FERMILAB UPGRADE: MAIN INJECTOR CONCEPTUAL DESIGN REPORT

January 10, 1990

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APPENDICES

1. INTRODUCTION AND SUMMARY

This report contains a description of the design and cost estimate of a new 150 GeV accelerator, designated the Main Injector, which will be required to support the upgrade of the Fermilab Accelerator Complex. The construction of this accelerator will simultaneously result in significant enhancements to both the Fermilab collider and fixed target programs. The Main Injector (MI) is to be located south of the Antiproton Source and tangent to the Tevatron ring at the FO straight section as shown in Figure 1-1. The MI will perform all duties currently required of the existing Main Ring. Thus, operation of the Main Ring will cease following commissioning of the MI, with a concurrent reduction in background rates as seen in the colliding beam detectors. The performance of the MI, as measured in terms of protons per second delivered to the antiproton production target or total protons delivered to the Tevatron, is expected to exceed that of the Main Ring by a factor of two to three. In addition the MI will provide high duty factor 120 GeV beam to the experimental areas during collider operation, a capability which does not presently exist in the Main Ring.

The location, operating energy, and mode of construction of the Main Injector is chosen to minimize operational impact on Fermilab's ongoing High Energy Physics (HEP) program. The area in which the MI is to be situated is devoid of any underground utilities which might be disturbed during construction, while the separation between the MI and Tevatron is sufficient to allow construction concurrent with Tevatron operations. The energy capability of the MI is chosen to match the antiproton production and Tevatron injection energies presently used in the Fermilab complex. The Main Injector will be built from newly constructed dipole magnets allowing a large portion of the installation process to proceed independent of Tevatron operations. The use of newly designed dipoles is also desirable from the standpoint of enhanced performance and reliability, and results in a reduction of the operating costs by 33% relative to what would be obtained by recycling existing Main Ring magnets.

The Total Project Cost (TPC) of the Main Injector is estimated to be $176,400,000 including a Total Estimated Cost (TEC) of $156,800,000 and $19,600,000 in associated R&D, pre-operating, and capital equipment costs. Included within the scope of the project are all technical and civil construction components associated with the ring itself, with beamlines needed to tie the ring into the existing accelerator complex, and with modifications to the Tevatron and switchyard required to accomodate the relocated injections. The project involves the construction of 15,000 ft of tunnel enclosures, 11 service buildings encompassing a total of 39,000 ft^2, a new industrial building of 19,200 ft^2, and a new 345 KVolt substation. The Main Injector ring and all beamline interconnections to existing facilities are shown schematically in Figure 1-2. It is proposed to complete construction over a three-and-one-half year period starting on October 1, 1991. Design of civil construction will be overseen by the Fermilab Construction Engineering Services Group. Design and fabrication of technical components will be done by Accelerator Division and Technical Support Section personnel. It is anticipated that construction and operation of the new Main Injector will not require any expansion of the Fermilab permanent staff.

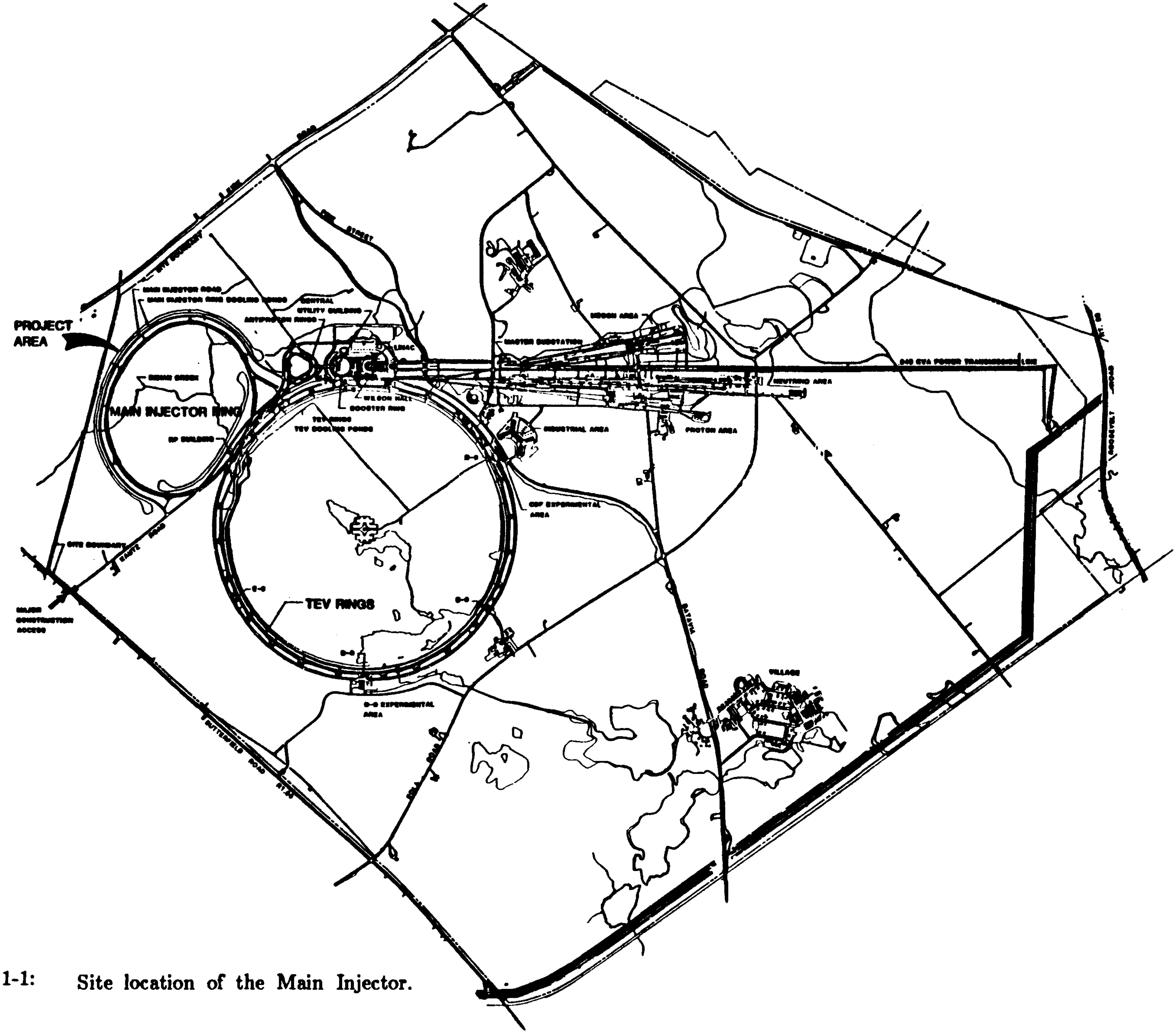

Figure 1-1: Site location of the Main Injector.

1.1 Role in the Upgrade Program

The primary purpose of the upgrade is to maintain the growth in physics output of the Fermilab HEP program during the pre-SSC era. The Fermilab Antiproton-Proton Collider is operating at 1.8 TeV (center-of-mass) with initial luminosities routinely in excess of 1.5×10^{30} $cm^{-2}sec^{-1}$, 50% above the design value. During fixed target operations the Tevatron delivers up to 1.8×10^{13} protons at 800 GeV every minute. The goal of the upgrade is to increase the luminosity by a factor of 50, and the fixed target intensity by a factor of 3.

The upgrade will take place in stages. Projects already underway include upgrades to the Antiproton Source to improve the yield by a factor of three, development of new low-β systems which will allow the implementation of a second high luminosity interaction region, development of separators to allow multibunch operation, and the installation of cold compressors to raise the Tevatron energy. On October 1, 1989 work was initiated on raising the Linac energy from 200 MeV to 400 MeV for the purpose of increasing the antiproton production rate by 75% and reducing proton beam emittances by 40%. As a result of these enhancements it is expected that the luminosity of the collider will gradually increase to 1×10^{31} $cm^{-2}sec^{-1}$ by 1993. It is also anticipated that these developments will increase the number of protons delivered from the Tevatron up to 3×10^{13} per minute.

Further improvements to performance will require the construction of a new accelerator. The present bottleneck in the production of antiprotons and in the delivery of intense beams to the Tevatron is the Main Ring. The Main Ring is not capable of accelerating the quantity of beam which can be provided at injection by the 8 GeV Booster. This is for the simple reason that the aperture of the Main Ring (12π mm-mr as measured in normalized units at 8.9 GeV/c) is about half the size of of the Booster aperture (20π mm-mr). As a result the Booster is run at about two thirds of its capability during normal operations. Additionally, the Main Ring is not capable of accelerating antiprotons delivered from large stacks in the Antiproton Source due to the larger emittances associated with larger stacks. As a result the Source is limited to stacks containing 6×10^{11} antiprotons (about two-thirds of its present capability) during collider operations. The restricted aperture in the Main Ring is due to perturbations to the ring which have been required for the integration of overpasses and new injection and extraction systems related to operations with antiprotons. With the 400 MeV Linac upgrade the Booster aperture at injection will be increased to 30π mm-mr due to increased adiabatic damping within the new linac, and the ability to produce larger antiproton stacks will be increased. The mismatches between Booster/Antiproton Source and Main Ring capabilities will become even more acute. **Only with the construction of the Main Injector will these mismatches be removed, and the full benefit to the collider and fixed target programs of the upgrade projects currently underway be realized.**

The construction of the Main Injector will also provide beams of up to 3×10^{13} protons at 120 GeV to the experimental areas during collider runs. Such beams are envisioned as being used for detector development, for the debugging and shakedown of fixed target experiments prior to commencement of 1 TeV fixed target runs, and for supporting certain specialized rare K decay and neutrino experiments which can benefit from the high average intensity deliverable from the MI. The Main Ring as presently configured does not support a slow spill, nor is it felt that implementation of a high intensity slow spill in the existing ring would be feasible in light of the small machine aperture and the need to minimize backgrounds in the collider experiments.

Specifically, benefits expected from the construction of the Main Injector include:

1. An increase in the number of protons targeted for $\bar{p}$ production from 5.0×10^{15}/hour (following the Linac upgrade) to 1.2×10^{16}/hour.

2. An increase in the total number of protons which can be delivered to the Tevatron to 6×10^{13}.

3. The ability to accelerate efficiently antiprotons originating in stacks containing 2×10^{12} $\bar{p}$ for injection into the Tevatron Collider.

4. The ability to produce proton bunches containing up to 3×10^{11} protons for injection into the Tevatron Collider.

5. The reduction of backgrounds and deadtime at the CDF and DO detectors through removal of the Main Ring from the Tevatron enclosure.

6. Provision for slow extracted beams at 120 GeV year around and potential development of very high intensity, high duty factor ($\geq1\times10^{13}$ protons/sec at 120 GeV with 34% duty factor) beams for use in high sensitivity K decay and neutrino experiments.

7. The potential for development of a third interaction area at CO.

8. The creation of space in the Tevatron enclosure for eventual installation of a second superconducting accelerator.

It is expected that with the construction of the Main Injector and the completion of planned improvements to the Antiproton Source the antiproton production rate will exceed 1×10^{11} $\bar{p}$/hour, and that a luminosity of 5×10^{31} $cm^{-2}sec^{-1}$ will be supportable in the existing collider.

1.2 Performance

The Main Injector parameter list is given in Table 1-1. It is anticipated that the Main Injector will perform at a significantly higher level than the existing Main Ring as measured either in terms of protons delivered per cycle, protons delivered per second, or transmission efficiency. For the most part

Table 1-1: Main Injector Parameter List

Circumference	3319.419 meters
Injection Momentum	8.9 GeV/c
Peak Momentum	150 GeV/c
Minimum Cycle Time (@120 GeV)	1.5 sec
Number of Protons	3×10^{13}
Harmonic Number (@53 MHz)	588
Horizontal Tune	22.42
Vertical Tune	22.43
Transition Gamma	20.4
Natural Chromaticity (H)	-27.5
Natural Chromaticity (V)	-28.5
Number of Bunches	498
Protons/bunch	6×10^{10}
Transverse Emittance (Normalized)	20π mm-mr
Longitudinal Emittance	0.4 eV-sec
Transverse Admittance (at 8.9 GeV)	40π mm-mr
Longitudinal Admittance	0.5 eV-sec
β_{max} (Arcs)	57 meters
β_{max} (Straight Sections)	80 meters
Maximum Dispersion	2.2 meters
Number of Straight Sections	8
Length of Standard Cell	34.3 meters
Phase Advance per Cell	90 degrees
RF Frequency (Injection)	52.8 MHz
RF Frequency (Extraction)	53.1 MHz
RF Voltage	4 MV
Number of Dipoles	300
Dipole Length	6.1 meters
Dipole Field (@150 GeV)	17.3 kGauss
Dipole Field (@8.9 GeV)	1.0 kGauss
Number of Quadrupoles	202
Quadrupole Gradient	196 kG/m
Number of Quadrupole Types	3
Number of Quadrupole Busses	2

expected improvements in performance are directly related to the optics of the ring. The MI ring lies in a plane with stronger focussing per unit length than the Main Ring. This means that the maximum betas are half as big and the maximum (horizontal) dispersion a third as big as in the Main Ring, while vertical dispersion is nonexistent. As a result physical beam sizes associated with given transverse and longitudinal emittances are significantly reduced compared to the Main Ring. The elimination of dispersion in the rf regions, raising the level of the injection field, elimination of sagitta, and improved field quality in the dipoles will all have a beneficial impact on beam dynamics. The construction of new, mechanically simpler magnets is expected to yield a highly reliable machine.

The Main Injector is seven times the circumference of the Booster and slightly more than half the circumference of the existing Main Ring and Tevatron. Six Booster cycles will be required to fill the MI and two MI cycles to fill the Tevatron. The MI is designed to have a transverse admittance of 40π mm-mr (both planes, normalized at 8.9 GeV/c). This is 30% larger than the expected Booster aperture following the 400 MeV Linac upgrade, and a factor of three larger than that of the existing Main Ring. It is expected that the Linac upgrade will yield a beam intensity out of the Booster of $5\text{-}7\times10^{12}$ protons per batch with a 20-30π mm-mr transverse and a 0.4 eV-sec longitudinal emittance. (All emittances in this report are quoted as 95% normalized values.) A single Booster batch needs to be accelerated for antiproton production while six such batches are required to fill the MI. The MI should be capable of accepting and accelerating these protons without significant beam loss or degradation of beam quality. Yields out of the MI for a full ring are expected to lie in the range $3\text{-}4\times10^{13}$ protons ($6\text{-}8\times10^{13}$ delivered to the Tevatron.) By way of contrast the existing Main Ring is capable of accelerating 1.8×10^{13} protons in twelve batches for delivery to the Tevatron.

The power supply and magnet system is designed to allow a significant increase in the number of 120 GeV acceleration cycles which can be run each hour for antiproton production, as well as to allow a 120 GeV slow spill with a 35% duty factor. The cycle time at 120 GeV can be as low as 1.5 seconds. This is believed to represent the maximum rate at which the Antiproton Source might ultimately stack antiprotons and is to be compared to the current Main Ring capability of 2.6 seconds. The dipole magnets to be used are designed with twice the total cross section of copper and half as many turns as existing Main Ring dipoles. This is done to keep the total power dissipated in the dipoles during antiproton production at roughly the same level as in present operations while keeping the number of power supplies and service buildings low.

1.3 Operational Modes

At least four distinct roles for the MI have been identified along with four corresponding acceleration cycles. These are listed in Table 1-2 along with the average ring power <u>over the cycle</u> for each case. For reference the current 120 GeV antiproton production cycle runs at 2.6 seconds and 4.3 MW. More detailed description of the acceleration cycles and power supply requirements are given in Section 2 of this report.

Table 1-2: Main Injector Operational Modes

Operational Mode	Energy	Cycle	Flattop	Power
Antiproton Production	120 GeV	1.5 sec	0.05 sec	7.1 MW
Fixed Target Injection	150	3.0	0.05	6.2
Collider Injection	150	9.0	3.0	10.9
High Intensity Slow Spill	120	2.9	1.0	11.9

In the antiproton production mode a single Booster batch containing $5x10^{12}$ protons is injected into the Main Injector at 8.9 GeV/c. These protons are accelerated to 120 GeV and extracted in a single turn for delivery to the antiproton production target. As mentioned earlier it is anticipated that with this flux of protons onto the target and expected improvements in the Antiproton Source the antiproton production rate will exceed $1x10^{11}$/hour.

For fixed target injection the MI is filled with 6 Booster batches each containing $5x10^{12}$ protons at 8.9 GeV/c. Since the Booster cycles at 15 Hz, 0.4 seconds are required to fill the MI. The beam is accelerated to 150 GeV and extracted in a single turn for delivery to the Tevatron. The MI is capable of cycling to 150 GeV every 3 seconds. Two MI cycles are required to fill the Tevatron at 150 GeV at one minute intervals.

The MI operates on a 9 second, 150 GeV cycle for delivery of beam to the Tevatron for collider operations. The acceleration cycle and beam manipulations are the same for both protons and antiprotons. A 3 second flattop is required for bunch coalescing and cogging of the beams prior to injection into the Tevatron. Under the currently envisioned filling scenario a maximum of fifteen cycles of the MI are required to load the Tevatron with protons and antiprotons. Assuming a one minute Antiproton Source cycle time, this results in a 10 minute collider fill time. It is anticipated that the collider will require filling approximately every 20 hours.

A much higher intensity, high duty factor (34%) beam can be delivered at 120 GeV with a 2.9 second cycle time. The average proton current delivered is about 2 μA ($3x10^{13}$ protons/2.9 seconds). Running in this mode does not put any peak power demands on the power supply system beyond those imposed by the antiproton production cycle, but it does expend 67% more average power. This cycle can also be used to provide test beams to the experimental areas during collider running. In this instance it is likely that a much lower cycle rate, accompanied by a much lower average power, would satisfy experimenters' needs.

Combinations of the above operational modes are also possible. One such example is simultaneous operation for antiproton production and high intensity slow spill. One might load the MI with six Booster batches containing $3x10^{13}$ protons, accelerate to 120 GeV, fast extract one batch to the antiproton production target, and slow extract the remainder of the beam over a second. This would produce slightly more than half the antiproton flux into the source and 83% of the average intensity of the dedicated scenarios listed in Table 1-2.

2. THE MAIN INJECTOR

The Main Injector (MI) is a 150 GeV accelerator with a circumference 28/53 times that of the existing Main Ring. The primary design goals are to increase the admittance to 40π and lower the cycle time to 1.5 sec. The MI will be situated tangent to the Tevatron at the FO straight section on the southwest side of the Fermilab site. Other possible sitings have been considered, including locations inside the existing Tevatron ring, but these were deemed less desirable than the site shown in this report. The MI, as described here, is constructed using newly designed (conventional) dipole magnets. The choice of building new magnets is based on considerations of field quality, aperture, and reliability. With the major exception of the dipoles, existing components from the Main Ring are for the most part recycled. Such components specifically include quadrupoles and the radio frequency (rf) systems. The use of all 18 existing rf cavities in a ring roughly half the size of the Main Ring will support an acceleration rate of 240 GeV/sec as compared to 120 GeV/sec in the present Main Ring. The power supply systems described are designed to support this rate.

