78	---	---	---
AUG	---	---	5,441	2,099,918	5,441	2,099,918	79	5,784	1,831,633	73
SEP	4,565	1,645,498	---	---	4,565	1,645,498	75	5,917	1,602,654	79
OCT	2,616	868,905	---	---	2,616	868,905	73	---	---	---
NOV	1,724	561,312	---	---	1,724	561,312	65	---	---	---
DEC	950	451,280	---	---	950	451,280	47	---	---	---
TOTAL	---	3,526,996	---	9,411,703	---	12,938,698	---	---	3,434,287	---

The peak plant output was estimated by adding the chiller output to the ice plant output for each interval. Since the data is recorded at four hour intervals, the plant output for each interval was divided by four to estimate the peak hourly load. The chiller output is based upon unit flow and temperatures recorded in the log data. The ice output was calculated by multiplying the remaining storage percentage by the design capacity of the ice tanks and then subtracting the remaining storage (in ton-hours) from the previous interval and again dividing by four. This is the same approach utilized in the previous studies.

2.6 EXISTING COOLING LOAD

2.6.1 Peak Load

The connected building cooling loads are based on the Utilities Mini Master Plan of 1997 and were updated in the 2002 and 2006 Utility Master Plan Updates, with data provided by GMU personnel. 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 (5,900 tons) to the total connected load of the system (10,990 tons), a diversity of 54% was estimated. This diversity was utilized to estimate the individual peak loads of each building, which are summarized in Table No. 2-6. Also in this table is a comparison of the estimated loads from the 2006 Update to the Utility Master Plan. By comparison, the 2006 load projections are within 9% of the current peak plant output.

2.6.2 Existing Chilled Water Firm Capacity

The firm capacity is the total cooling capacity of the system without the operation of the largest chiller. The single largest chilled water-generating machine in the plant is one of the 1,470 ton chillers (Chiller Nos. 3 or 4). The firm capacity for the chiller plant is approximately 6,800 tons without the installation of Chiller No. 9. A summary of the existing peak load versus the system firm capacity is presented in Table No. 2-7. If Chiller No. 3 or 4 were unavailable during a peak cooling day, the chilled water plant could still serve 100% of the campus cooling load by energizing the ice chillers in a chilled water mode.

2.7 CHILLED WATER DISTRIBUTION

The chilled water generated in the Central Plant is supplied to the individual campus facilities by a supply and return chilled water piping system. The entire campus chilled water flow is currently supplied by one set of 24-inch diameter supply and return distribution mains extending west from the Central Plant. Unlike the HTHW system, all chilled water distribution piping is direct buried and is comprised of various material types including transite, fiberglass, polyvinyl chloride (PVC), steel, ductile iron, and copper. The maximum allowable flow and velocity for the

