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Pumping Rates for Water Drainage in the Main Ring Tunnnel: Scale Considerations of the SSC

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I. Introduction

The Fermilab site has water bearing, geologic units distributed uniformly above a flat bedrock surface. These units, i.e. glacial tills, sands, and gravels are seasonably fed by fluctuations in rainfall and melting snow. Since the overall site topography is flat, ground water settles, often saturates the soil, and creates a challenge to the relatively dry requirements of the accelerator tunnel. Subsurface pumping of the water is achieved by the operation of online sump pumps (see Fig. 1), one pump in each of the 24 service buildings which access the tunnel. Drainage overflows are exhausted into a network of interconnected ponds.

The objective of this note is to calculate the pumping rate for water drainage in the Main Ring Tunnel, correct for statistical and engineering fluctuations, and to discuss pumping requirements on the SSC scale.

II. Data

Pump Run Time Readings

Building	Reading A	Reading B	Total Run Time
A1	25029.9	25751.3	721.4
A2	88999.5	89762.0	762.5
A3	79149.3	79429.4	280.1
A4	69531.3	69863.7	332.4
B1	-	-	dark tunnel (602.5)
B2	91046.6	91046.6	dead meter (408.2)
B3	08633.6	09207.7	574.1
B4	65223.3	65659.0	436.7
C1	21551.3	22022.8	471.5
C2	10317.1	10773.7	456.6
C3	67937.9	68324.9	387.0
C4	67980.9	68253.0	272.1
D1	82629.7	82859.9	230.2
D2	-	-	dead meter (561.3)
D3	09077.9	09582.4	504.5
D4	33811.0	33811.0	dead meter (173.4)
E1	79720.7	81133.3	1412.6
E2	70695.4	70794.5	99.1
E3	23741.1	25869.4	2128.3
E4	88043.7	88562.1	518.4
F1	07006.7	07730.5	723.8
F2	06891.9	07543.1	651.2
F3	-	-	dead meter (617.9)
F4	92049.5	92528.3	478.8

Reading A represents time in minutes and was recorded at 2100, 2/17/84.
Reading B represents time in minutes and was recorded at 0900, 2/28/84, or 10.5 days later.
dark tunnel represents the conditions which prevented this reading from being recorded.
dead meter is an obvious description.

Note!! The total run times were estimated for B1, B2, D2, D4, and F3 with the mean values and standard deviations calculated for each region A, B, C, D, E, and F.

$$B1 = \langle t_B \rangle + \sigma$$

$$B2 = \langle t_B \rangle - \sigma$$

$$D2 = \langle t_D \rangle + \sigma$$

$$D4 = \langle t_D \rangle - \sigma$$

$$F3 = \langle t_F \rangle$$

III Results and Conclusions

Each sump pit has a floor area of 20 ft^2 and a depth of 6 ft. There is an underdrain pipe approximately 3 ft above the floor which routes water into the pit and eventually into the ponds. The best estimate for the pumping speed is (125 ± 62.5) ft^3/min., where the ±50% error represents pump impellar variations around the tunnel, variations in the water lift distances, and the discharge line impedances.[1]

Calculate the volume of water pumped in 10.5 days by all 24 sumps:

$$R(\text{gallons/hr}) = (125 \pm 62.5\ ft^3/\text{min.})(7.5\ \text{gal./ft})(60\ \text{min./hr.})$$
$$= (\text{between } 28{,}125 \text{ and } 84{,}375 \text{ gallons/hr.})$$

$$V(\text{gallons}) = R(\text{gal./hr.})\ (13804.7\ \text{min.})(0.0167\ \text{hr./min.})$$
$$= (\text{between } 6{,}483{,}895 \text{ and } 19{,}451{,}685 \text{ gallons})$$

Drainage into the tunnel appears to be under control with more than adequate pumping available. Water levels in the pits are comparable and depend on meteorological and pump systematics. Intermittent measurements should be taken of the pump run times and qualitative observations made of moisture in the tunnel. When combined with other tunnel histories, we can better understand drainage as a function of depth, hydrogeology, and tunnel construction materials.

The SSC scale could be an order of magnitude greater than the Main Ring; therefore the pumping requirements could scale with ring size or remain the same with modified pumps, i.e. ten times the sump pit volume and pumping speed. If the hydrogeology differs for both sites or SSC overlaps with the Fermilab site, then the pumping requirements would be considerably less than a factor of ten.