2.1 Lattice

The design of the MI is driven by a number of considerations. Once the siting is determined (as described below) a maximum physical size of the ring is established by the proximity of the site boundary. This in turn leads to a minimum needed field strength in the magnets. The number and location of the straight sections is determined by the roles the ring is asked to play. In all phases of design the motivation has been to produce a lattice in which the transverse beam sizes are smaller than in the Main Ring over the energy range 8.9 to 150 GeV/c. The two lattice parameters which affect beam size are the beta function, β, and the dispersion, η. In this design β is kept small by using 90° cells with a short distance between quadrupoles. This is a cost effective approach because the quadrupoles will be taken from the existing Main Ring. The η is kept smaller in the MI than in the Main Ring in part due to the 90° cells, but more importantly due to careful dispersion matching around all straight section insertions. Dispersion matching insures that the maximum dispersion in the ring is no larger than the maximum dispersion in the standard cell. Of course the MI will not have overpasses, in contrast to the present Main Ring, and therefore the vertical dispersion will be zero.

<u>Siting Considerations</u>

The MI must serve a number of purposes. It must function as a bi-directional injector into the Tevatron. This means it must be near and approximately tangent to the Tevatron. Secondly, it must receive 8 GeV protons from the Booster and 8 GeV antiprotons from the Antiproton Source. It must also provide 120 GeV protons to the antiproton target. This constraint requires a portion of the MI to lie south of and nearly tangent to the present beamline which provides these functions. Finally, the MI must provide a 120 GeV test beam to the present Fermilab switchyard. In light of these constraints two sites were considered: the one chosen, and a site inside and concentric to the Main Ring tunnel between FO to AO. It was found that the transfer lines were of equal length in both site options. However, the considerable interferences with the existing accelerator utilities on the inside of the Main Ring tunnel, the larger circumference required, and the greater potential impact on existing wetland areas led to rejection of the inner site.

<u>Lattice Design</u>

The present Main Ring lattice is made of FODO cells with four dipoles between adjacent quadrupoles. Two of these dipoles (B1) have a 1.5 inch vertical by 5.0 inch horizontal aperture and are placed nearest the horizontally focusing quadrupoles. The other two dipoles (B2) have a 2.0 inch vertical by 4.0 inch horizontal aperture, and are placed near the vertically focusing quadrupoles. The MI will use new dipoles with a 2.0 inch by 4.0 inch aperture.

Figure 2-1 shows the MI geometric layout. The standard cell of the MI is, like the Main Ring, a FODO design but with two dipoles between the quadrupoles as shown in Figure 2-2. The interelement spacing is the same as in the present Main Ring so that the length of the half cell is shorter by the length of two dipoles and the short drift spaces which follow them, i.e. by about half. Because of the shorter circumference, there are fewer than half as many dipoles as in the Main Ring. This leads to higher fields in the dipoles, and a larger bending angle in each. The resulting sagitta is 16 mm. The new dipoles will be built with a curvature which eliminates loss of aperture due to sagitta. A 90° phase advance per cell is chosen, resulting in a maximum β in the cells of 58 meters and a maximum η in the cells of 2.0 meters. By comparison the Main Ring has a maximum β/η of 110/6.6 meters. Thus the beam size due to transverse emittance will be only 70% of what it is presently, and the maximum beam size due to momentum spread will be down by a factor of three from the Main Ring. Figure 2-3 shows the MI lattice functions.

The MI contains eight straight sections, six of the "long straight" type and two "rf" type. Their locations are shown in Figure 2-1 and details of their layout are shown in Figures 2-4 and 2-5. Their numbering and their functions are as follows:

10 - 8 GeV proton injection
20 - (unused)
30 - (unused)
40 - proton abort
50 - (unused)
60 - 150/120 GeV proton extraction;
8 GeV antiproton injection
70 - MI RF section
80 - 150 GeV antiproton extraction

The first type of straight section (10, 20, 40, 50, 60, 80), illustrated with MI-20 in Figure 2-4, of which two are used for 150 GeV extraction, are designed using matching quadrupoles. This design requires two new quadrupole types, similar to existing Main Ring quadrupoles, but of different lengths. These quadrupoles are powered off the main quadrupoles busses. The long straight section insertion is dispersion matched to the cells. Space is provided 90° from the long straight for kickers and septa, a situation not provided for in the present Main Ring lattice.

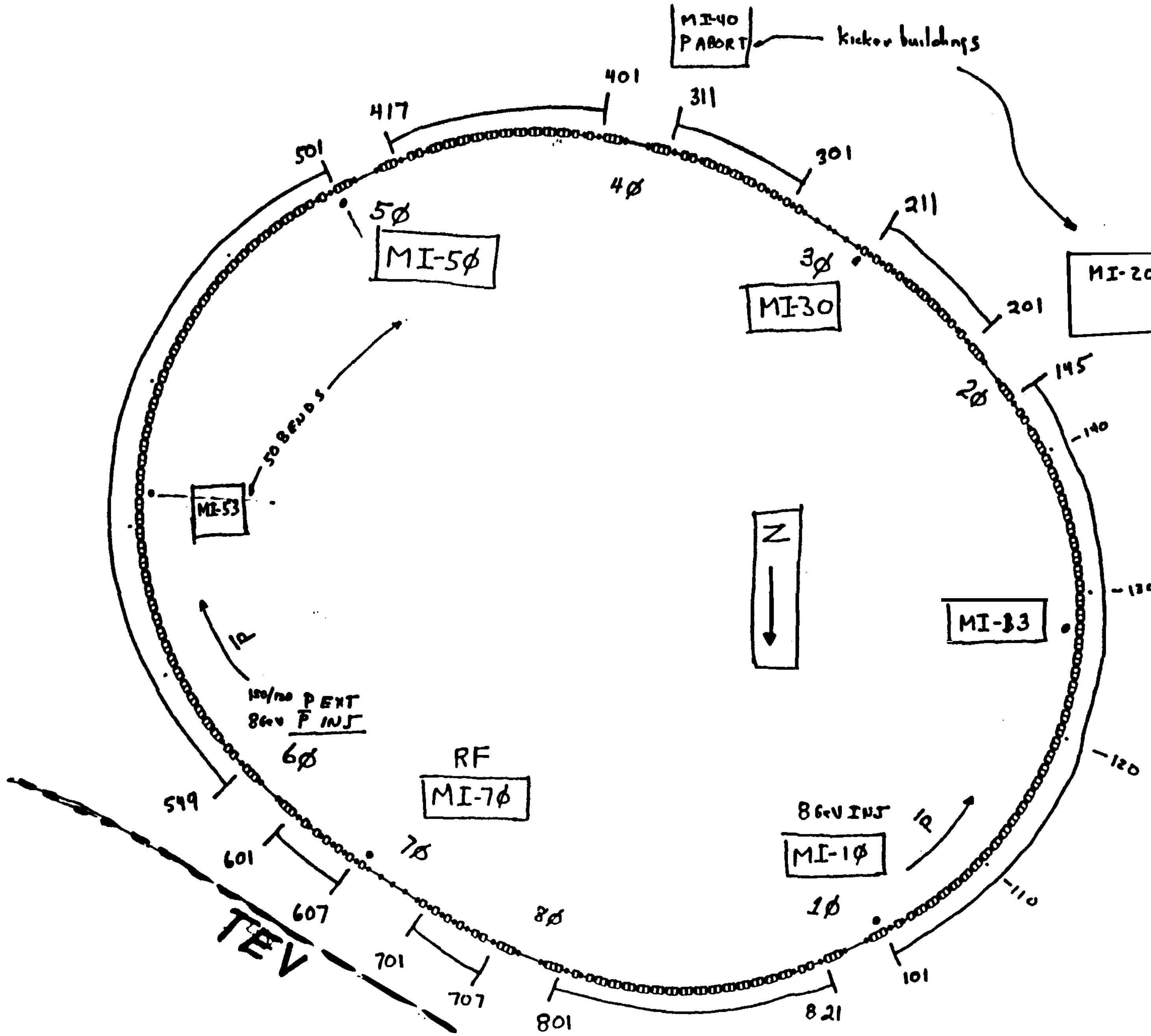

Figure 2-1: Main Injector geometric layout. Locations of the eight straight sections and eight service buildings are indicated.

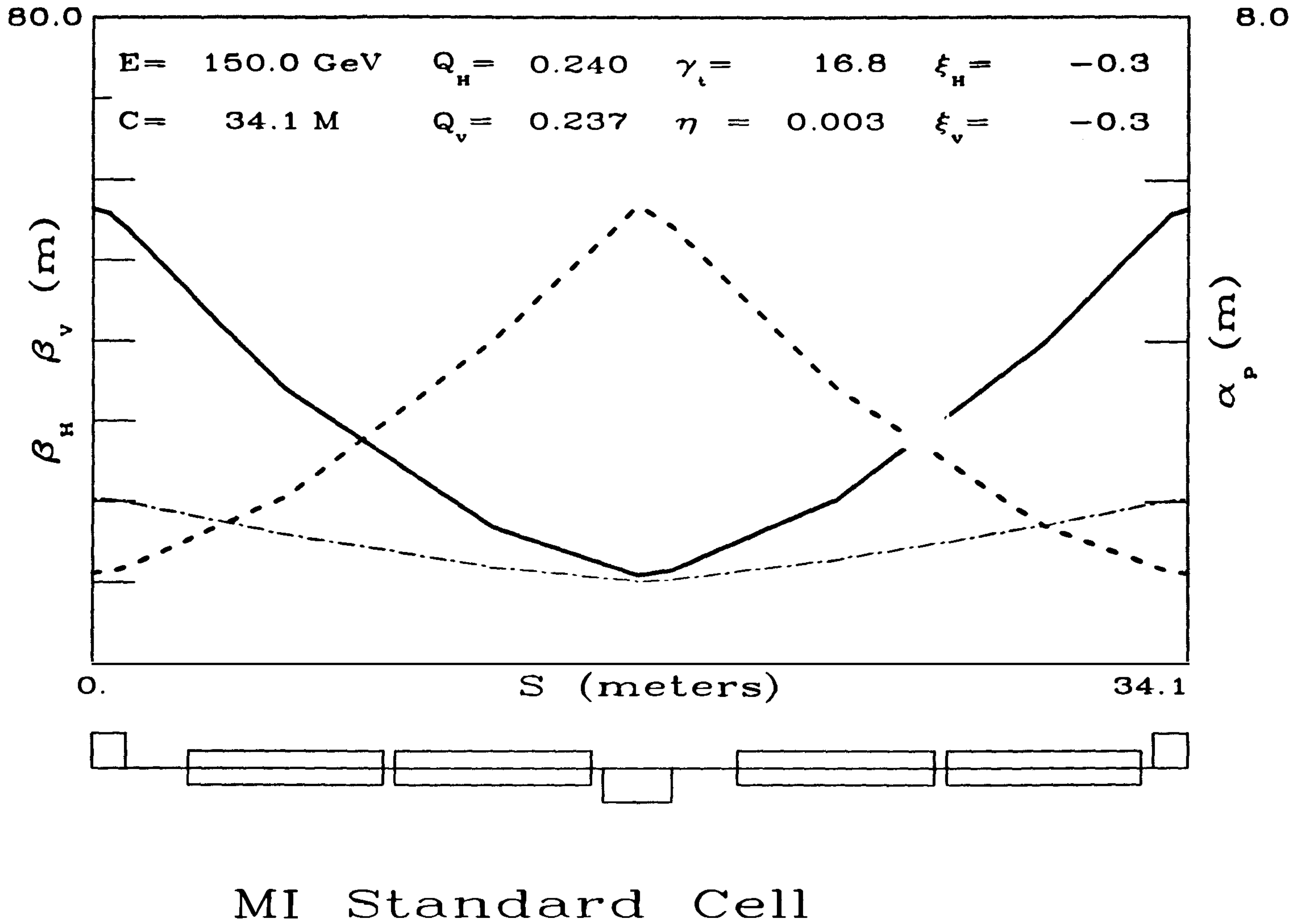

Figure 2-2: Main Injector standard cell.

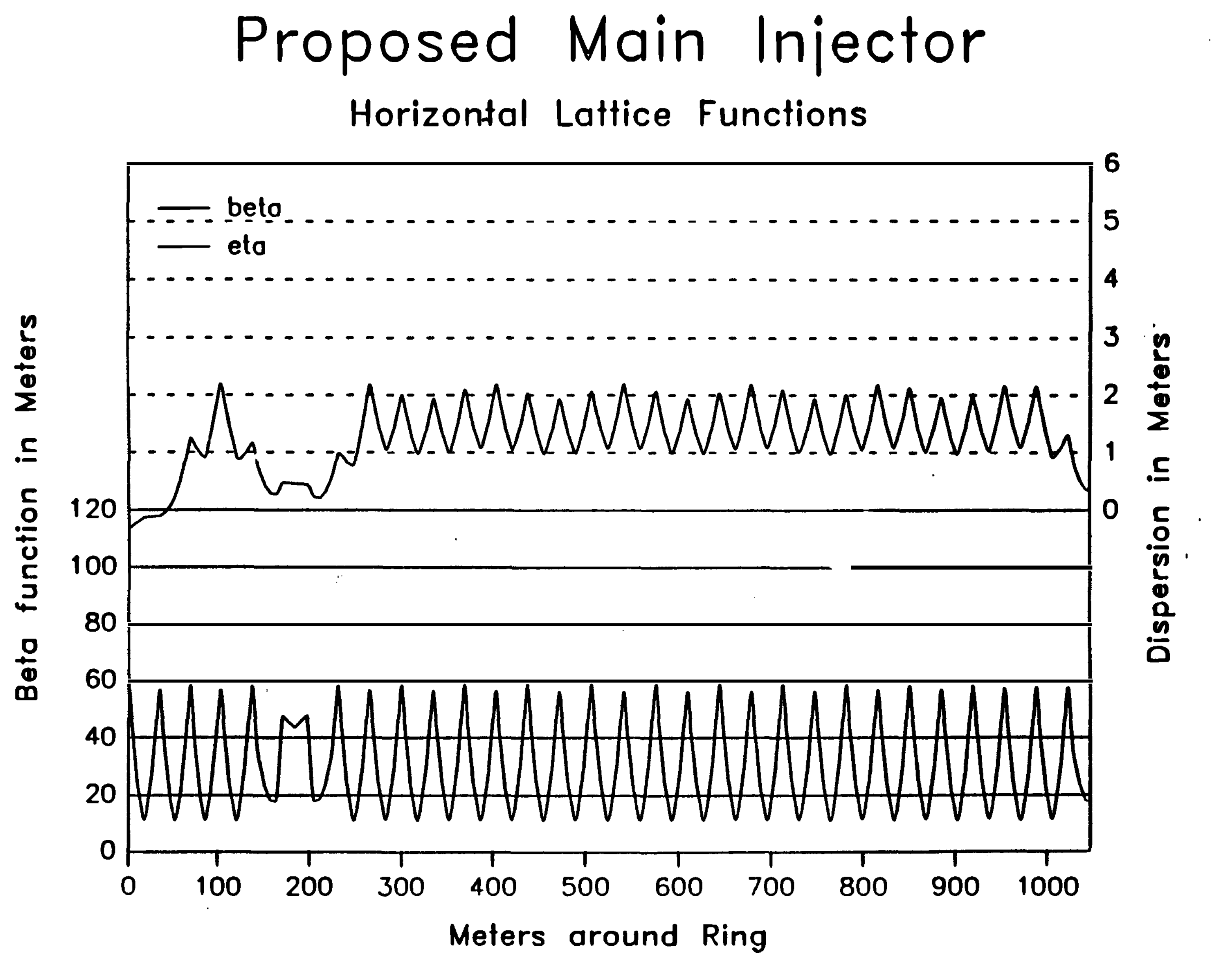

Figure 2-3: Main Injector lattice functions. Approximately one third of the ring is shown starting at the RF straight section.

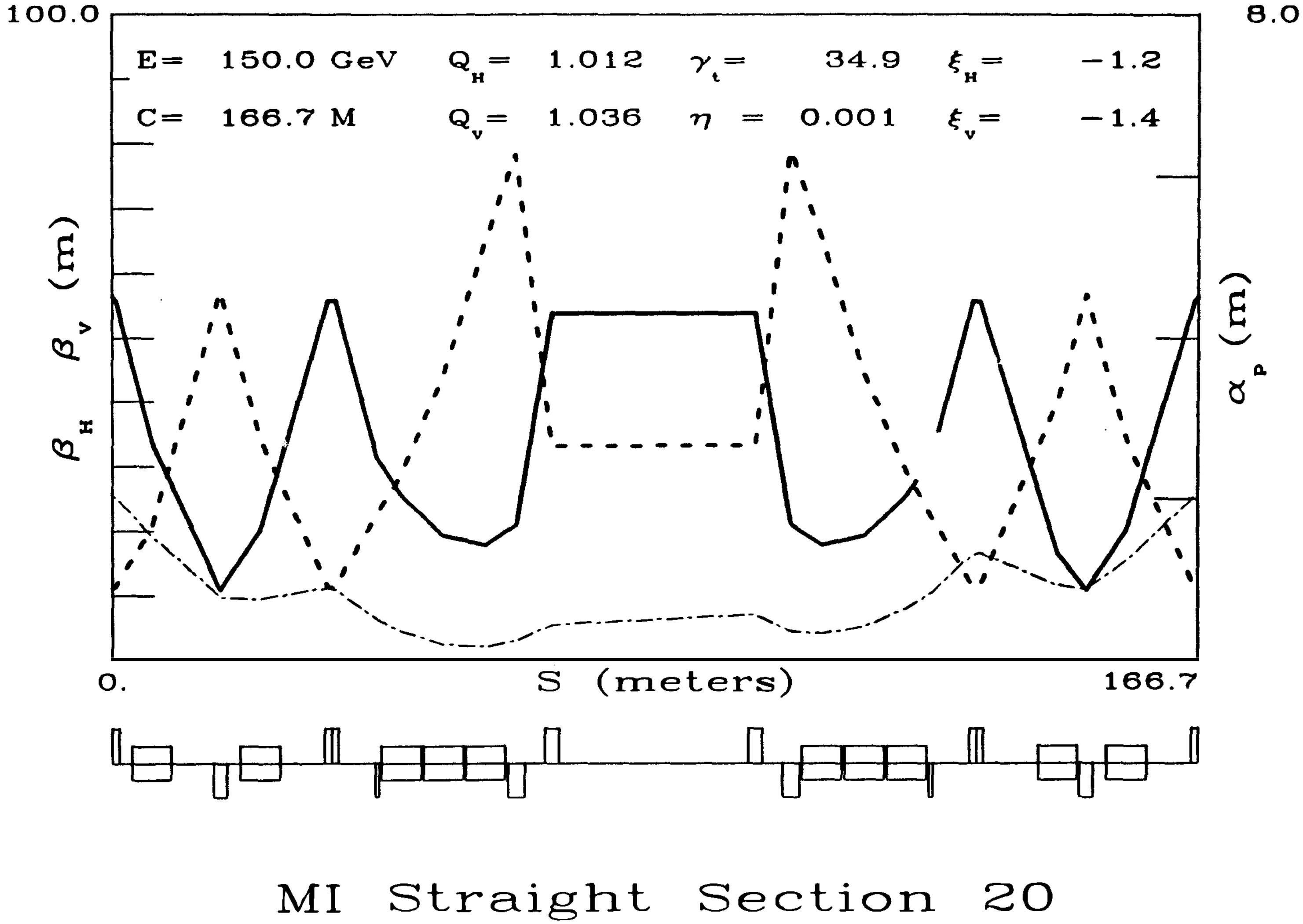

Figure 2-4: Optical layout of the long straight section, MI-20.