TABLE NO. 2-6: EXISTING BUILDING COOLING SUMMARY
GEORGE MASON UNIVERSITY

BLDG NO.	BUILDING NAME	GROSS AREA (GSF)	2009 MASTER PLAN UPDATE			CENTRAL PLANT COOLING LOAD 2006 MASTERPLAN			
			CENTRAL PLANT COOLING AREA (GSF)	CONNECTED COOLING LOAD (TONS)	PEAK COOLING LOAD (TONS)	CENTRAL PLANT COOLING AREA (GSF)	UNITARY LOAD (GSF/TON)	CONNECTED COOLING LOAD (TONS)	PEAK COOLING LOAD (TONS)
38	ACADEMIC IIIA (KING HALL)	83,600	83,600	324	174	83,600	258	324	194
40	CAROW HALL	7,500	7,500	44	24	7,500	170	44	26
4	EAST BLDG.	13,100	13,100	62	33	13,100	211	62	37
69	ENTERPRISE HALL	100,000	100,000	289	156	100,000	346	289	173
1	FINLEY BLDG.	20,500	20,500	73	39	20,500	280	73	44
74	HUMANITIES I	81,900	81,900	308	166	81,900	266	308	185
75	HUMANITIES II	101,300	101,300	427	230	101,300	237	427	256
76	HUMANITIES III (CONCERT HALL)	59,400	59,400	380	205	59,400	156	380	228
77	JOHNSON CENTER	317,850	317,850	1,100	592	317,850	289	1,100	660
610	KRASNOW INSTITUES	22,695	22,695	50	27	22,695	454	50	30
2	KRUG HALL	32,000	32,000	117	63	32,000	273	117	70
6	LECTURE HALL	8,000	8,000	46	25	8,000	174	46	28
5A	LIBRARY I	32,600	32,600	110	59	32,600	296	110	66
5B	LIBRARY II	58,000	58,000	221	119	58,000	263	221	132
5C	LIBRARY III	50,000	50,000	92	50	50,000	541	92	55
58	PATRIOT CENTER	162,200	162,200	860	463	162,200	189	860	516
41-49	STUDENT APARTMENTS	109,100	109,100	195	105	109,100	559	195	117
60-67	UNIVERSITY COMMONS	101,900	101,900	206	111	101,900	495	206	124
80-85	PRESIDENTS PARKS I	97,000	97,000	265	143	97,000	366	265	159
86-92	PRESIDENTS PARK II	101,700	101,700	212	114	101,700	480	212	127
51	COMMONWEALTH HALL	51,200	51,200	88	47	51,200	582	88	53
52	DOMINION HALL	48,800	48,800	88	47	48,800	555	88	53
34A	ROBINSON A	100,000	100,000	287	155	100,000	348	287	172
34B	ROBINSON B	110,500	110,500	348	187	110,500	318	348	209
70	SCIENCE &TECHNOLOGY I	95,100	95,100	421	227	95,100	226	421	253
71	SCIENCE &TECHNOLOGY II	100,000	100,000	420	226	100,000	238	420	252
33	STUDENT UNION I, PHASES I & II	83,100	83,100	442	238	83,100	188	442	265
53	STUDENT UNION II	91,000	91,000	270	145	91,000	337	270	162
3	WEST BLDG.	18,400	18,400	62	33	18,400	296	62	37
78	INNOVATION HALL (ACADEMIC IV)	105,584	99,560 [3]	400	215	105,584	250	420	273
94-98	LIBERTY SQUARE (HOUSING V)	166,535	183,040 [3]	410	221	166,535	450	370	241
99	POTOMAC HEIGHTS (HOUSING VI)	171,166	192,470 [3]	430	232	171,166	450	380	247
31	AQUATIC CENTER & EXPANSION	81,410	90,740 [3]	450	242	81,410	200	410	246
102	RESEARCH NO. 1	104,897	98,840 [3]	400	215	104,897	250	420	252
92A	EISENHOWER EXPANSION	6,513	16,880 [3]	80	43	6,513	200	30	18
106-107	BLUE RIDGE \ SHENANDOAH (H-VII)	355,050	121,270 [3]	300	162	355,050	450	790	474
108-109	PEIDMOUNT \ TIDEWATER (H-VII)		117,550 [3]	263	142				
110	NORTHERN NECK (H-VII)		123,140 [3]	300	162				
112-113	SKYLINE FIT CTR \ SOUTHSIDE DIN. (H-VII)		54,480 [3]	146	79				
TOTAL		3,249,600	3,356,415	10,990	5,916	3,249,600	---	10,630	6,440

NOTES:
1. CONNECTED LOADS BASED UPON MINI MASTER UTILITY PLAN UPDATE 1997.
2. PEAK COOLING LOAD BASED UPON PLANT LOG DATA AND CORRESPONDS TO APROXIMATELY A 54% DIVERSITY.
3. BUILDING AREAS UPDATED SINCE 2006 STUDY BASED UPON *MAIN CAMPUS BUILDING SUMMARY* FROM GMU's WEBSITE.
4. [ ] - BUILDINGS CONNECTED SINCE 2006 STUDY