[1] Stanley Pruss, private communication

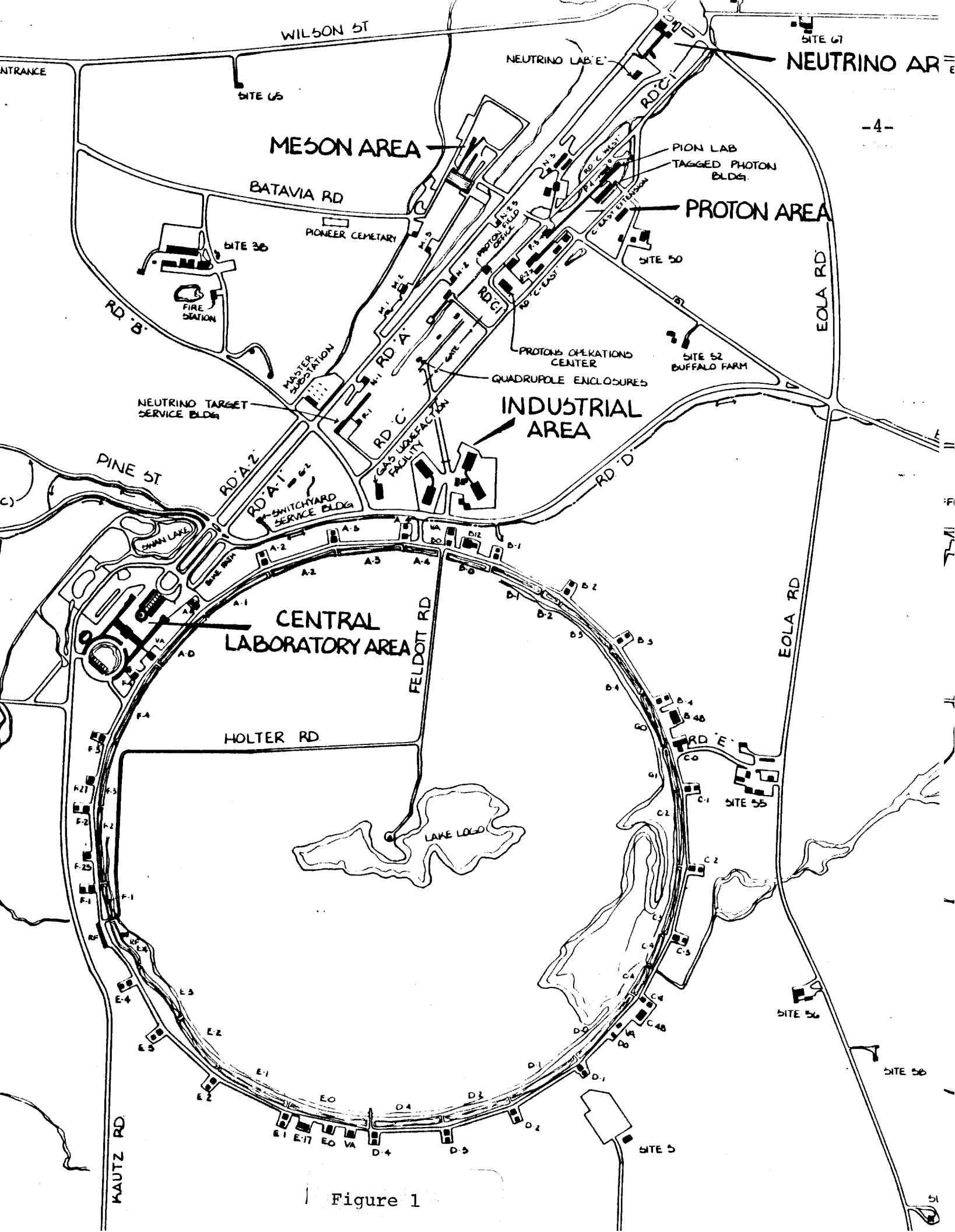
WILSON ST
NTRANCE
SITE 65
SITE 67
NEUTRINO LAB 'E'
NEUTRINO AR
MESON AREA
BATAVIA RD
PIONEER CEMETARY
SITE 36
FIRE STATION
RD 'B'
RD 'C'
PION LAB
TAGGED PHOTON BLDG.
PROTON AREA
SITE 50
EOLA RD
PROTONS OPERATIONS CENTER
QUADRUPOLE ENCLOSURES
SITE 52 BUFFALO FARM
MASTER SUBSTATION
RD 'A'
NEUTRINO TARGET SERVICE BLDG
INDUSTRIAL AREA
GAS LIQUEFACTION FACILITY
PINE ST
RD 'A' 2
RD 'A' 1
SWITCHYARD SERVICE BLDG
RD 'D'
SWAN LAKE
CENTRAL LABORATORY AREA
FELDOTT RD
HOLTER RD
RD 'E'
SITE 55
LAKE LOLO
SITE 56
SITE 58
SITE 5
KAUTZ RD

Figure 1