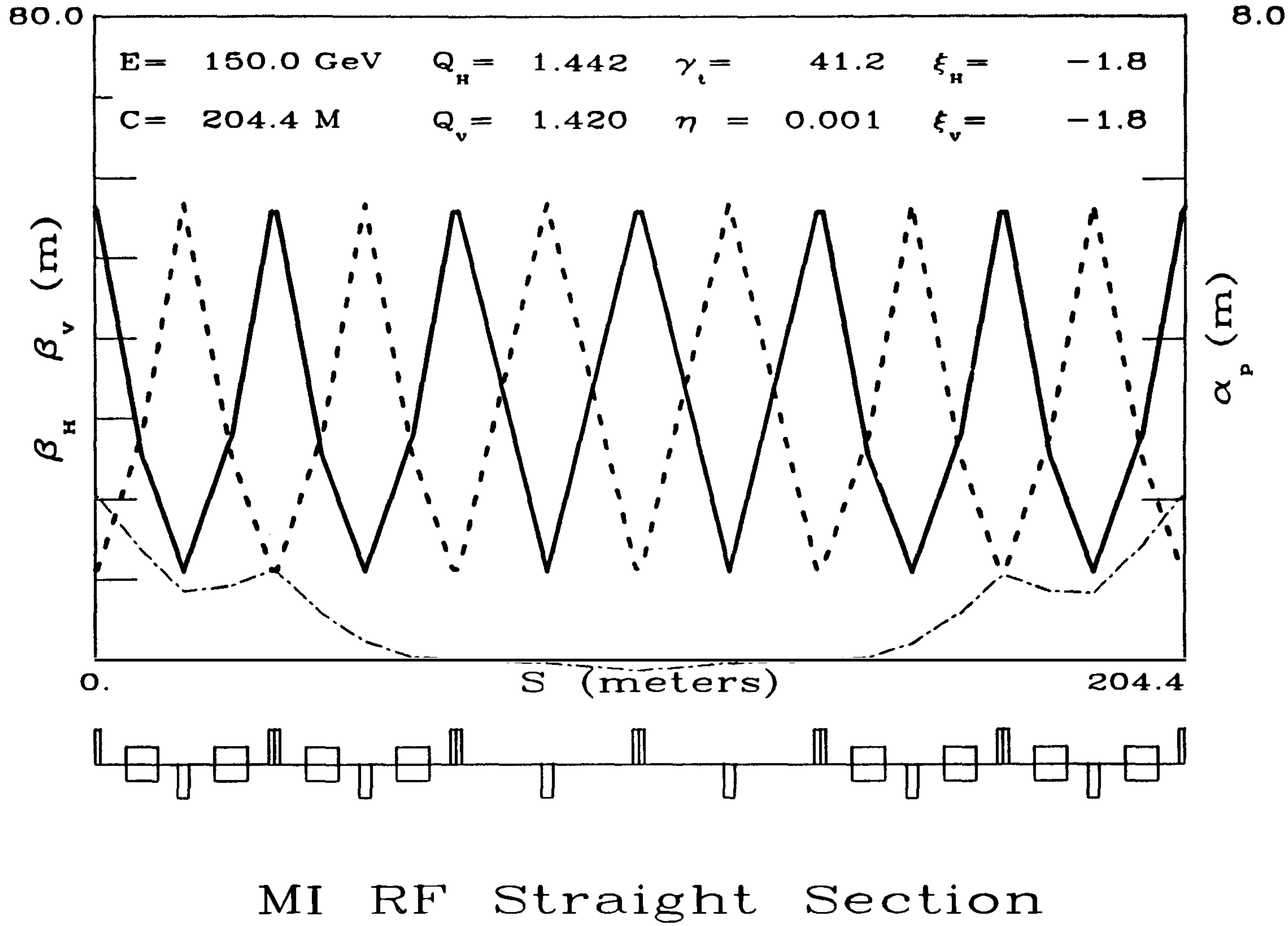

Figure 2-5: Optical layout of the RF straight section, MI-70.

The second type of straight section (30, 70), illustrated with MI-70 in Figure 2-5, is provided by omitting dipoles while retaining the standard quadrupole spacing. This straight section is designed for rf systems. Only one is needed at present.

The six long straight sections are capable of beam extraction at the highest MI energy. Due to the fact the ring lies 10 meters from the Tevatron, two of these (60, 80) are required to provide injection into the Tevatron, one each for protons and antiprotons. On the opposite side of the ring are two additional straight sections (20, 40) which can be used for beam abort. They are not symmetric with long straight sections MI-60 and MI-80 in order to avoid tangents which intersect the nearby site boundaries. Finally, straight section MI-10 is necessary for injection of protons from the Booster. Straight section MI-50 was added on the opposite side, but in a nonsymmetrical position in order to avoid a tangent which interferes with the site boundary.

2.2 Acceleration Cycles

There are four acceleration cycles, shown in Figure 2-6, serving each of the four operational modes of the MI:

(a) The antiproton production cycle: 1.5 second cycle, peak energy of 120 GeV.
(b) The Tevatron fixed target injection cycle: 3.0 second cycle for Tevatron injection at 150 GeV.
(c) The Tevatron collider injection cycle: 9.0 second cycle with a 3 second flattop at 150 GeV for coalescing and cogging.
(d) The 120 GeV slow spill cycle: 2.9 second cycle with a one second slow spill at 120 GeV to the fixed target area.

The operational limits for the rf cavities and power supply systems are discussed in Sections 2.4 and 2.6 respectively. The 18 existing Main Ring cavities in their current running mode are adequate for all of the above cycles.

2.3 Magnets

The MI uses conventional iron core magnets. A total of 300 dipole, 202 quadrupole, 136 sextupole, and 202 correction dipole magnets are required. The magnet apertures need to be sufficient to provide a transverse admittance of 40π mm-mr and a momentum aperture of $\pm 1.4\%$ at transition. The dipole and sextupole are newly designed and manufactured magnets. The quadrupoles and correction magnets are to be recycled from the Main Ring. Dipole and quadrupole parameters are listed in Table 2-1. The sextupole and correction dipole magnets are described in Section 2.5.

The decision to construct the MI using newly designed dipole magnets is made for several reasons. First, the existing Main Ring magnets are straight. Recycling these magnets into the MI would result in a loss of about 16 mm of aperture due to sagitta. This aperture is recovered by constructing curved

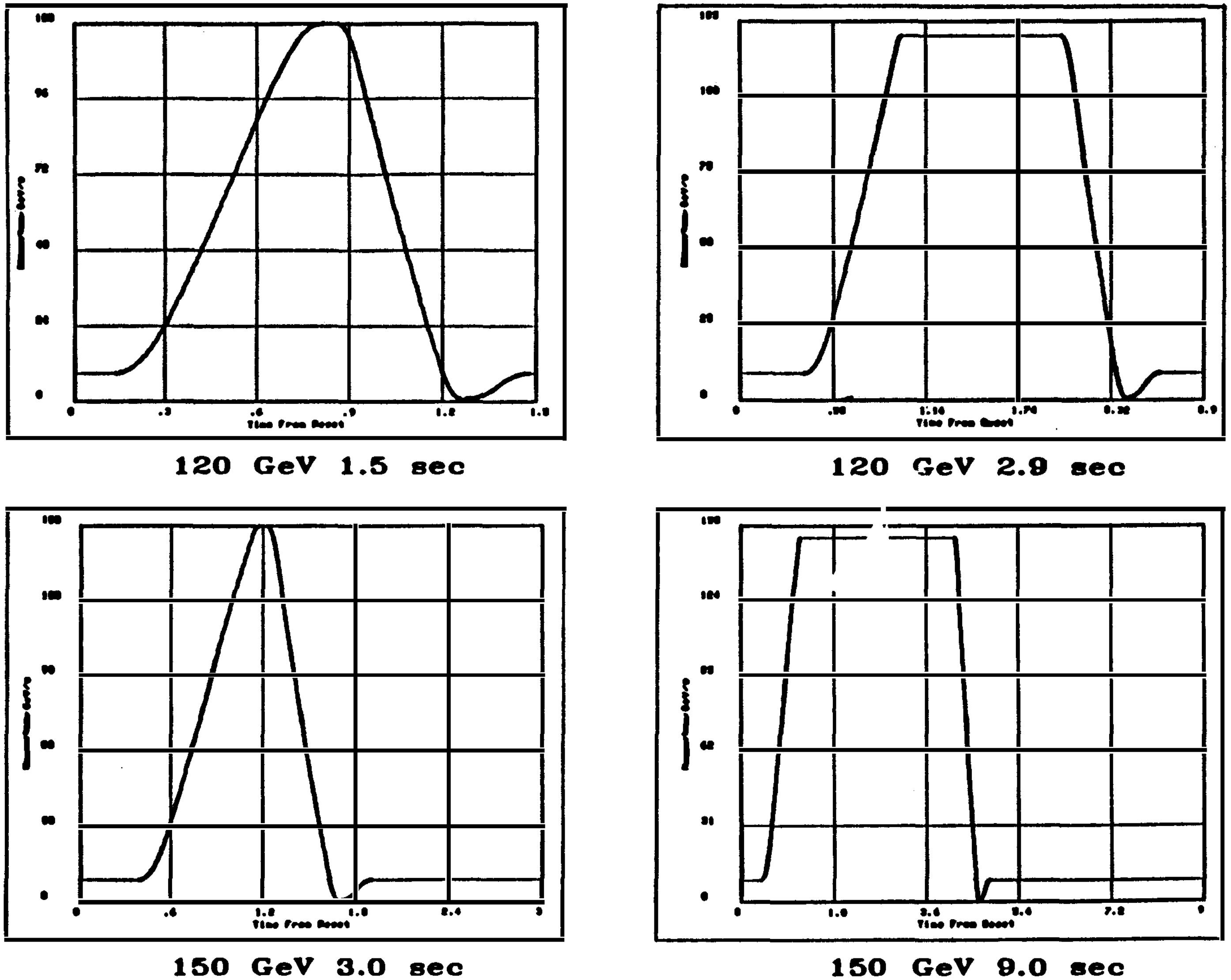

Figure 2-6: Beam momentum versus time for the four operational modes described in the text.

magnets. Second, the existing magnets suffer from reliability problems. Most of the failures in the existing magnets occur at conductor joints within the coil. The number of such joints per magnet will be reduced in the new magnet and at the same time the reliability of the joints improved. Third, it is believed that higher field quality can be achieved in a newly constructed magnet so that the dynamic aperture is only limited by the magnet physical aperture - a situation not achieved in the existing Main Ring.

Table 2-1: Main Injector Magnet Parameters

	Dipole	Quadrupole
Strength (@150 GeV)	17.3 kG	196.0 kG/m
Length	6.1 m	2.1 m
Full Aperture	15x5 cm^2	7.6 cm
Turns/pole	4	4
Maximum Current	9417 A	3630 A
Coil Resistance	0.8 mΩ	4.5 mΩ
Coil Inductance	2.0 mH	1.3 mH
Peak Power	75 kW	59 kW
Number Required	300	202
Newly Constructed	Yes	No

Once it was decided to build new dipole magnets, a cost optimization was performed which minimized the sum of construction plus operating costs over five years. The result is a magnet with twice as much conductor and half as many turns as the existing Main Ring B2 magnet. The dipole magnet cross section is shown in Figure 2-7. The magnet is 6.07 meters long, the same length as the existing magnets. The core is constructed from 0.060" thick laminations which are split on the magnet midplane. The coil consists of four turns per pole of a 1" x 4" conductor. Since no conductor is contained in the median plane of the magnet, the coil can be wound as two "pancakes" with no bends along the long dimension of the conductor. This conductor is available in 40 foot lengths so each coil can be made with four joints. The joints will be of a type with demonstrated reliability in which conductors are brazed together with a ferrule inserted between the conductor water holes. The water hole is 0.5 in. in diameter. A single water circut in each pancake (two circuts per magnet) provides sufficient cooling.

A four terminal construction has been chosen for the dipole magnet. In a magnet of this design the role of return bus is filled by one of the conductor turns within the magnet. This has the advantage of removing the need for approximately 12,000 ft of 4 in^2 copper bus (@ $40/ft) in the MI enclosure. The price paid for this benefit is the requirement that the insulation be sufficient to hold off 1000 volts between conductors within the coil.

2.4 Power Supplies

The MI power supply system has been designed to ramp the magnet system from an injection level of 8.9 to 150 GeV/c excitation at a repetition rate

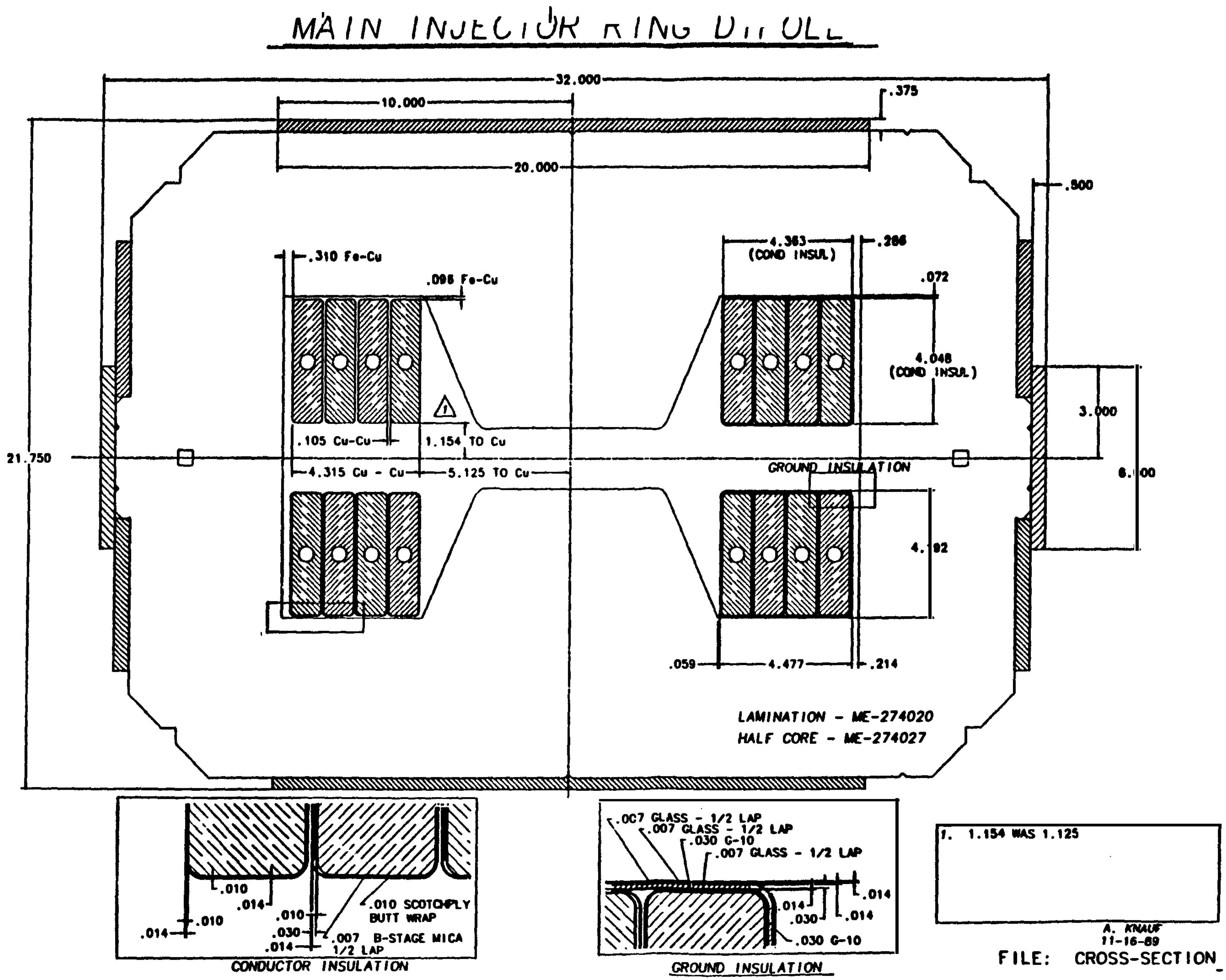

Figure 2-7: Main Injector dipole magnet cross section.

adequate to meet requirements for Antiproton Source stacking, Tevatron injection, and slow spill operation. The power system consists of 12 new rectifier power supplies for the bend bus, reuse of existing equipment on the quadrupole bus including six main bus supplies, a new power feeder system for all the supplies, a new harmonic correction system, and the reuse of many smaller items from the present Main Ring. A summary of the MI power supply requirements is given in Table 2-2.

Table 2-2: Power Supply Summary for the MI System

	Power Supplies	Voltage	Current
Bend	12 new	1000	5000 rms
Quad F	3	850	2800 rms
Quad D	3	850	2800 rms
	Other Equipment Needed:		
Quad regulator	2 new	300 volts	500 amps
Regulation			
Transductors	2 new		10,000 amps
Transductors	2 new		5,000 amps
Computer link	1 new		
Harmonic filter	1 new		

Power supply spacing for minimum voltage to ground requires an equal number of magnets between power supplies on the dipole bus. The proposed system will have six service buildings with two dipole supplies per building, one on each of two busses and one quadrupole supply. The buildings are spaced so that there are 25 dipole magnets between each supply, with the magnets on a folded bus loop. The third supply in each of the six buildings is configured such that three are in series with the focussing quadrupole magnet bus; three are similarly used with the defocussing quadrupole bus.