TABLE NO. 2-7: CHILLED WATER GENERATION CAPACITY
GEORGE MASON UNIVERSITY

CHILLER NO.	MANUFACTURER	EXISTING CAPACITY (TONS)
1	TRANE	1,000
2	TRANE	1,000
3	TRANE	1,470
4	TRANE	1,470
5	YORK	435 / 304
6	TRANE	388 / 260
7	TRANE	388 / 260
8	TRANE	388
---	ICE MELT NO. 1	890
---	ICE MELT NO. 2	890
TOTAL		8,319
EXISTING FIRM CAPACITY		6,849
EXISTING PEAK LOAD		5,920

various piping systems are summarized in Table No. 2-8. A site plan indicating the campus chilled water distribution is presented in Figure No. 2-4.

A computerized hydraulic model of the existing distribution system was also developed for the chilled water system to simulate the flow and pressure conditions which occur at various load intervals. A chilled water distribution schematic representing the current (2009) peak operating conditions is presented in Figure No. 2-5. Based upon plant log data, the chilled water temperature differential during peak load periods was 14°F which was utilized to estimate the peak flow to each building. This schematic indicates the chilled water flow and velocity in each pipe and the piping distribution loss to each building. According to this data, the maximum distribution loss of 46 feet occurs at the Finley/East/West/Krug complex. The highest velocity is 8.3 feet per second (FPS) in the transite main pipe from the Central Plant to the Library III. This velocity is below the maximum allowable velocity for a transite pipe. However, as noted in the previous studies, the velocity in the pipe leading to the Patriot Center is above the recommended maximum allowable velocity for PVC pipe. The 12-inch PVC piping between Krasnow Institutes and the President's Park is also above the recommended maximum allowable velocity. Continually exceeding the velocity can increase the risk of pipe failure resulting from water hammer, caused by sudden changes in system flow or velocity.

Since the 2006 load projections are within 10% of the current chilled water load, the results of the hydraulic analysis are similar to the previous (2006) analysis.