Criteria for Ramps and Constraints on Power Supply Layout

The overriding design criterion was to design a combined magnet and power supply system that would be cost effective during operation. A system was chosen to have low power consumption and a safe power supply voltage without being unduly expensive to construct and unwieldy in physical size. A new 40 MVA power distribution transformer located at the new Kautz Road Substation will be used in the new installation with an operational limit set at 120 MVA peak and an rms value less than 15 MW. There will be a 13.8 kV feeder cable system installed in a double loop around the Main Injector ring. The rms current rating of the entire system is 1,800 amps.

The maximum rate of rise will be set by the use of the existing Main Ring rf system which has at present an operational limit of about 240 GeV/sec. The maximum ramp repetition rate is set by the 1,800 amp feeder current limit and a chosen rms dipole bus current of 4700 amps. The use of three supplies on the quadrupole bus further limits the rate of rise at high currents; the three supplies give a total bus voltage of 2500 volts and a peak current of 4200 amps, which yields the limits described below.

The dipole configuration is two busses internal to the new magnets with a fold at MI-70 allowing for six upper bus supplies and six lower bus supplies. The impedance of the magnet load in the Main Injector dipole bus is 0.6 Henries and, with the use of 4 in^2 cross section copper for the magnets and power supply bus, will have a dc resistance of 0.3 ohms. The required peak power supply voltage is 12,000 volts for the bend bus.

The quadrupole configuration is two separate busses in continuous loops around the injector with current flowing in opposite directions, one focusing and one defocussing, each having three supplies for ramping and a transistor regulator supply for injection current regulation. Each quadrupole magnet loop impedance is 0.132 Henries, and with the use of 2 in^2 power distribution bus, will have a dc resistance of 0.46 ohms. Thus the required peak power supply voltage is 2,500 volts for each quadrupole bus. With only three power supplies on the quadrupole bus, the ramp rate will need to decrease above 120 GeV from 240 GeV/sec to 178 GeV/sec. This is required due to the lack of power supply voltage to maintain high inductive voltage and high resistive voltage at the same time. The lower rate of rise slightly increases the rms current in the magnets and feeders. The feeder current limit sets the maximum repetition rate at 3.0 seconds for a 150 GeV ramp with a 50 msec flat top and the slower acceleration rate described above.

Ramp Details

For antiproton stacking the voltage and number of power supplies are chosen to provide a repetition rate of 1.5 seconds and a maximum rate of rise of 240 GeV/sec. This requirement also set the upper limits on the operation of test beams and 150 GeV injection rates. Figure 2-8 and Table 2-3 give details on this mode of operation.

Table 2-3: Parameters for antiproton stacking. (All currents are rms)

Peak dipole bus current: 7168 amps
Peak quadrupole bus current: 3360 amps

	Ramp power	Feeder current	Peak MVA	Bus current
Bend	4.1 MW	1206 amps	69.8	3691 amps
Quad (each)	1.5 MW	165 amps	9.5	1698 amps
Totals	7.1 MW	1536 amps	88.8	

Table 2-4 and Figure 2-9 give details on operation during injection into the Tevatron. Maximum energy is 150 GeV with a 50 millisec flattop and a 3 sec repetition rate.

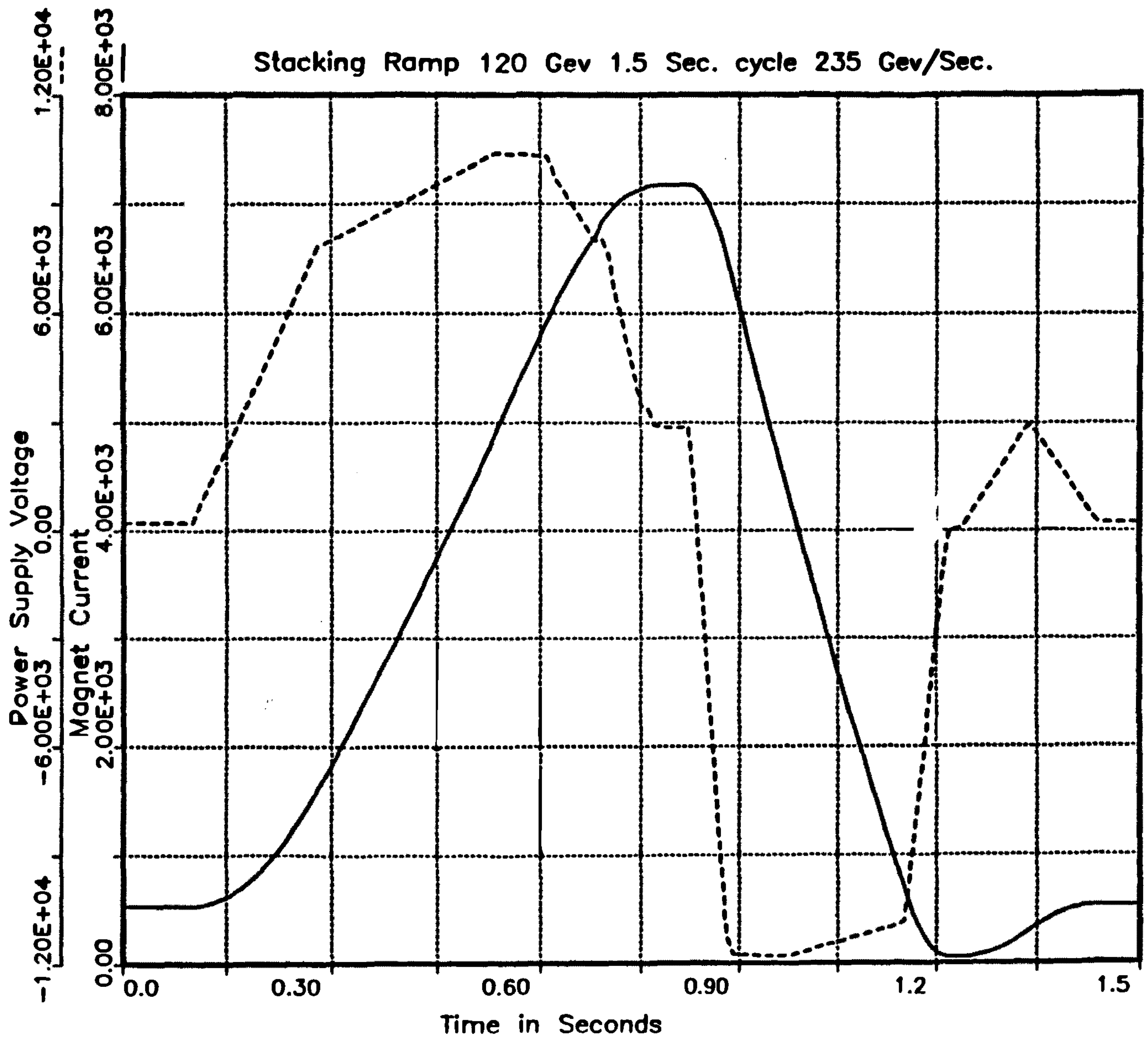

Figure 2-8: Ramp parameters for the antiproton stacking cycle.

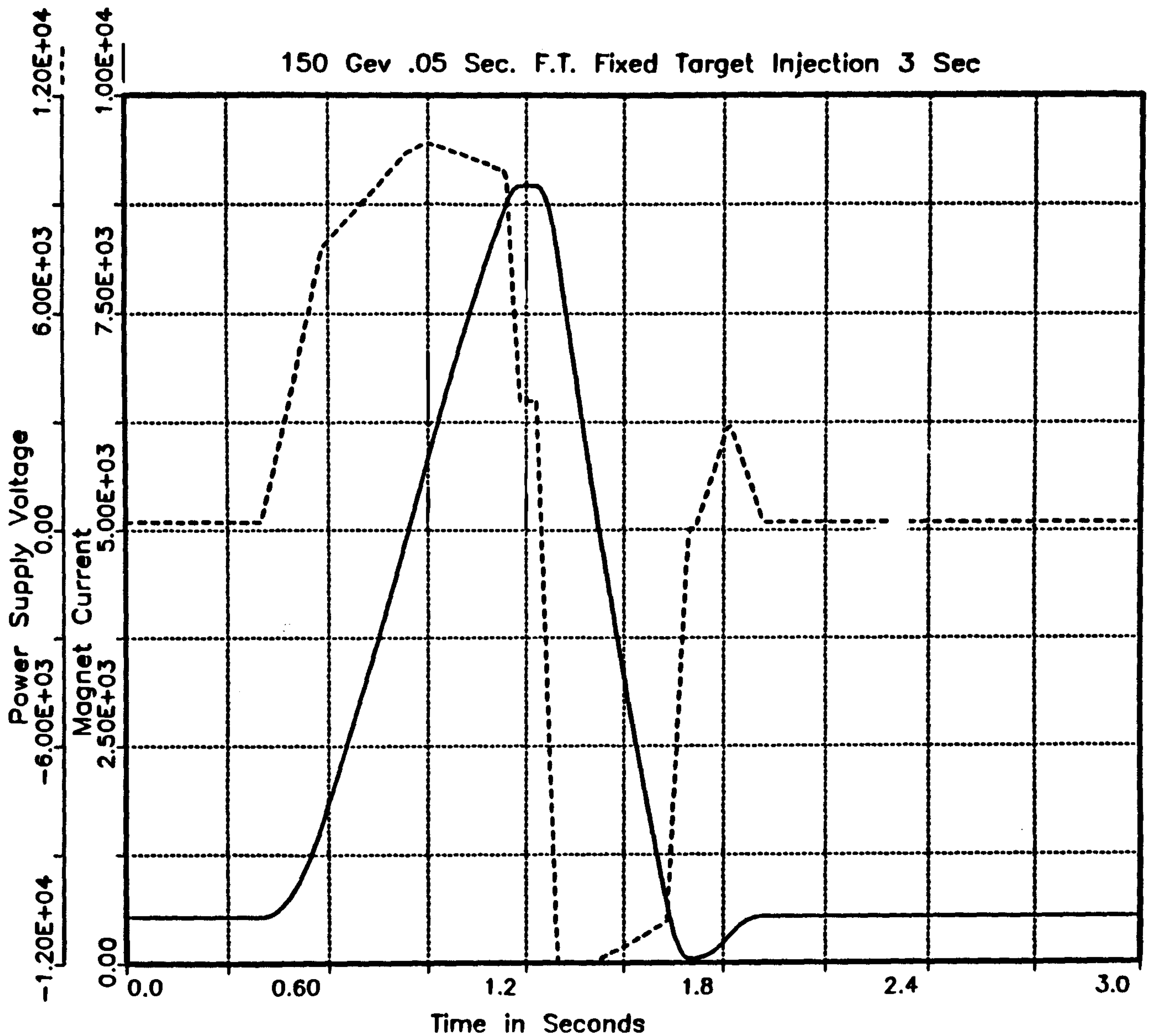

Figure 2-9: Ramp parameters for Tevatron fixed target injection cycle.

Table 2-4: Parameters for Tevatron injection.

Peak dipole bus current: 9417 amps
Peak quadrupole bus current:4200 amps

	Ramp power	Feeder current	Peak MVA	Bus current
Bend	3.8 MW	1211 amps	89.3	3560 amps
Quad (each)	1.2 MW	167 amps	15.6	1679 amps
Totals	6.2 MW	1545 amps	120.5	

Power supply parameters for the Tevatron collider injection cycle are shown in Table 2-5 and Figure 2-10. The maximum energy is 150 GeV with a 3 second flattop for cogging and coalescing. The cycle can be repeated every 9 seconds.

Table 2-5: Parameters for collider injection.

Peak dipole bus current: 9417 amps
Peak quadrupole bus current:4200 amps

	Ramp power	Feeder current	Peak MVA	Bus current
Bend	6.5 MW	830 amps	89.3	4650 amps
Quad (each)	2.2 MW	252 amps	15.6	2180 amps
Totals	10.9 MW	1334 amps	120.5	

Finally, operation with the MI can provide 120 GeV beam to the fixed target areas for beamline and experiment setup. The ramp will have a 0.4 sec injection time and a 1 sec slow extraction flattop for a total cycle time of 2.9 sec. Power supply parameters for this mode are shown in Table 2-6 and Figure 2-11.

Table 2-6. Parameters for 120 GeV slow spill.

Peak dipole bus current: 7168 amps
Peak quadrupole bus current: 3360 amps

	Ramp power	Feeder current	Peak MVA	Bus current
Bend	7.1 MW	971 amps	69.8	4862 amps
Quad (each)	2.4 MW	186 amps	9.5	2274 amps
Totals	11.9 MW	1343 amps	88.8	

<u>Power Feeder Loading</u>

The main 13.8 kV power feeders have an operating limit of 1800 amps rms. to the ring will be 1,800 amps. The power supplies around the ring will be supplied in a two feeder loop to ensure proper current sharing. More details are given in Section 2-14.

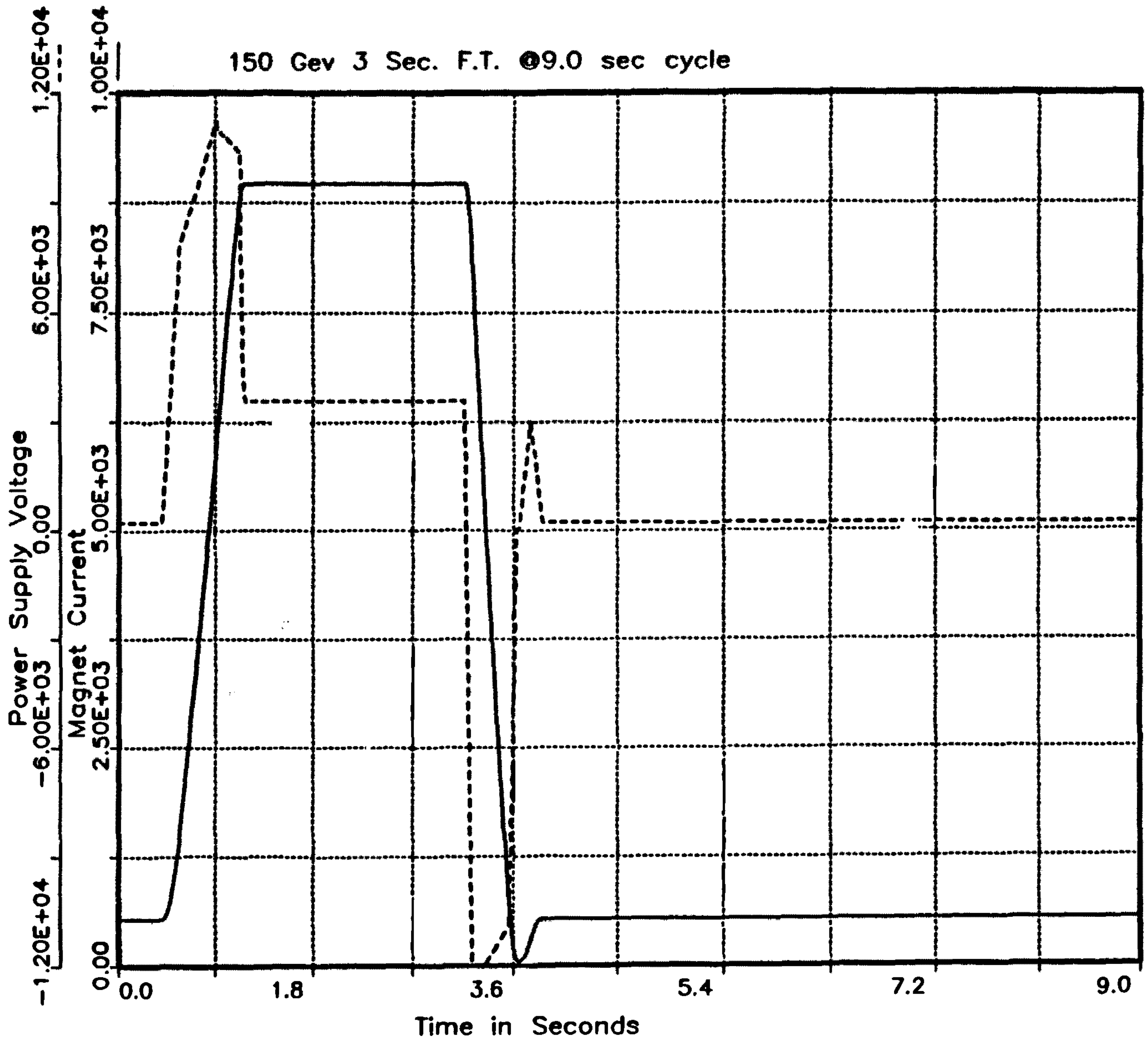

Figure 2-10: **Ramp parameters for Tevatron collider injection cycle.**

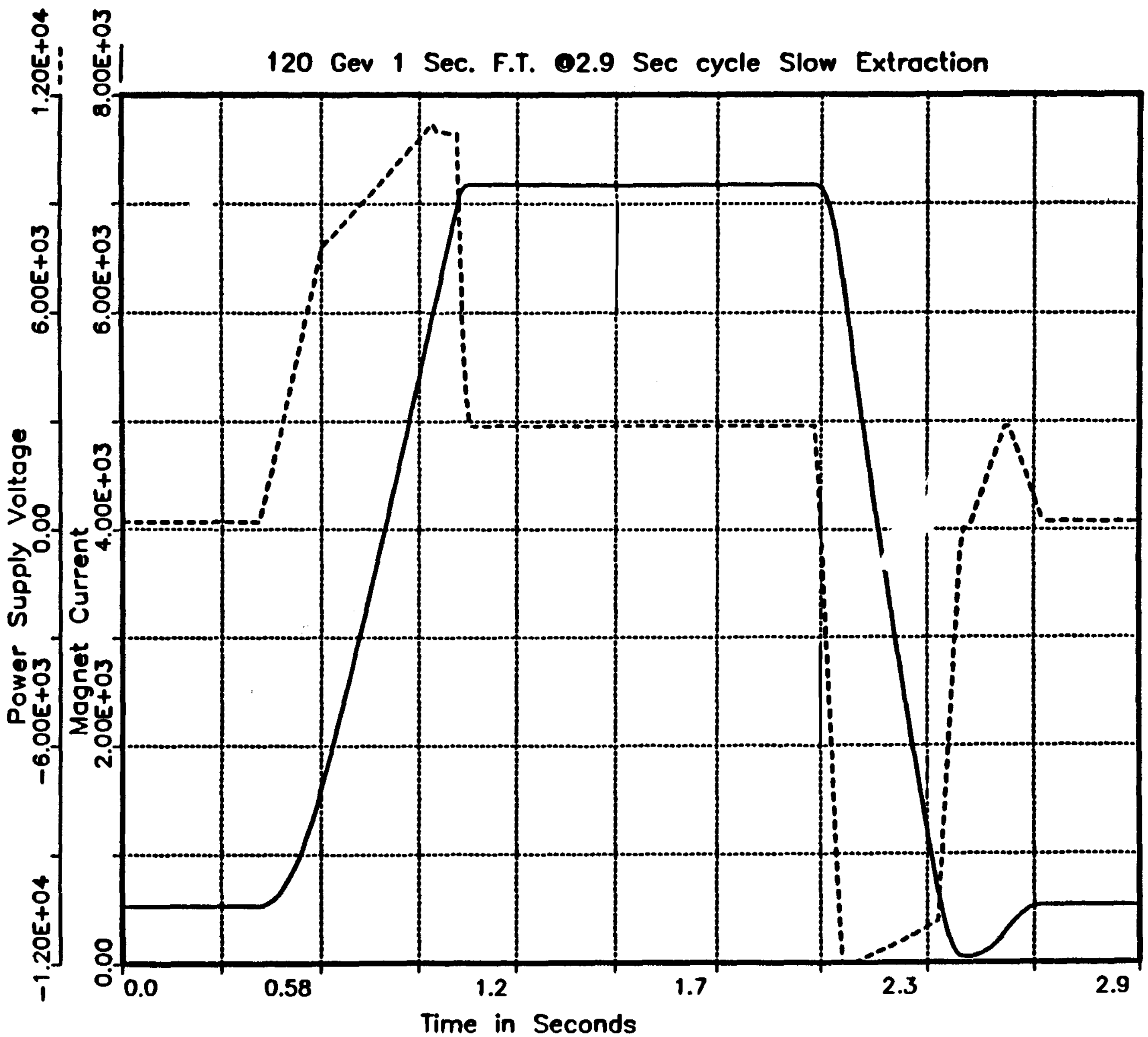

Figure 2-11: **Ramp parameters for 120 GeV slow spill cycle.**

The use of rectifier power supplies on this system draws current pulses from the feeders which then drive harmonic resonances, causing higher voltages at the resonant frequencies to be imposed on the power equipment. The present Main Ring has an harmonic filter to limit the peak voltages of higher frequencies superimposed on the 60 Hz line voltage. The MI will run with 12 power supplies at two times the current of the Main Ring, requiring the filter to damp four times more harmonic power. Therefore, in the MI a new filter needs to be designed to correct for the higher harmonic driving force of the system. This new filter will be installed at the switch in the feeder system where the feeders change from direct feed to loop feed (at the Kautz Road Substation).

2.5 Correction Elements

The MI correction element inventory includes steering dipoles, trim quadrupoles, sextupoles, and skew quadrupoles. Wherever possible exisiting components will be reused. The steering dipoles, trim quadrupoles, and skew quadrupoles will be recycled Main Ring components. The sextupoles will be a modified version of the Antiproton Source sextupole. Correction elements will be placed next to each quadrupole. A horizontal (vertical) steering dipole will be placed at each focussing (defocussing) quadrupole. Sextupoles will be placed next to quadrupoles in the arcs where the dispersion is large. The trim quadrupoles and skew quadrupoles will be placed around the ring as needed. In addition, a small number of sextupoles to cancel harmonics due to the chromaticity sextupoles will be located in the straight sections.

<u>Steering Dipoles</u>

The steering dipoles correct the closed orbit. The primary sources of orbit distortion are quadrupole placement errors, dipole strength errors, and dipole rotation. These errors cause orbit distortions proportional to β, and, if uncorrected, would yield an rms error of 1.5 mm. If the gap in the existing Main Ring steering dipoles is increased to 2" they will produce a field strength of 0.13 kG-m at their full excitation. Use of these magnets will allow insertion of bumps of up to ±22 mm at 8.9 GeV/c, which will easily correct closed orbit errors, permit aperture scans and allow other bumps to be installed as needed. The correction element power supplies to be relocated from the Main Ring will allow programming of the steering dipoles throughout the acceleration cycle.

<u>Trim Quadrupoles</u>

The main quadrupoles of the MI will run on two separate busses and will be used for all necessary tune adjustments. Trim quadrupoles are needed for harmonic generation or cancellation. A sufficient number of Main Ring trim quadrupoles will be installed around the ring to cancel half-integer stopbands, if they are significant. In addition, slow extraction will require a small number of trim quadrupoles for excitation of the half-integer resonance.

Sextupoles

Sextupoles will be used primarily for correction of the MI chromaticity. The natural chromaticities of the MI are -27.5 horizontally and -28.5 vertically. The lattice has been designed to have low β and η (58 m and 2.2 m are the maximum values in the arcs). Thus, very strong sextupoles will be needed to cancel the natural chromaticity. The configuration chosen places an F(D) sextupole at each F(D) main quadrupole in the arcs where η is large. Sixty-four of each sextupole type will be needed. The strengths (B"L) at 150 GeV are 675 kG/m^2-m (D) and 325 kG/m^2-m (F). There is also a large sextupole component in the dipole magnet induced by saturation of the steel as the beam energy approaches 150 GeV. This effect produces "natural" chromaticities of -93 horizontally and +37 vertically at 150 GeV. The correction sextupole magnets must also be capable of compensating this effect. Based on a requirement that the sextupoles be capable of producing a corrected chromaticity of +10 in each plane the sextupoles are designed to have a maximum field strength of 900 kG/m^2-m. These magnets will be similar to the "Debuncher Sextupoles" built for the Tevatron I project, but with a reduced aperture (3.5" vs. 5.625") and increased length (26" vs. 8").

With the strong sextupoles required in this ring there may be some concern that the dynamic aperture of the machine might be adversely affected. Tracking studies completed to date indicate that there is no loss of dynamic aperture due to the sextupole correction system. However, we will still distribute eight individually powered sextupoles into one of the unused straight sections for control of third order resonant driving terms.

Skew Quadrupoles

At present the magnitude of the possible coupling in the MI is unknown. However, skew quadrupoles will be installed to cancel coupling. They will be recovered from the Main Ring.

2.6 Radio Frequency System (rf)

The 18 existing 53.1 MHz Main Ring rf cavities will be installed in straight section MI-70 and operated at harmonic number 588. The operating levels below transition are determined by an interplay between cycle time, bucket area, and synchrotron frequency. A bucket area of at least 0.5 eV-sec is required to accept beam out of the Booster. Historically, it has been necessary to keep the synchrotron frequency in the Main Ring below 720 Hz to avoid resonance with power supply ripple at the sixth harmonic of the line frequency. Figure 2-12 shows the rf voltage, bucket area, synchrotron frequency, and synchronous phase through the 120 GeV antiproton production cycle. A bucket area of 0.5 eV-sec is maintained with a synchrotron frequency always less than 720 Hz. The momentum spread in the beam, $\delta p/p$ (95% half width), is $\pm$0.2% at injection, increasing to about $\pm$1.4% near transition, and decreasing to $\pm$0.1% at extraction.

The rf system has the capability of generating enough voltage at injection to produce a 1.0 eV-sec bucket area at injection. In this mode the synchrotron frequency lies well above 720 Hz at injection and descends rapidly, crossing 720 Hz when the beam energy is about 15 GeV. Operational experience will dictate which scenario is used.

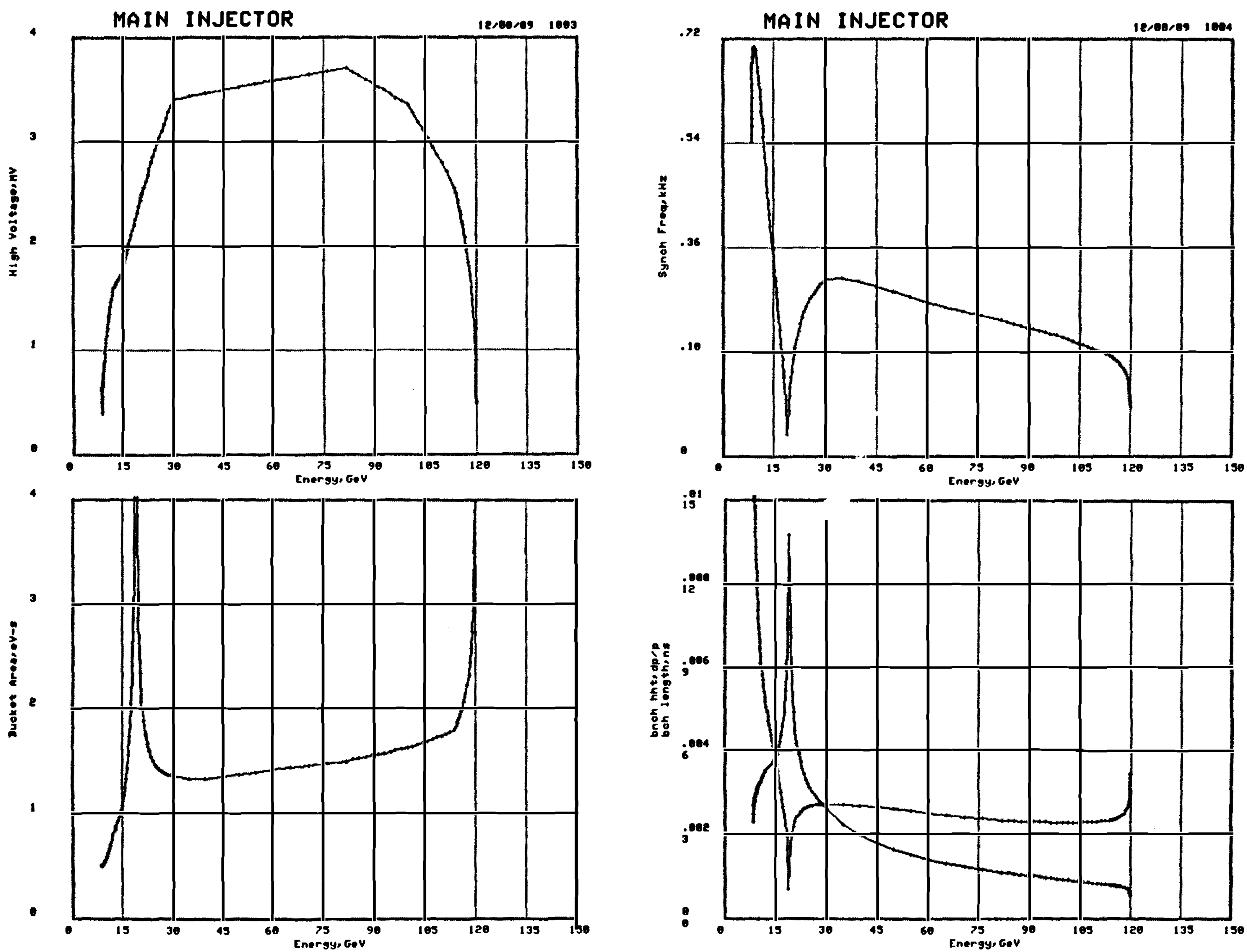

Figure 2-12: RF parameters for the 120 GeV $\bar{p}$ production cycle. Momentum spread and bunch length are for $\epsilon_L = 0.5$ eV-sec.

The Main Ring coalescing rf cavities (2.5 MHz and 5 MHz) will also be employed in the Main Injector for use during collider loading. The change in harmonic number, coupled with the change in γ_t, results in the coalescing cavity bucket height increasing by a factor of 1.5 relative to the Main Ring. This should improve the coalescing efficiency, enhancing the ability to make bunches of the desired intensity for delivery to the Tevatron Collider. Alternatively, if the need arose the voltage in these cavities could be reduced keeping the coalescing bucket height the same as currently used in the Main Ring.

2.7 Vacuum System

The vacuum system for the MI will be similar to the Main Ring system. Each dipole magnet chamber will have a port for a 30 liter/sec ion pump and straight sections will have a port approximately every six meters for the same type of pump. Care will be taken in the design of the vacuum chamber to limit the impedence presented to the beam. Ion pumps and their power supplies from the Main Ring will be reused. The stainless steel vacuum chambers will be chemically polished. Since two inch aperture magnets are used throughout the MI, the conductance will be higher, and an average pressure lower than the Main Ring should be achievable. The design goal is an average pressure of $<5 \times 10^{-8}$ Torr. With this pressure storage times of minutes at 8.9 GeV/c will be available for studies.

Gate valves will be used to divide the MI into sectors. There will be a gate valve at the end of each straight section with appropriate interlocks. There will be a total of 32 gate valves in the system.

The beamlines will use 30 liter/sec ion pumps of the same type as the MI, spaced approximately every 12 meters.

Vacuum pressure during pump down will be monitored by a combination of thermocouple and cold cathode gauges; high vacuum will be monitored by the current readout of each ion pump. Vacuum pump down will be done using portable turbomolecular units that can be wheeled to any area being worked on. Ten units are provided.

2.8 Instrumentation

Beam Position Detector (BPM)

The beam position system for the MI is patterned after the existing Main Ring system. At each F(D) main quadrupole there will be a horizontal (vertical) pickup. BPM's will also be located at the ends of the straight sections. New beam position detectors will be built for the MI. The processing electronics are the Fermilab standard amplitude-to-phase conversion style with a center frequency of 53 MHz. The system will be capable of producing first turn orbits, turn-by-turn readouts, and closed orbits.

Beam Loss Monitors (BLM)

The loss monitor system will utilize the recently constructed Main Ring ion chambers at each quadrupole in the ring and be of the same type as the present Tevatron system.

Other Special MI Diagnostics

The MI will employ a second harmonic dc current transducer. This will enable accurate acceleration efficiency measurements and will also be used for dc storage studies.

In order to analyze longitudinal and transverse instabilities, the MI will be equipped with a broad band longitudinal pickup and two broad band transverse pickups, one for each plane. These detectors should be very useful in studies of coupled bunch and head tail instabilities common to such high intensity rings.

The MI will also be equipped with three flying wires to allow dynamic emittance and momentum spread measurements during acceleration.

Dampers and Scrapers

The MI damper systems will be patterned after the Tevatron bunch-by-bunch system. The system will allow damping of injection oscillations and coherent instabilities, as well as providing the capability of knocking out selected bunches or heating the beam transversely in either plane.

The MI will have beam scrapers for measuring the acceptance of the machine in both planes and a momentum scraper to aid in beam transfer function measurements.

2.9 Controls

The entire accelerator complex, from the ion source to the Tevatron and antiproton rings, is controlled by a uniform system known as ACNET (shown in Figure 2-13). As shown each accelerator subsystem has a front end computer which drives a link attached to all appropriate hardware for that subsystem; all links constructed recently are CAMAC while some older systems utilize different technologies. Application programs and file storage, as well as a central database detailing all electronic components, are under control of VAX computers networked to the front ends. Also connected to this network are a number of operator consoles, attached in such a manner that any console can monitor and control any accelerator.

ACNET is currently being upgraded in a number of important aspects, with more modern hardware and software being added. However, the basic structure described is not being changed. A major upgrade is the reworking of Main Ring controls in CAMAC. Much of the MI hardware will be these CAMAC modules and associated equipment, moved to the new location. Also ongoing as part of the Main Ring upgrade is the installation of 24 channels of fiber optic cable as the conduit for various controls and timing links. Similar cable will be used for the MI, with a path from the Cross Gallery roughly along the 120 GeV beamline. This path is chosen so that beamline controls can be handled by these same links.

The MI fits naturally into the existing system. To the current complement of ten front ends will be added one for the MI; there exists

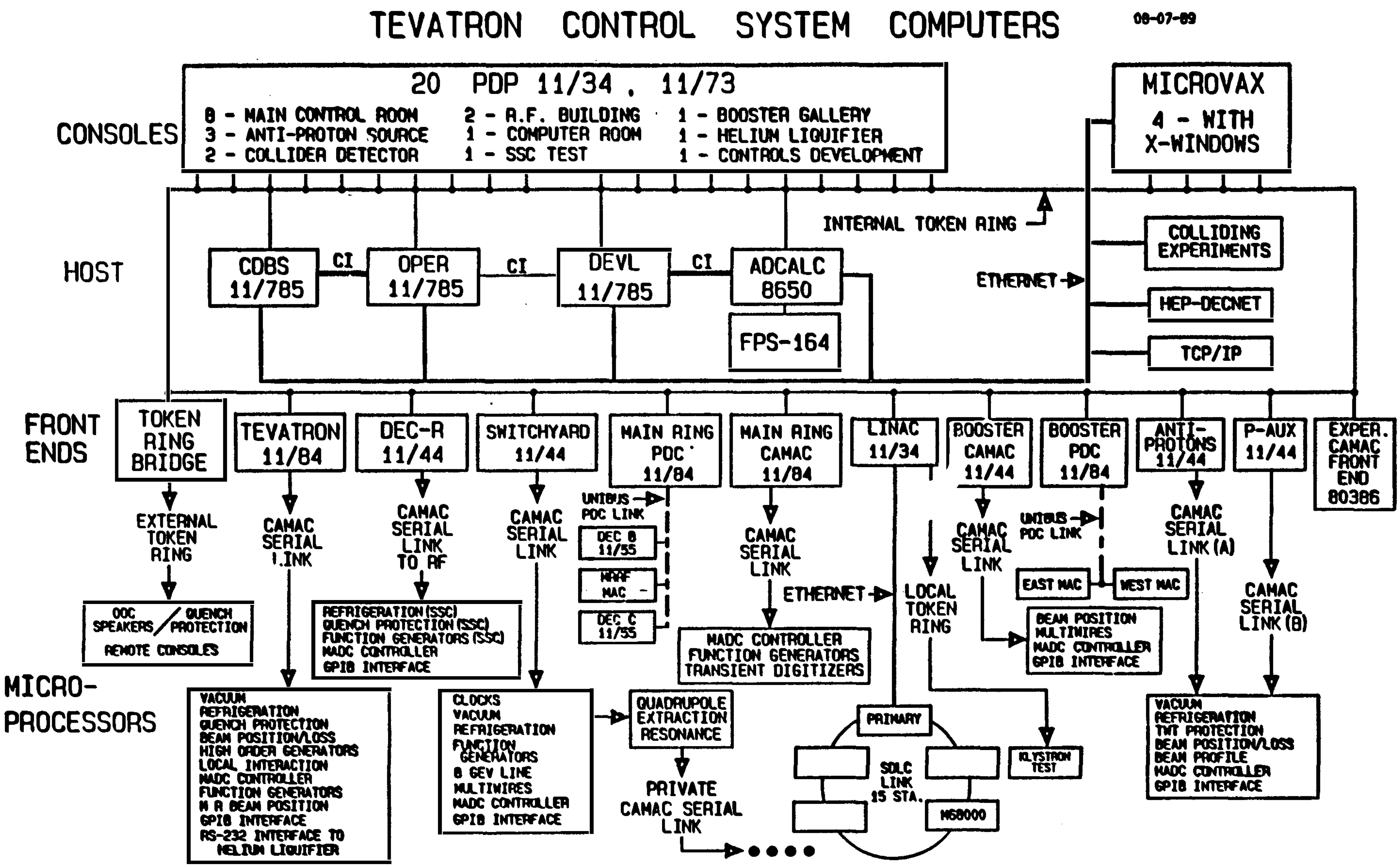

Figure 2-13: Schematic diagram of the Accelerator Controls Network (ACNET).

sufficient network bandwidth and VAX computer cycles that this addition can be made with minimal impact. (Remember the Main Ring will be disappearing.) A new front end is needed because the one installed for the Main Ring system cannot be easily moved since it has been convenient to attach some Tevatron devices to it. The new computer will drive a CAMAC link running to and around the MI; this link will connect to a number of crates and relay racks, and will have a number of cable terminations, scaled according to experience with the Main Ring. Twelve thousand feet of fiber and 84 repeaters are appropriate to provide this link, as well as to distribute timing signals and real-time accelerator data, and to extend the laboratory wide Token Ring network.