2.8 EXISTING SANITARY SEWER COLLECTION

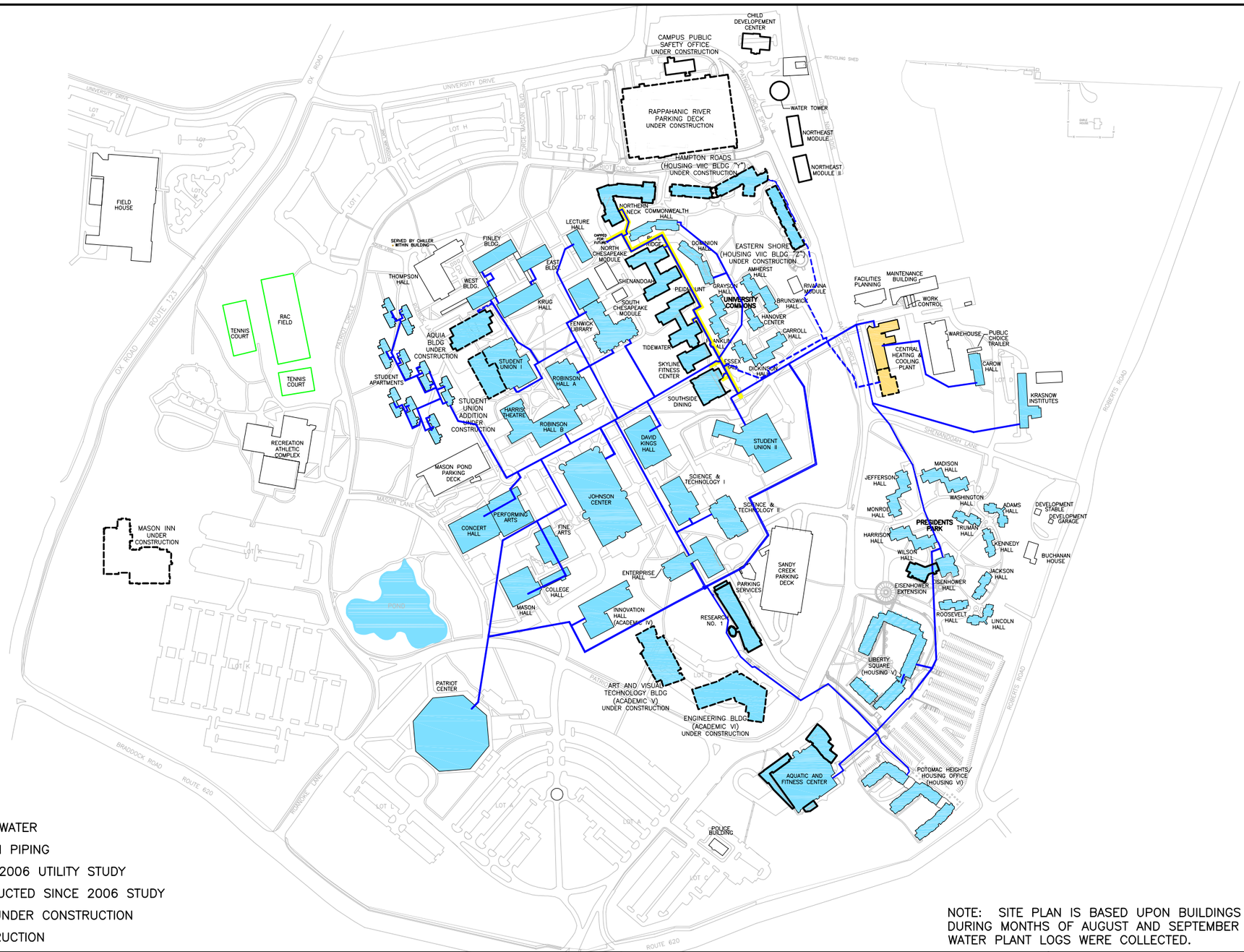
The sanitary sewer system is owned and maintained by Fairfax County. There are three mains that serve the campus. The first two run along the east and west sides of the core of the campus and service the majority of the campus. Both mains combine into one single main at the southern edge of the campus, and continue south of the campus through residential areas of Fairfax County. The third main is underneath Roberts Road and serves a small number of buildings east of Patriot Circle. A summary of 2009 sanitary sewer loads is presented in Table No. 2-9. Based upon a generalized analysis, the existing "East" and "West" mains are carrying a little more than 50% of the estimated capacity. A site plan of the 2009 sanitary sewer distribution system is presented in Figure No. 2-6.