Since most of the new hardware connected to the control system will be copies of existing modules, the software effort necessary for support is expected to be manageable. Applications and front end code should be straightforward migrations of what is currently being created for the Main Ring. However, there are other computers associated with the current Main Ring beyond those normally associated with data collection. The ramp is generated by a pair of PDP-11's (DEC-B and DEC-C); with the variety of MI operational modes some software effort will be needed in transferring these machines to the MI.

The Main Ring high level rf is controlled by one of the few remaining Lockheed "MAC" computers in the Laboratory, along with its associated MIU (module interface unit). A new computer and hardware system, and associated software effort, will be required for this function.

2.10 Abort Systems

The proposed proton abort system for the new MI relies heavily on the technology and design utilized in the existing Main Ring abort system commissioned in 1983. This system has successfully provided clean single-turn abort capability for all subsequent Main Ring proton beam operation. The abort system for the new MI reuses much of the hardware of the present Main Ring system, with the exception of the beam dump.

The system will track the energy of the MI ring, and be capable of aborting the beam at any point in the 8.9 - 150 GeV/c range, within 50 μsec (5 turns) of the abort command. A 1.5 μsec abort kicker risetime matched to a corresponding minimum gap in the circulating beam allows abort efficiency approaching 100%.

Two 2.2 m long kicker magnets are located about 39 m upstream of the 25.7 m long straight section MI-40. The peak kicker field required is 1.9 kG with the 90° phase advance between the kicker location and two 4.9 m long Lambertson magnets at the upstream end of the long straight section. A horizontal displacement of the aborted beam of about 44 mm at the first Lambertson magnet positions the beam appropriately for the abort channel.

The two Lambertsons, with peak fields of 6.3 kG, then deflect the aborted beam vertically downward at an angle of 11.7 mr so as to clear the quadrupole at the downstream end of straight section MI-40 and exit the MI tunnel toward the abort beam dump.

The beam dump will be constructed with a graphite core of length 4.4 m, similar to the existing Main Ring beam dump. A small kicker building, MI-40, located on the berm directly above the kicker location enables the use of relatively short cables (<25 m) between pulsing units and kicker magnets. This is crucial for maintaining the kicker pulse shape.

Because of the low intensities transported, there is no $\bar{p}$ abort.

2.11 Slow Extraction

The slow extraction system has been designed to provide 120 GeV/c resonant extracted beam with a uniform spill over times of one second with losses of less than 1%. Slow spill of the entire beam is easily achieved with half-integer extraction. Extraction is implemented by using special quadrupoles and octopoles to bring the beam onto the half-integer resonance in such a manner that the amplitude of betatron oscillations will grow in a controlled fashion until the particles are deflected by an electrostatic septum. The kick supplied by the electrostatic septum provides enough space between the circulating beam and the extracted beam to allow magnetic septa to be used to extract the beam.

Septa

The choice of the location of the magnetic septa (Lambertson magnets) is dictated by the location of the extraction channel to the A0 area of the Tevatron. The Lambertsons will be placed in the upstream region of the MI-60 straight section in order to maximize the transverse separation between the extracted beam and the downstream (MI) quadrupoles. The expected separation of 31 cm, generated over a 19 m length by two standard 5 m Lambertsons running with a field of 9 kG, will be adequate to miss the first quadrupole.

The placement of the electrostatic septum is made easy by the fact that a location 90° in phase is available in the cell immediately upstream of the long straight. The slot length is adequate for a septum of length 3.6 m. It is desirable to have a separation of 6 mm at the magnetic septa between the circulating beam and the extracted beam. A 120 μr kick from the electrostatic septum will achieve this, and with the length available, the applied voltage gradient of 40 kV/cm will not be excessive.

Harmonic Elements

The appropriate harmonics for quadrupoles (45th) and octopole (0th) will be provided by special magnets designed for this purpose. Quadrupoles will be located at points equidistant in phase around the ring, while the special octopoles will be located in phase with the quadrupoles. Air core quadrupoles are sufficient to provide the necessary stop band width to ensure total extraction of the beam. Required strengths for the quadrupoles are 60 kG-in @ 1 inch, and for the octopoles 116 kG-in @1 inch.

Phase Space

Extraction starts by raising the normal horizontal tune from 22.42 towards 22.5, while turning on a 0th harmonic octopole. The octopole is used

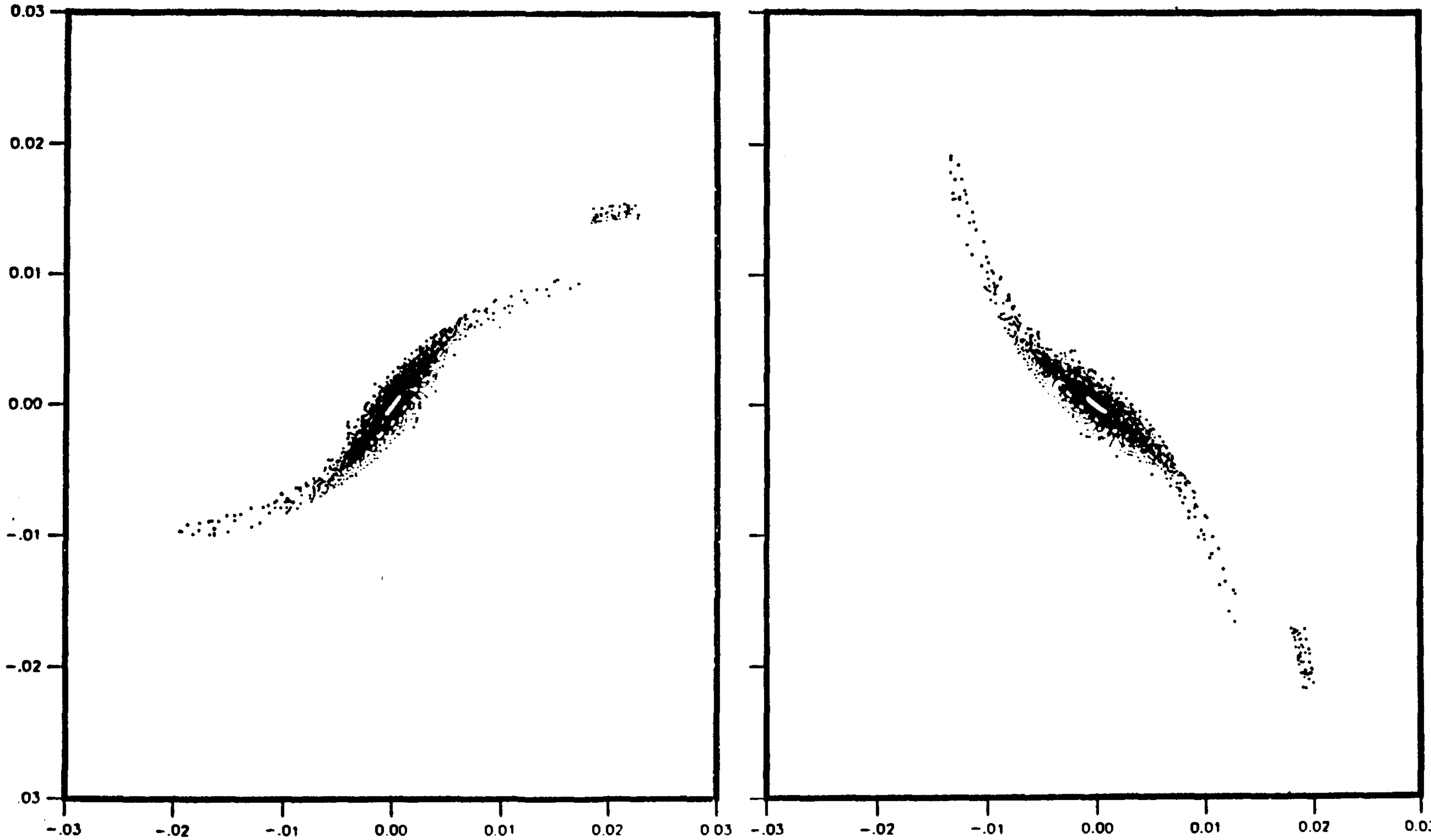

Figure 2-14: Phase space distributions at the electrostatic septum (left) and at the extraction Lambertson (right) during slow extraction.

to produce an amplitude dependent tune; thus a larger amplitude has a larger tune and is closer to the half-integer. Then a 45th harmonic quadrupole is used to increase the width of the half-integer stop band. Small ampltude (smaller tune) particles are stable while larger amplitude particles stream out along the separatrix until they encounter the electrostatic septum. Phase space distributions produced by these elements at the electrostatic septum and at the magnetic septa are shown in Figure 2-14. The rough angle of 45° exhibited by the beam is a compromise between high extraction efficiency (where the angle would be zero) and aperture considerations at the location of the magnetic septa. For the extracted phase space shown the emittance is 6π, with an extraction inefficiency of 1%.

Quadrupole Extraction Regulator System (QXR)

The goal of the slow extraction system is to provide a constant rate of extraction during the slow spill. This is accomplished by moving the stop band smoothly through the beam using the quadrupole extraction regulator system, QXR. There are two parts to this system, distinguished by strength and bandwidth. The stronger, lower bandwidth components are tied to a normal beam intensity monitor which is insensitive to fast fluctuations. After the signal is sampled during the spill and compared to an ideal signal, the resultant smoothed error signal is used to modify the power supply output. This system is the base from which the weaker, faster responding system works. Monitoring is based on a fast reacting detector in the extracted beamline itself. Power supply ripple up to 360 Hz can be compensated by this system.

2.12 Environmental and Shielding Considerations

The proposed construction of the MI lies in approximately 400 acres southwest of the existing Main Ring tunnel, between the FO building and the site boundary. Access to the construction project will be via the existing Kautz Road. Efforts will be made throughout the construction period to protect and enhance the local conditions. Details are discussed in Appendix C.

Calculations have been made of radiation dose near the tunnel when beam is lost on the magnets or dumped intentionally. The dose is estimated both on the surface of the earth berm covering the tunnel and at the site boundary at the point of closest approach (approximately 75 m) to the MI. A berm thickness of 17 ft, corresponding to that of the present Main Ring, is assumed, although near the site boundary an additional 3 feet will be added. The dose rate in the vicinity of the abort dump (Section 2.10) is also investigated and found to be lower than required.

The highest muon dose is only 0.3 mR and occurs about 70 m downstream of the loss point, where the berm meets grade level (assumed to be 10 ft above the center of the tunnel). The average exposure rate due to muons during routine operation at the surface of the berm is also small and amounts to approximately 12 mR/year. The dose at the site boundary is estimated at 0.3 mR for the worst case loss scenario and at 10 mR/year for routine operation. See Appendix C for details.

The most important component of radiation for shielding considerations is hadrons. Appendix C contains details of the assumptions made in calculating hadron dose and required shielding. For accidental loss the prediction is 3 mR at the surface of the berm, thus requiring this area to be defined as minimal occupancy. Further from the berm the dose falls off rapidly so that 60 feet from the berm the dose is below the minimal occupancy limit of 1 mR. A small amount of beam is lost continuously. This results in integrated levels of less than the 500 mR/year limit for permanent occupancy. By adding an extra 3 feet to the berm at the closest approach to the site boundary, the off-site dose is a factor of 5 below the required limit of 10 mR/year.

2.13 Component Alignment

The final goal of the alignment procedure is to minimize the closed orbit distortions. In practice this means precise transverse alignment of the quadrupoles and attention paid to dipole roll. After tunnel construction is complete there are two main steps towards the final alignment of the components: installation of properly generated monuments, and prealignement of the magnet stands.

Monuments

There will be two sets of monuments for placement of the components in space. One set will be used for vertical alignment and the other set will be used for both longitudinal (along the beam direction) and horizontal alignment. The MI elements will be placed in a Cartesian plane whose normal will be parallel to gravity in the center of the ring. In order to accomplish this there will be a set of vertical monuments of known elevation. The monuments will be located on the floor near the quadrupoles and their relative accuracy using direct leveling methods will be 0.003 inches. Component elevations will be calculated so that the components lie in a plane.[1] During prealigment of the stands and alignment of the elements the nearby monument will be used as a basis for elevation determination.

Setting the horizontal control points is not as straightforward as in the vertical case. Above ground the relative geometry between each octant will be determined using a combination of triangulation and trilateration incorporating the ME5000 Mekometer and the E2 theodolite. The relative position of these control points can be determined to ±0.080 inches. A check of this scheme will be made on several of the points by using a satellite ranging scheme.

These control points will be extrapolated into the tunnel and distributed to a series of monuments (brass plugs in the floor) using a trilateration scheme (linear measurements only) within the tunnel. These measurements will consist of a mixture of length measurements and offset measurements similar to the configuration incorporated in the LEP tunnel geometry.[2] The length will

1. C. D. Moore, "The Vertical Alignment of the D0 Overpass in the Fermilab Main Ring," (to be published).
2. M. Mayoud, "Applied Metrology for LEP," CERN 87-01, p. 233.

be measured with the Mekometer to an rms accuracy of ±0.010 inches. The offset measurements will be made using optical tooling procedures with an rms accuracy of ±0.005 inches. The original layout of the horizontal monuments will have an rms accuracy of ±0.008 inches, with an associated longitudinal rms accuracy of ±0.015 inch.

Pre-alignment of Stands

With the monuments installed it will be relatively easy to pre-align quickly the stands to an accuracy of ±0.080 inches using fixturing and methodology already developed. This accuracy has been achieved in the installation of the overpasses[3] and there should be no reason not to achieve a similar accuracy in an easier geometry.

Final Accuracy

It is expected that the total vertical error in reading a quadrupole position will be on the order of 0.006 inch, a combination of original error in the monument placement, rereading the monument position, and reading the scales on the quadrupole. It is apparent that the reproducibility of the fiducials on the magnet is crucial in determining the final accuracy. For the discussion in the next section an rms accuracy of ±0.010 inch in setting the quadrupole will be asssumed. This includes a reasonable tolerance for the surveyors to use in the actual setting.

Proper planning will allow setting the horizontal tunnel monuments near the theoretical bend centers along the orbit so that lines connecting these monuments will be parallel to the quadrupoles. Alignment of the fiducial point of the quadrupoles to this line can be done to an accuracy of ±0.005 inch. Hence an rms accuracy of 0.012 for the horizontal quadrupole positions should be attainable (again allowing a reasonable tolerance of 0.005 for the surveyors in setting the quadrupole).

Closed Orbit Considerations

From these estimates of the rms of the random quadrupole displacements the maximum closed orbit deviation can be estimated. There is approximately a factor of two in the maximum deviation between 50% and 98% probability. Results below are for the 98% case using a convenient parametrization:[4]

$$X = Y = 12.5 * f(v) * v^{1/2} * (\Delta Q)rms$$

where $v=22.4$ and $f(v) * v^{1/2} = 6.44$. Therefore

$$X = Y = 80.5 * (\Delta Q)rms.$$

3. C. D. Moore and T. A. Topolski, "Polar Coordinate Alignment of the Magnet Stands in the BO Overpass Region of the Fermilab Main Ring," Proc. 1987 Particle Accelerator Conf., Washington, DC, March 1987.

4. C. D. Moore et al., "SSC Closed Orbit Correction," Report of the 1983 Ann Arbor Workshop on Accelerator Physics Issues for the Superconducting Super Collider, p. 78.

This implies Y = 0.8" from the quadrupole deviations, i.e. there is a 98% probability that the maximum vertical deviation resulting from a 0.01" rms in the quadrupole error distribution, will be ≤0.8". (This also implies that there is a 50% probability that the maximum deviation will be 0.4".) The contribution to the closed orbit from the dipole roll should be less than this. A similar calculation for the maximum deviation for a given rms in the roll distribution gives:

$$Y = 950 \text{ inches} * \Delta\Phi$$

Hence, if $\Delta\Phi \sim 1$ mrad the two effects will be of the same magnitude, but in fact it will be easy to do better by a factor of four. There will be a 0.078 mrad systematic roll to account for the earth's curvature.

For the horizontal the (98%) maximum deviation is X = 1". In conclusion, there is a finite probability of having some circulating beam with no correction dipoles activated.

2.14 Utilities

Main Injector Low Conductivity Water System and Magnet Bus Connections

The proposed system for connecting the power and water to the MI is similar to the Main Ring. This system requires minimum maintenance. Stainless steel headers supply low conductivity water (LCW) to copper pipes which conduct both power and cooling water to the magnets. Ceramic feedthroughs, with flexible metal braid hoses, electrically insulate the piping from the copper bus system. All connections are either brazed or welded.

The MI components and associated utilities are grouped together at the outside wall of the tunnel leaving most of the enclosure space for servicing, as shown in Figure 2-15. All connections to the magnets are designed so they are accessible from the inner space of the tunnel. There will be six utility buildings uniformly spaced along the perimeter of the Main Injector. These are labelled MI-10, 13, 30, 50, 53, and 70. Each utility building will supply power and cooling water to about 1815 feet of circumference in the MI.

Four service building will have three pumps each, and the remaining two buildings will have four pumps all connected in parallel. Each pump has a 50 HP motor, and delivers 300 gpm of LCW with a pressure head of 162 psi (375 TDH). The heat from the magnets is transferred to the LCW and dissipated in a tube and shell heat exchanger placed above the pumps in each service building. Pond water is circulated in the tube side of the heat exchanger to remove the heat by evaporation.

From the existing LCW system in the Main Ring, 12 pumps with starters and controllers, and six heat exchangers will be reused for the MI. Seven existing spare pumps will also be used, and one new pump will be required. The remaining water cooling equipment in the Main Ring will remain as part of the Tevatron. New extra strong copper bus (2.875" o.d. by 1.771" i.d. for the dipoles, and 2.00" o.d. by 1.2" i.d. for the quadrupoles) will be used for the MI. The old copper bus from the Main Ring (1.625" o.d. by 0.187" wall) with the porcelain clamps will be reused for the beamlines.