TABLE NO. 2-8 : PIPE MATERIAL INNER DIAMETERS & MAXIMUM VELOCITIES
GEORGE MASON UNIVERSITY

NOMINAL (IN)	TRANSITE		FIBERGLASS		PVC		STEEL		DUCTILE IRON	
	INNER DIAMETER (IN)	MAXIMUM FLOW (GPM)	INNER DIAMETER (IN)	MAXIMUM FLOW (GPM)	INNER DIAMETER (IN)	MAXIMUM FLOW (GPM)	INNER DIAMETER (IN)	MAXIMUM FLOW (GPM)	INNER DIAMETER (IN)	MAXIMUM FLOW (GPM)
1.00	1.049	38	---	---	1.049	13	1.049	32	---	---
1.25	1.380	65	---	---	1.380	23	1.380	56	---	---
1.50	1.610	89	---	---	1.610	32	1.610	76	---	---
2.00	2.067	147	2.235	122	2.067	52	2.067	126	---	---
2.50	2.469	209	---	---	2.469	75	2.469	179	---	---
3.00	3.068	323	3.360	277	3.068	115	3.068	277	3.340	328
3.50	3.548	432	---	---	3.548	154	3.548	370	---	---
4.00	4.026	556	4.360	466	4.026	199	4.026	477	4.160	509
5.00	5.047	874	---	---	5.047	312	5.047	749	---	---
6.00	6.065	1,262	6.405	1,005	6.065	451	6.065	1,082	6.220	1,138
8.00	7.981	2,186	8.360	1,713	7.981	781	7.981	1,873	8.330	2,041
10.00	10.020	3,445	10.360	2,631	10.020	1,230	10.020	2,953	10.340	3,145
12.00	11.938	4,890	12.280	3,696	11.938	1,747	11.938	`	12.400	4,522
14.00	13.124	5,910	14.020	4,818	13.124	2,111	13.124	5,066	14.460	6,150
16.00	15.000	7,721	16.020	6,290	15.000	2,757	15.000	6,618	16.540	8,046
18.00	16.876	9,773	---	---	---	---	16.876	8,376	18.620	10,197
20.00	18.812	12,143	---	---	---	---	18.812	10,409	20.700	12,603
24.00	22.624	17,563	---	---	---	---	22.624	15,054	24.860	18,177
30.00	28.750	28,362	---	---	---	---	28.750	24,311	30.980	28,228
36.00	34.500	40,842	---	---	---	---	34.500	35,007	37.140	40,570
42.00	42.000	60,529	---	---	---	---	42.000	51,882	40.700	48,720
48.00	48.000	79,059	---	---	---	---	48.000	67,765	49.360	71,659

NOTE: MAXIMUM FLOWS ARE BASED UPON THE FOLLOWING MAXIMUM VELOCITIES:

- TRANSITE - 14 FT/SEC
- FIBERGLASS - 10 FT/SEC
- PVC - 5 FT/SEC
- STEEL - 12 FT/SEC
- DUCTILE IRON - 12 FT/SEC



LEGEND

- EXISTING CENTRAL PLANT
- EXISTING BUILDING SERVED CHILLED WATER
- CHILLED WATER SUPPLY AND RETURN PIPING
- NEW BUILDING CONSTRUCTED SINCE 2006 UTILITY STUDY
- NEW CHILLED WATER PIPING CONSTRUCTED SINCE 2006 STUDY
- CHILLED WATER PIPING CURRENTLY UNDER CONSTRUCTION
- BUILDING CURRENTLY UNDER CONSTRUCTION

NOTE: SITE PLAN IS BASED UPON BUILDINGS THAT WERE CONNECTED DURING MONTHS OF AUGUST AND SEPTEMBER 2008 FOR WHICH CHILLED WATER PLANT LOGS WERE COLLECTED.

250 0 250 500

SCALE: 1" = 500' – 0"

GEORGE MASON UNIVERSITY
SUMMER 2008 CHILLED WATER SITE PLAN

SCALE: 1" = 500'