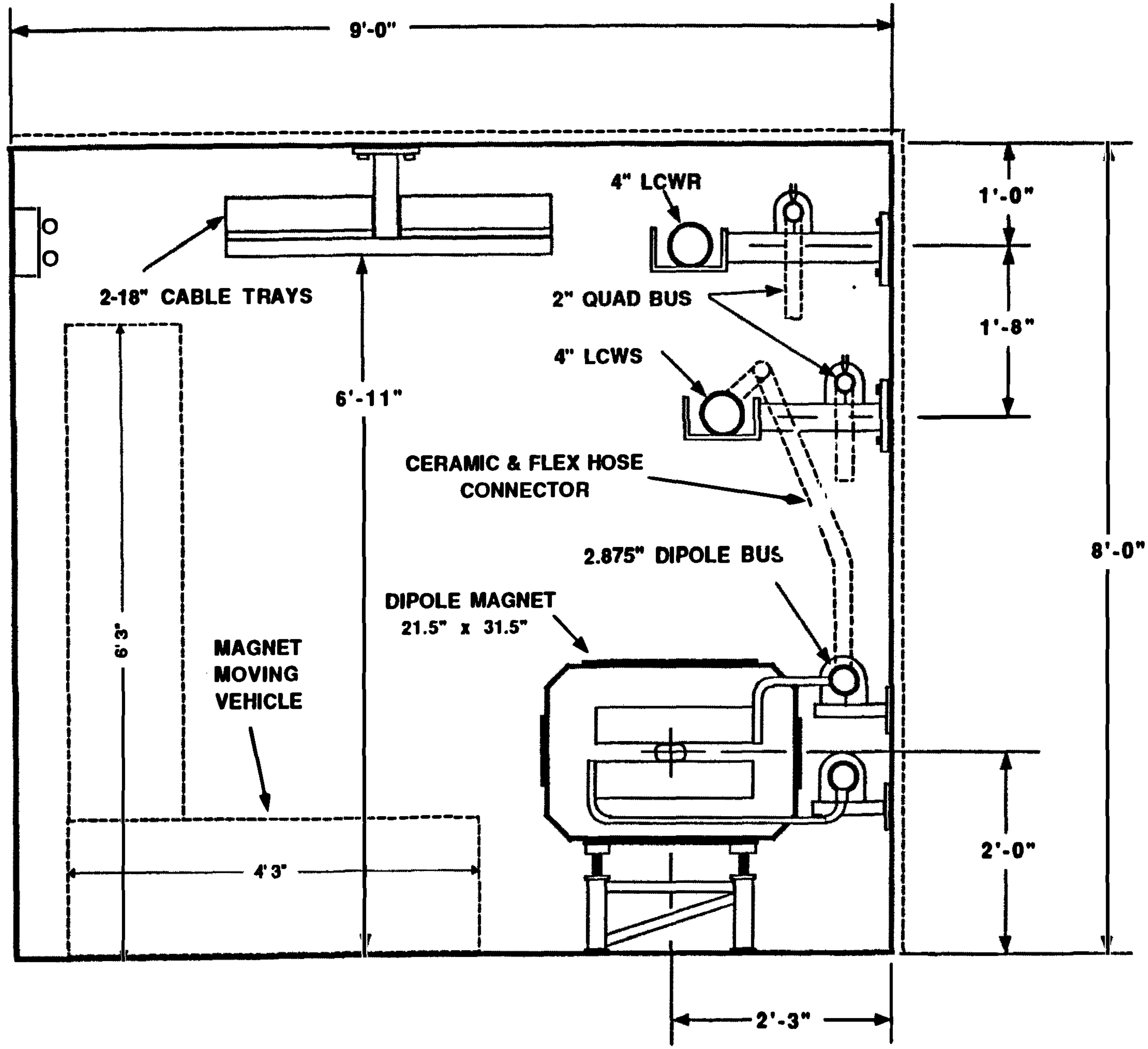

Figure 2-15: **Typical cross section of Main Injector Enclosure**

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Two 4 in. stainless steel pipe headers will be installed over the magnets along the 10,891 ft circumference of the MI. A total of 20 pumps (300 gpm each) will be connected in parallel across the supply and return pipes. All magnet and bus systems will also be connected in parallel across the LCW headers. Flow control devices, used in the Main Ring, will be altered and can be reused in the new injector to limit the water flowing to 8 gpm through the dipole magnets. For 120 GeV operation (4342 amps rms), the water temperature rise across the magnets is calculated to reach about 7°C. An average of 950 GPM of LCW from each of the six service buildings will be required to cool magnets, bus, power supplies, chokes, and electronics equipment. The heat load removing capacity per building is about 2 MW limited by the cooling pond.

At each utility entrance, the enclosure will have an enlarged cross section. The walls will extend one foot from the regular tunnel. The purpose of this extra space is to make room for expansion joints for the 4 in stainless steel pipes, copper bus, and trays. At this position the enlarged enclosure allows the utilities to cross over without obstructing the regular tunnel clearance for the magnet moving vehicle.

A net counterclockwise flow in the ring will be accomplished with restricting valves at each of the entrances. In one of the larger service buildings (MI-70), a LCW processing system will be installed. A continuous polishing flow action is required to keep low conductivity in the water. Two mixed bed de-ionizers will be used with about 80 gpm flow going through one of the beds. An average of 9 MΩ-cm resistivity of the LCW will be maintained in the ring. An expansion tank and a 3,000 gallons storage tank are also to be used. The MI will required an estimated 29,000 gallons of low conductivity water to fill the pipes, tanks, bus, and magnets.

Power Distribution for the MI

There are three separate power systems associated with the MI system: 1) power system for pulsed power supplies; 2) conventional power system; and 3) power system for beamlines. The power distribution system is shown schematically in Figure CDR-28 (Appendix E).

Power System for Pulsed Power Supplies

This system consists of the new 40 MVA transformer at the Kautz Road Substation and a new 13.8 kV distribution system to the MI. A 13.8 kV switchgear area, located within the Kautz Road Substation, allows sectionalizing of the system. From this switchgear, two direct buried loop feeders are used for the pulsed power to the ring.

At each service building, there is a disconnect switch to supply power to the power supplies. From the disconnect switch to the power supply transformers, the feeders are routed in a ductbank. A paralleling switch at the south side of the ring enables uneven loading of each segment without overloading the feeders. This switch can also be used for feeder isolation for maintenance purpose.

Each feeder consists of three 750 MCM aluminum 15 kV power cables, each 2000 feet long so that no splices are needed between service buildings. Feeder construction will be cross-linked polyethelene, concentric neutral with overall jacket.

An harmonic filter will be installed at the Kautz Road Subtation between the feeders to ground, to prevent possible component damage due to excessive harmonic distortion caused by the non-linear power supplies. The filter will be similar to the existing filter in the Main Ring pulsed power system.

Conventional Power System for the MI

This system will consist of one 15 kV feeder around the MI ring, with a 500 kVA transformer at each of the six service buildings. The conventional power will be used for building power, lights, pumps, etc. Power is derived from the existing 82B transformer relocated to the Kautz Road Substation and is delivered to the MI-70 switchgear area by backfeeding through the existing feeder 45. From this switchgear, the feeder will continue as a direct buried feeder to the six service buildings. At each service building there will be a disconnect switch with a ductbank connection to the 500 kVA conventional power transformer.

Power for Beamlines

Total rms power required for the beamlines is 1.5 MW. This requires one feeder and a total of four 500 kVA substations. This power is delivered via a feeder in the ductbank from the Kautz Road Substation to the switchgear area at the MI-70 Building. In the switchgear area there is a switch module supplying power to substations at F0 (three substations adjacent to the switchgear area) and the North Hatch Building. In addition, power is required for operation of the beamline elements located in the Main Ring tunnel between F1 and A0. This power is supplied from existing Main Ring feeders and power supplies.

3. BEAMLINES AND BEAM TRANSFERS

Five new beamlines with a combined length of about 1500 meters are required to integrate the Main Injector into the existing Fermilab accelerator complex:

1. A 730-meter beamline for transport of 8.9 GeV/c protons from the Booster to the MI.

2. A 210-meter Tevatron injection beamline for clockwise injection of 150 GeV protons from the MI into the Tevatron.

3. A 210-meter beamline for counterclockwise injection of 150 GeV antiprotons from the MI into the Tevatron.

To link the new Main Injector complex to the Antiproton Source and Switchyard, the existing magnets and power supplies in F sector (from F0 to A0) of the Main Ring and of AP1 will remain in place. Two additional sections of beamline are required to integrate these sections of magnets into the MI complex:

4. A 210 meter section of magnets to provide beam transport between the Main Injector and Main Ring station F11. This section of beamline lies directly above the 150 GeV Tevatron injection beamline for protons (2 above) and transports 120 GeV protons from the MI for antiproton production, 8 GeV antiprotons from the Antiproton Source to the Main Injector, and slow extracted 120 GeV protons from the MI for delivery to the Switchyard.

The 120 GeV protons used for antiproton production will be transferred from F17 into the existing AP1 beamline using the present Lambertson system. The 120 GeV protons used for the "test beam" are transported through the entire F sector to A0 where the fifth beam line is to be installed:

5. A 130 meter section which connects F49 to the upstream end of Switchyard.

The site coordinates of all beamline elements have been determined and the beamline layout is shown in Figure CDR-10 (Appendix E). Optical designs currently exist for the 8.9 GeV/c Booster to Main Injector line and the two 150 GeV/c Main Injector to Tevatron beamlines. Optical designs of the other lines are in progress. Longitudinal beamline sections showing the disposition of the elements with the beam transfer lines are shown in Figures CDR-13 to CDR-18.

3.1 The 8 GeV Line

The 8 GeV line is composed of three major sections: a matching section from the Booster into the beamline, a section of three major achromatic bends incorporated in a periodic FODO lattice, and a final matching section into the MI. The primary geometrical constraints in the design of the 8 GeV transfer line are minimizing the total beamline length and minimizing the impact on existing roads and structures.

Protons are extracted from the Booster at straight section L3 at an elevation of 728'. A horizontal bending magnet is used to select beam for the existing AP4 line to the Debuncher, the new 8 Gev line to the Main Injector, or the AP4 beam dump. Figure 3-1 shows the organization of the upstream end of this extraction line. Energizing HB1A to about 15 KG selects the 8 Gev line, bypassing the dump steel, on a trajectory parallel to the AP4 line to the end of the current AP4 enclosure. Energizing the magnet to about 3.3 KG will send beam down the AP4 line into the Antiproton Debuncher ring. The beam dump is selected when the magnet is deenergized. A second (achromatic) horizontal bend is used to deflect the protons approximately 24° to the east starting the trajectory around the existing Antiproton Source complex. The protons enter a 500 meter FODO lattice in which the third and fourth achromatic bend centers of 30.3° and 56.4°, are seperated by a 100 meter periodic focussing section. The beamline crosses 54" below the existing AP2/AP3 beamlines roughly 430 meters downstream of the Booster extraction septum, still at an elevation of 728 ft. After crossing this enclosure, the beam enters a 160 meter section of periodic focussing where the beamline elevation is reduced to 723'10", the required elevation prior to injection in the MI. The fifth bend center of 38.1° places the protons on the proper horizontal trajectory and matches the horizontal dispersion to the MI. A final 33 mr vertical bend places the protons on the proper trajectory for injection.

The lattice functions for the 8 Gev line are shown in Figure 3-2. The horizontal (vertical) beta and dispersion functions are shown by the solid (dashed) curves. A maximum beta of 50 meters was chosen for the FODO lattice (made up of 90 degree cells) to keep the beam size to approximately $\pm$18 mm for a 95% normalized transverse emittance of 40π mm-mr and a $\Delta p/p$ of $\pm$.002. Figure 3-3 shows the 6 sigma beam envelopes as well as the physical apertures of the bending magnets and the beam pipe.

MI Injection

Injection of 8.9 GeV/c protons is accomplished in the MI straight section, MI-10. A plan and elevation view of the injection straight section are shown in Figure 3-4. The straight section is approximately 25 meters long and has to accomodate only the vertical injection Lambertson. This Lambertson is located about 7.2 meters downstream of the center of the straight section to allow clearance between the injected beam line and the upstream MI magnets. The beam trajectory at the entrance of the Lambertson is 37.7 mm above center with a downward 33 mr vertical angle and 60 mm outside and parallel to the the MI centerline. The Lambertson removes the 33 mr vertical angle to bring the beam onto the vertical closed orbit of the MI.

Four horizontal kicker magnet modules located 90° downstream of the Lambertson removes the 60 mm horizontal offset present at the Lambertson. The kickers provide a 1.5 mr bend to place the injected protons onto the horizontal closed orbit of the MI.

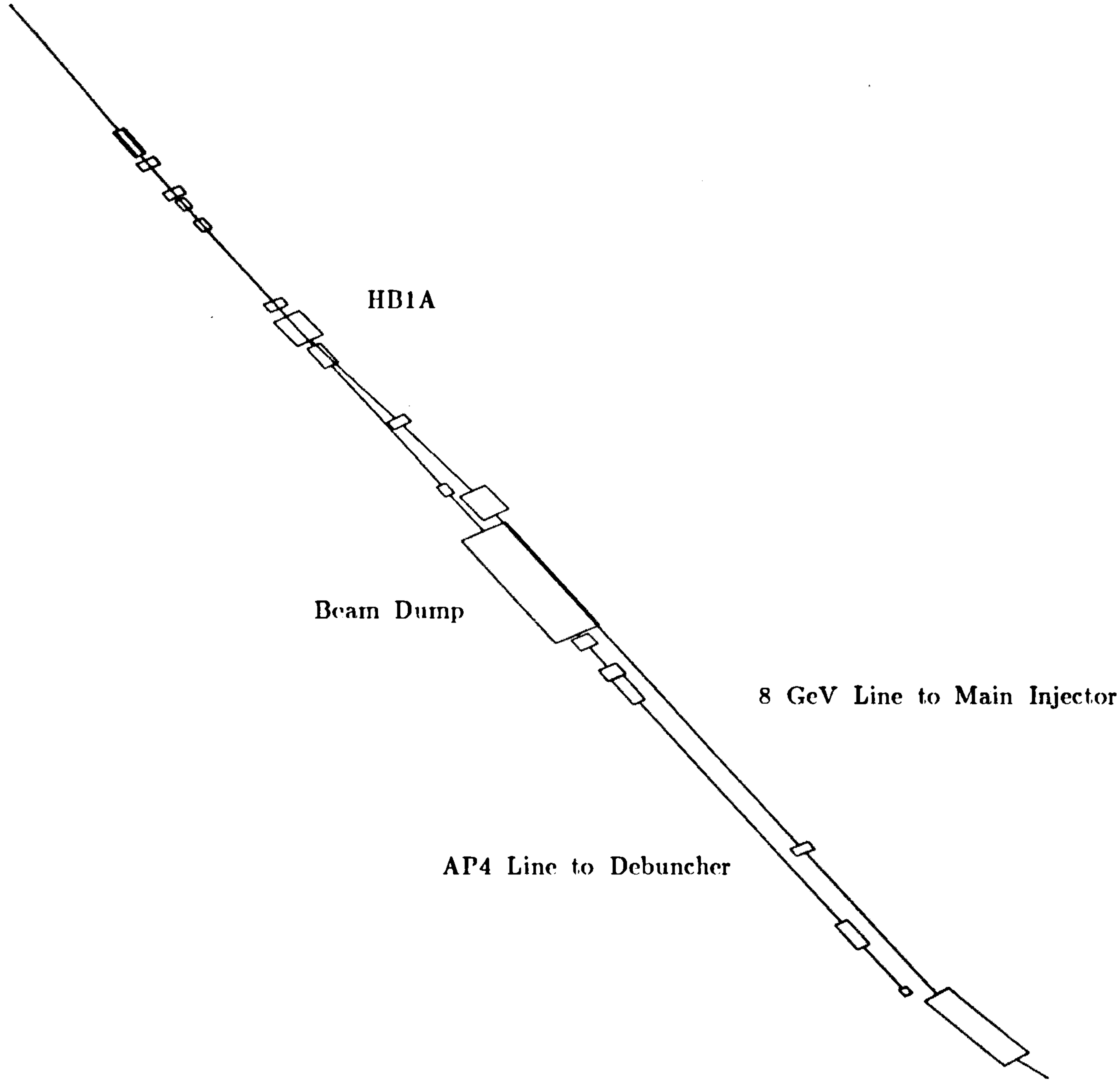


Figure 3-1: Upstream end of the 8 GeV line showing extraction from the Booster and the switching magnet (HB1A) which can direct beam to the MI, to the Antiproton Debuncher, or to the Booster dump.

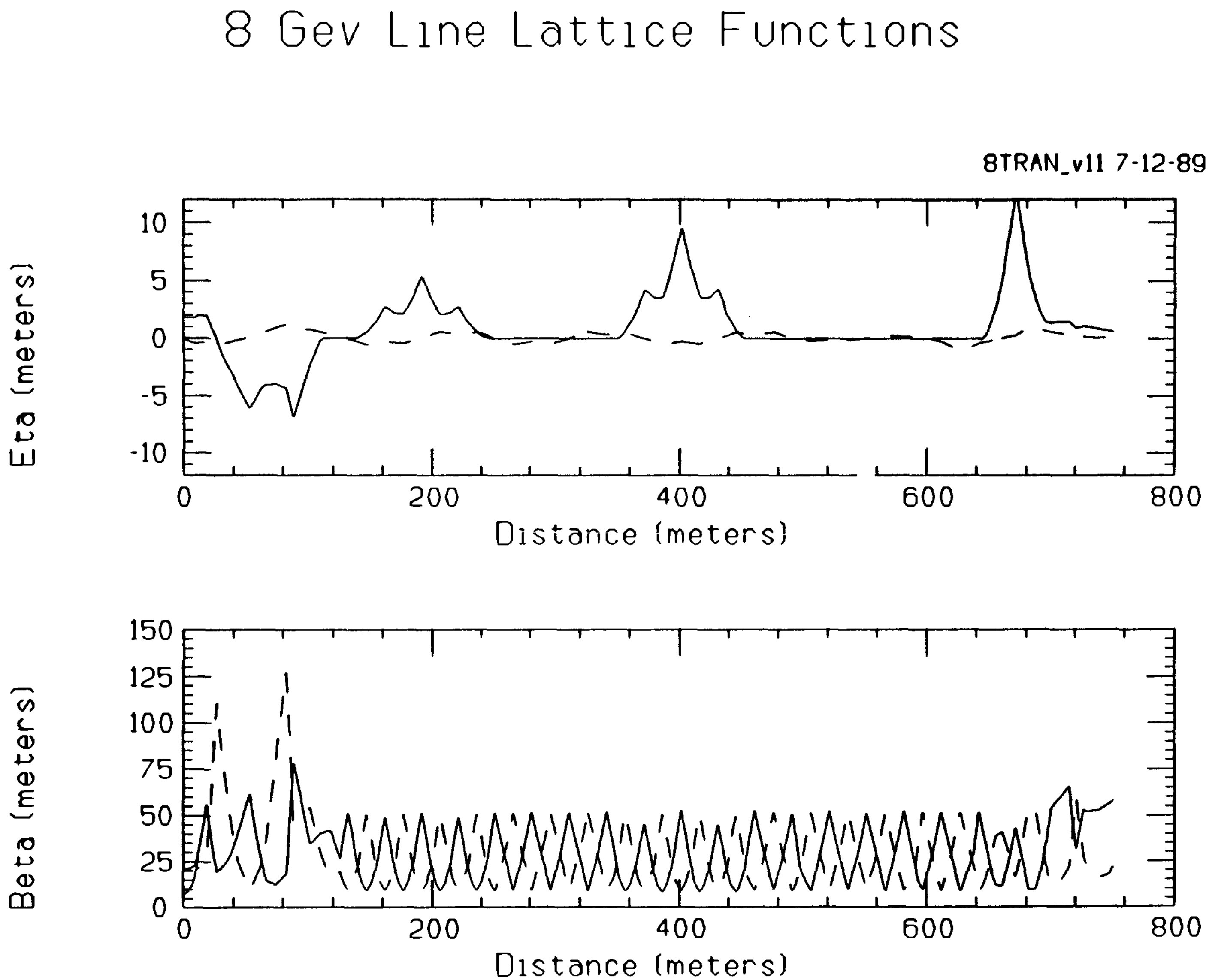


Figure 3-2: Horizontal (solid) and vertical (dashed) lattice function for the 8 GeV line.