GMU UPDATE TO UTILITY MASTER PLAN

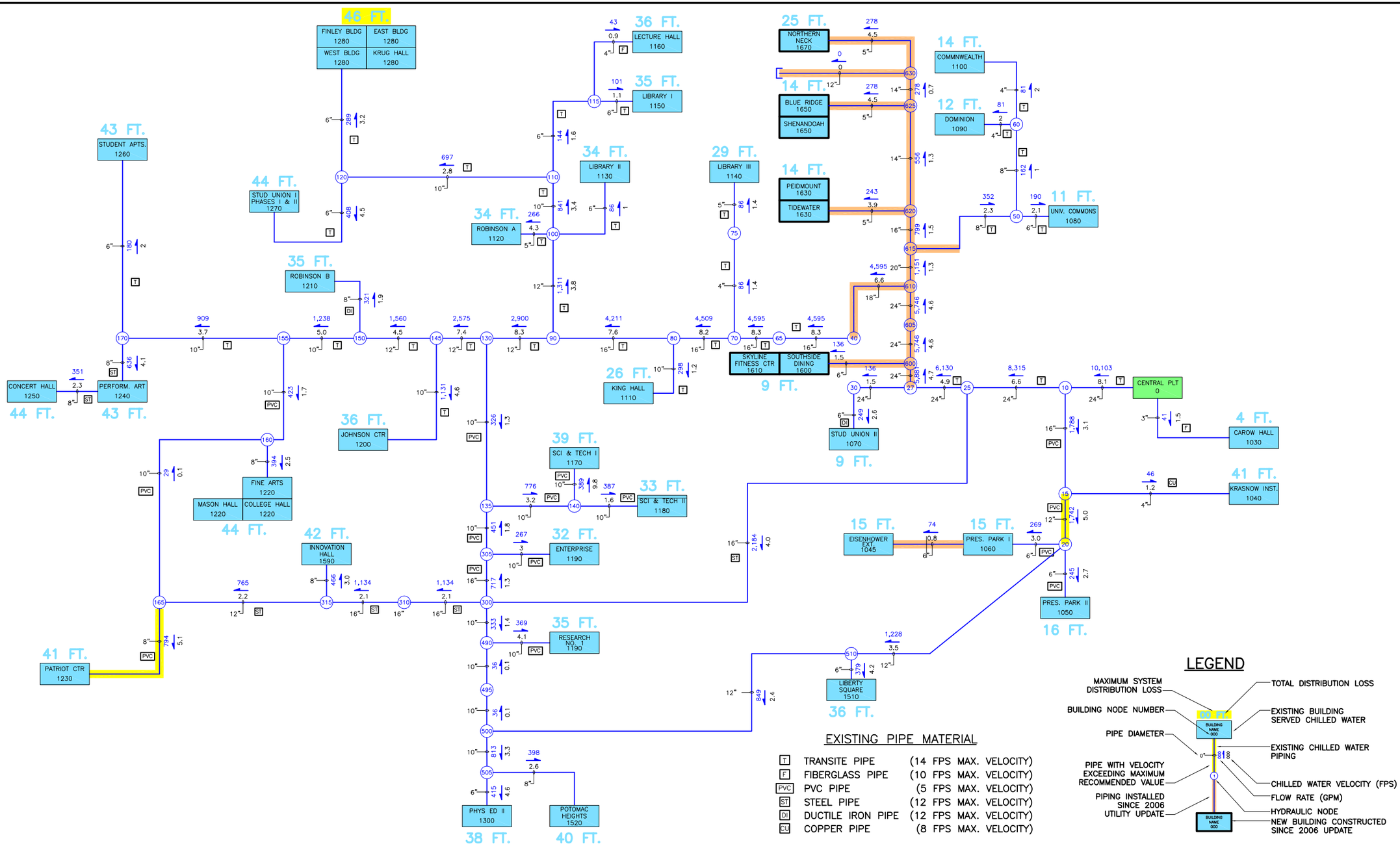
RMF ENGINEERING, INC. BALTIMORE, MD

GEORGE MASON UNIV. FAIRFAX, VA

28 JULY 2009

FIGURE NO. 2–4

FILE: H:\Proj\100083AO\MP\DWGS\100834-ex-siteplan.dwg



SUMMER 2008 CHILLED WATER SYSTEM SCHEMATIC

SCALE: NONE

GMU UPDATE TO UTILITY MASTER PLAN

RMF ENGINEERING, INC. BALTIMORE, MD

GEORGE MASON UNIV. FAIRFAX, VA

28 JULY 2009

FIGURE NO. 2-5

FILE: H:\Proj\109083A0\MPU\DWGS\V08SA-wp-chw.dwg

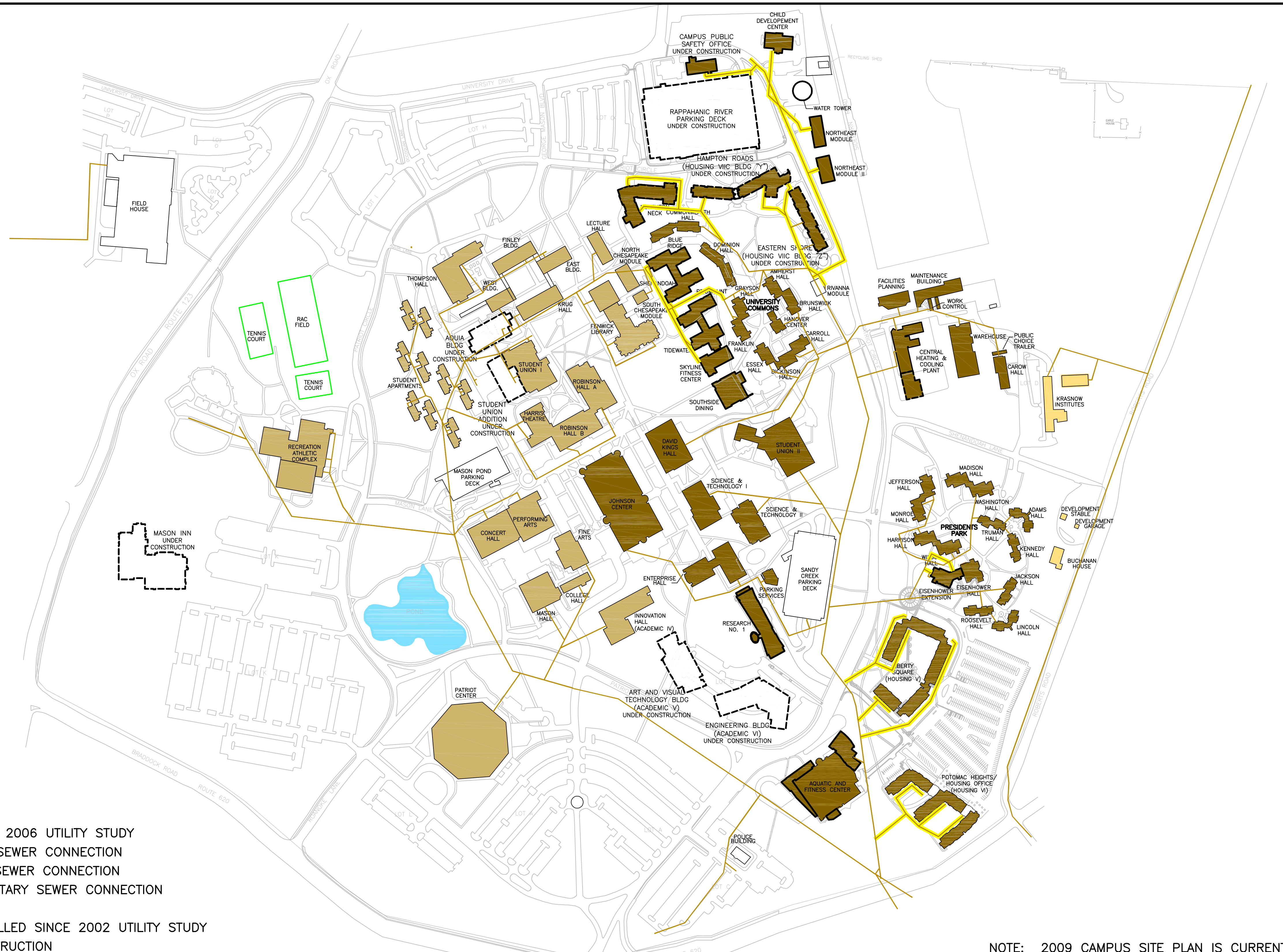
TABLE NO. 2-9: SEWER COLLECTION SUMMARY (2009)

GEORGE MASON UNIVERSITY

YEAR	BUILDING NAME	AREA (GSF)	SPACE UTILIZATION	UNITARY LOAD (GPM/GSF)	PEAK BUILDING DEMAND			BUILDING CONSUM. (GPD)
					WEST CONNECT. (GPM)	EAST CONNECT. (GPM)	ROBERTS ROAD CONNECT. (GPM)	
2002 TOTAL		2,629,915			363	488	11	362,360
CONST. SINCE 2002	AQUIA MODULE (DEMO)	(5,700)	CLASSROOM	0.0003	(1)	---	---	(480)
	CENTRAL MODULE (DEMO)	(6,900)	CLASSROOM	0.0003	(2)	---	---	(960)
	GREENHOUSE (DEMO)	(2,200)	CLASS / LAB	0.0005	(1)	---	---	(480)
	PATRIOT VILLAGE (DEMO)	(55,000)	APARTMENTS	0.0003	(14)	---	---	(5,380)
	POHICK MODULE (DEMO)	(6,900)	CLASSROOM	0.0003	(2)	---	---	(960)
	CHILD DEVELOPMENT CENTER	9,000	OFFICE	0.0003	---	2	---	960
	NORTHEAST MODULE	7,230	CLASSROOM	0.0003	---	2	---	960
	NORTHEAST MODULE II	7,000	CLASSROOM	0.0003	---	2	---	960
	INNOVATION HALL (ACADEMIC IV)	99,560	CLASSROOM	0.0003	25	---	---	12,000
	LIBERTY SQUARE (HOUSING V)	183,040	DORMITORY	0.0003	---	55	---	21,120
	POTOMAC HEIGHTS (HOUSING VI)	192,470	DORMITORY	0.0003	---	58	---	22,270
	AQUATIC EXPANSION	22,740	GYM	0.0004	---	9	---	4,320
	RESEARCH NO. 1	98,840	CLASS / LAB	0.0005	---	44	---	21,120
	EISENHOWER EXPANSION	16,880	DORMITORY	0.0003	---	5	---	1,920
	BLUE RIDGE \ SHENANDOAH (H-VII)	121,270	DORMITORY	0.0003	---	36	---	13,820
	PEIDMOUNT \ TIDEWATER (H-VII)	117,550	DORMITORY	0.0003	---	35	---	13,440
	NORTHERN NECK (H-VII)	123,140	DORMITORY	0.0003	---	37	---	14,210
	SKYLINE FIT CTR \ SOUTHSIDE DIN. (H-VII)	54,480	GYM/ASSEMBLY	0.0004	---	22	---	8,450
	SUBTOTAL	976,500	---	---	5	307	---	127,290
2009 TOTAL		3,606,415	---	---	368	795	11	489,650

NOTES: 1. EACH OF THE EXISTING 10-INCH MAINS HAS A CAPACITY THRESHOLD OF 1,120 GPM, BASED UPON AN ASSUMED CONSTANT GRADE OF 1%.

2. WEST AND EAST CONNECTIONS CARRYING 52% OF THE ESTIMATED COMBINED CAPACITY



LEGEND

- EXISTING BUILDING
- NEW BUILDING CONSTRUCTED SINCE 2006 UTILITY STUDY
- BUILDING WITH WESTERN SANITARY SEWER CONNECTION
- BUILDING WITH EASTERN SANITARY SEWER CONNECTION
- BUILDING WITH ROBERTS ROAD SANITARY SEWER CONNECTION
- EXISTING SANITARY SEWER PIPING
- NEW SANITARY SEWER PIPING INSTALLED SINCE 2002 UTILITY STUDY
- BUILDING CURRENTLY UNDER CONSTRUCTION

NOTE: 2009 CAMPUS SITE PLAN IS CURRENT AS OF APRIL 30, 2009

250 0 250 500

SCALE: 1" = 500' – 0"

GEORGE MASON UNIVERSITY
2009 SANITARY SEWER SITE PLAN

SCALE: 1" = 500'

GMU UPDATE TO UTILITY MASTER PLAN

RMF ENGINEERING, INC.
BALTIMORE, MD

GEORGE MASON UNIV.
FAIRFAX, VA

9 JUNE 2009

FIGURE NO. 2–6