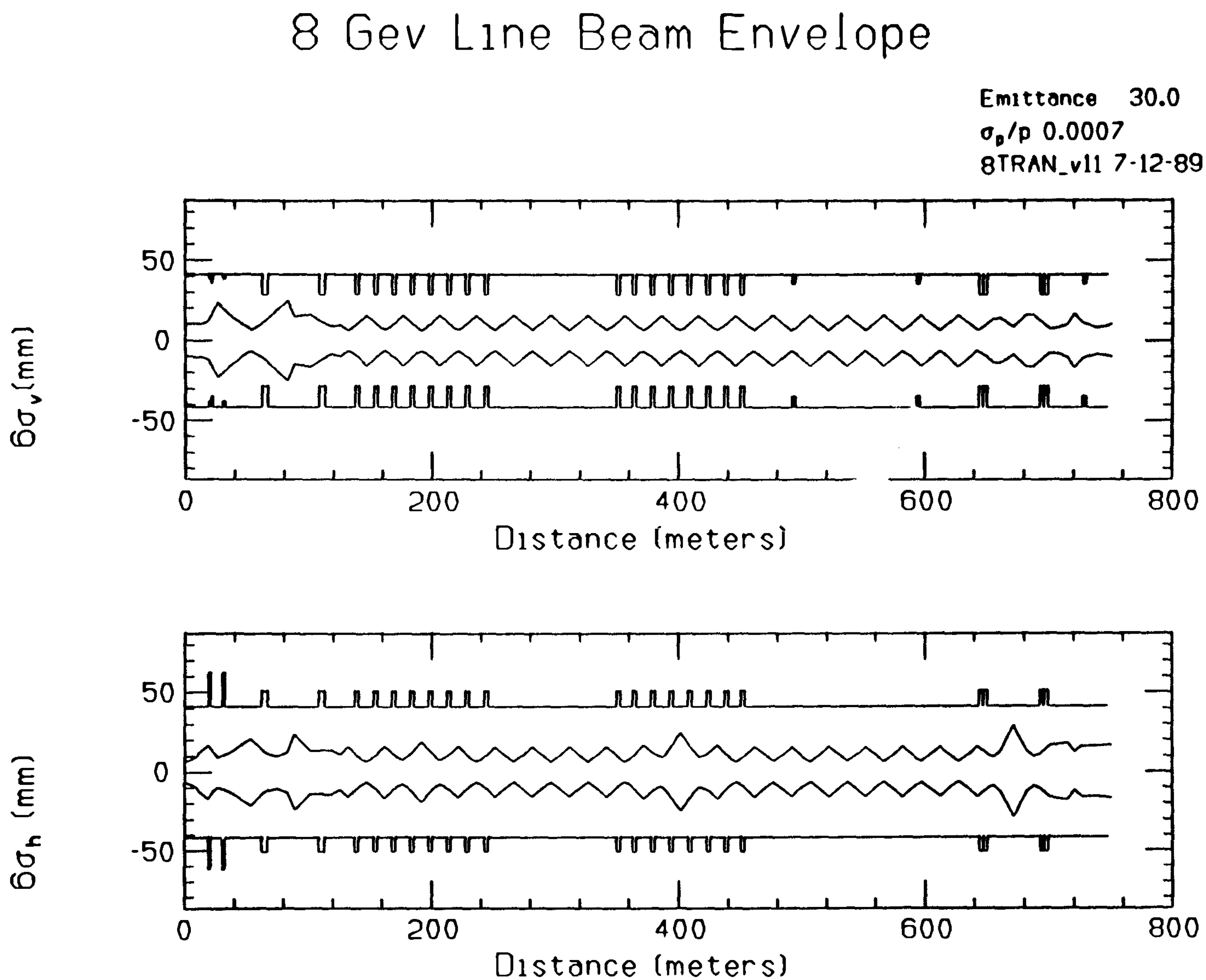


Figure 3-3: Six sigma beam envelopes for the 8 GeV line.

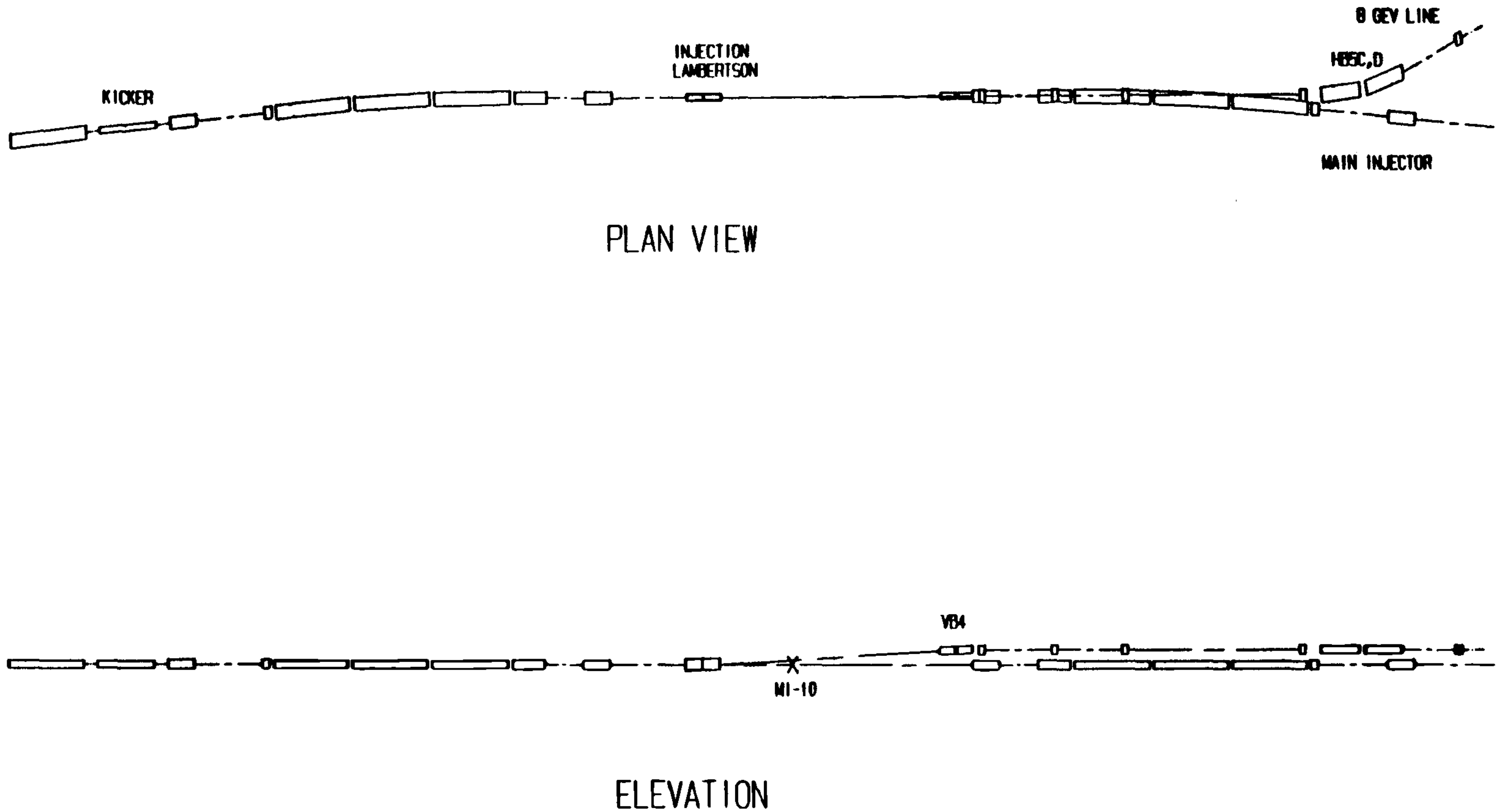


Figure 3-4: Plan and elevation views of the 8 GeV MI injection region.

No other magnetic elements are required for the injection of 8.9 GeV/c protons. The injection of 8.9 GeV/c antiprotons from the Accumulator takes place in straight section MI-60 which is also used for extraction as discussed in Section 3.3. The antiproton injection process uses the same vertical Lambertson and horizontal kicker as is used for proton extraction.

Proton Injection Magnets and Power Supplies

The Lambertson magnet and power supply currently being used for 8.9 GeV/c proton injection into the Main Ring will be used without any major modifications. The injection kicker magnets will be constructed following the existing Booster extraction kicker technology. The magnets will have a 2.5"x 2.5" aperture to allow room for a 2.25" (i.d.) ceramic beam tube. The four kicker magnets are each capable of a 0.5 mr kick. The existing injection kicker power supply will be used with minor modifications.

3.2 The 150 GeV Lines

Two beamlines connect the Main Injector to the Tevatron. One of these simply provides transport of the 150 GeV antiprotons. The other, in addition to delivering 150 GeV protons to the Tevatron, must share an extraction system in the MI with the beamline delivering protons for targetting or to the Switchyard. These additional functions are described in the following sections; here are described only the two optically identical beamlines which transport particles from the MI to the Tevatron.

The elevation of the MI is exactly 22.5" below the Tevatron. Protons (antiprotons) are extracted by kicker magnets which deflect the beam across a vertically bending Lambertson septum located in the MI-60 (MI-80) straight section. The Lambertson magnet deflects the beam upward by 10.4 mr and is followed by a vertical pitching magnet 55 meters downstream which levels the beam off at Tevatron beam elevation. When reversed this pitching magnet allows protons to continue upwards into the 120 GeV line. The total beamline length is 212 meters. Each of the lines includes eight recycled Main Ring B2 dipoles, a newly constructed half-length B3 magnet, and thirteen quadrupole magnets.

The lattice functions for the 150 GeV proton (antiproton) Tevatron injection lines are shown in Figure 3-5. The horizontal (vertical) beta and dispersion functions are shown by the solid (dashed) lines. The current optical solution has all lattice functions well matched except the vertical dispersion generated by the vertically bending dipoles in the line. The vertical dispersion mismatch is reduced by increasing the vertical beta function in the MI extraction straight MI-60 (MI-80) from 35 meters to 110 meters using special quad circuits in the MI.

The emittance growth due to the vertical mismatch can be written as:

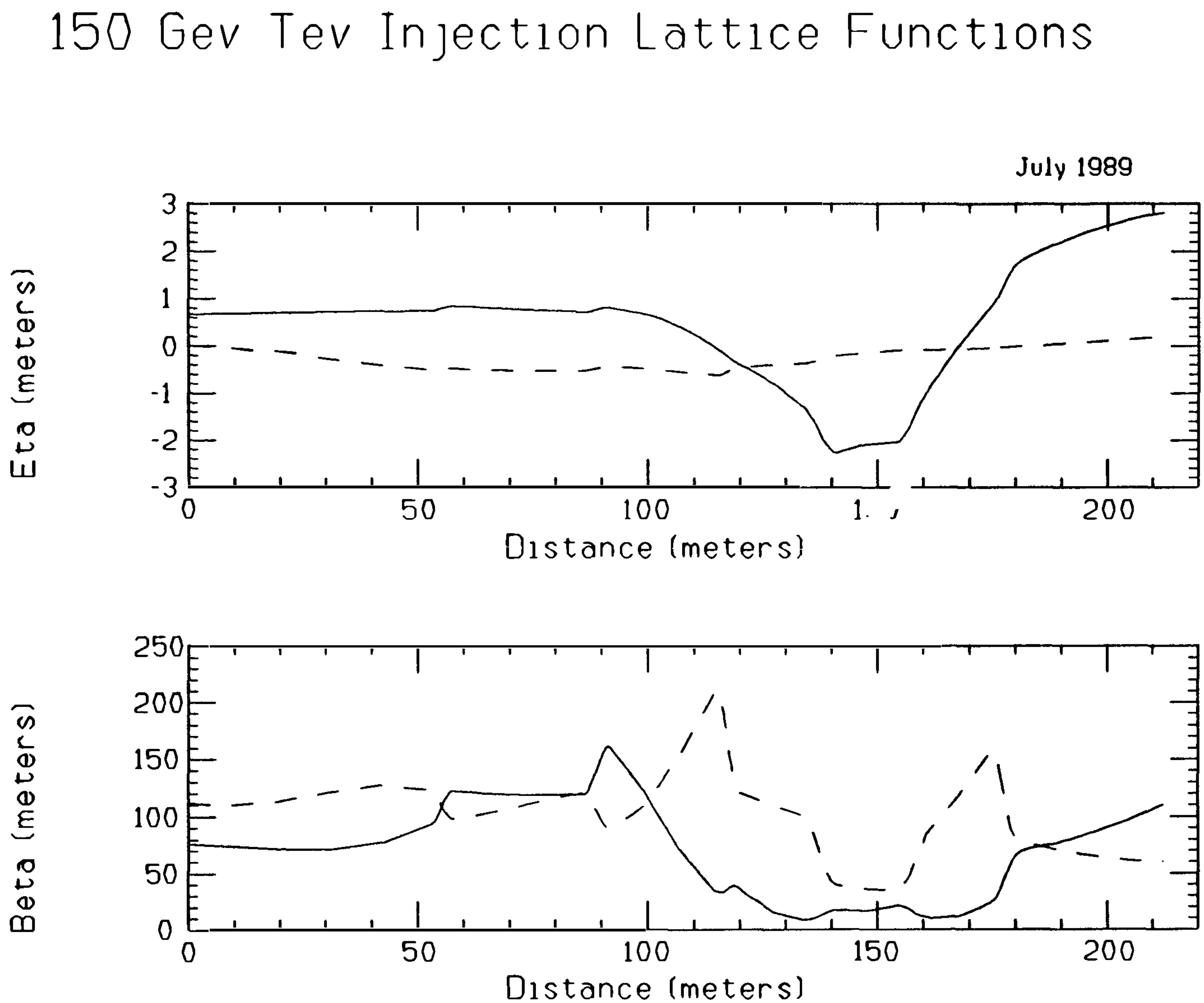


Figure 3-5: Horizontal (solid) and vertical (dashed) lattice functions for the MI-to-Tevatron beamline.

$$\frac{\Delta\epsilon}{\pi} = 3\ (\beta\gamma)\ \frac{\Delta D_{eq}^2}{\beta_0} \left(\frac{\sigma_p}{p}\right)^2$$

where

$$\Delta\ D_{eq} = \sqrt{\Delta D^2 + (\beta_0 \Delta D' + \alpha_0 \Delta D)^2}$$

and is calculated at the exit of the last vertical bending magnet. For the current design, the emittance growth for the coalesced beam injected into the Tevatron at 150 GeV/c (assuming a full momentum spread of ±0.2% and a rms distribution of 0.1%) is approximately 1π mm-mr.

MI Extraction

Extraction takes place at the two long straight sections near Tevatron straight section F0: MI-60 (proton extraction) and MI-80 (antiproton extraction). Figure 3-6 shows a plan and elevation view of long straight MI-60 and the first part of the extraction lines.

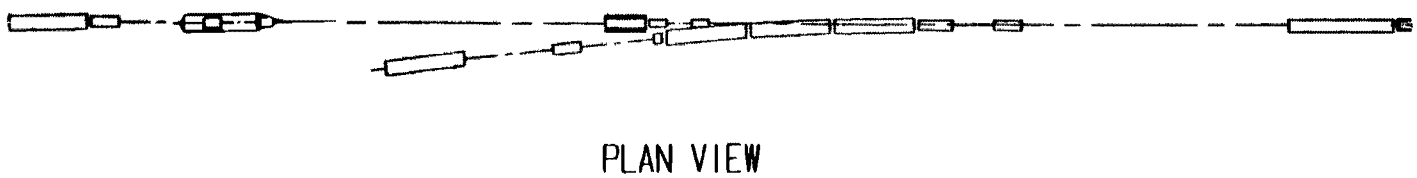
Transfer into the Tevatron is initiated by a kicker (or electrostatic septum in the case of slow extracted protons) located 90° upstream of the Lambertson septum magnet. The kicker displaces the beam horizontally across the Lambertson septum located at the upstream end of the long straight. The Lambertson magnet deflects the extracted beam upward by 10.4 mr for both the 150 GeV/c Tevatron injection lines and for the 120/c GeV extraction lines. The 10.4 mr angle is the minimum required for just clearing the top of the MI quadrupole at the end of the long straight section.

The requirements on the proton extraction Lambertson aperture are dictated not by the 150 Gev/c extraction, but by its use as the injection Lambertson for 8.9 Gev/c antiprotons. Thus a Lambertson magnet of the "F17 style" design will is used at MI-60. This is the magnet currently used for injection of 8.9 GeV/c antiprotons into the Main Ring. The aperture is sufficient for the acceptance of 24π mm-mr antiproton beams from the Antiproton Source. Two magnets each with a central field of 6.6 KG and a length of about 4 meters will produce the required 10.4 mr deflection at 150 Gev/c.

Tevatron Injection

Injection into the Tevatron is moved from its present location in the E0 straight section to the F0 straight section. This move leaves the E0 straight section completely free for possible use as an interaction region.

The F0 region is presently, and will continue to be, used to accomodate the Tevatron rf systems. By rearranging the accelerating cavities in the upstream end (proton beam direction) of the straight section, the proton and antiproton injection lines can converge toward a common set of injection septum magnets located at the downstream end of the straight section. This reduces the number of such elements needed in the Tevatron. In the present Tevatron, the accelerating cavities are arranged in a manner such as to ensure proper phasing between the proton and antiproton systems and to minimize the effects of cavity trips. Thus, a new layout of the cavities is necessary and its consequences must be investigated.



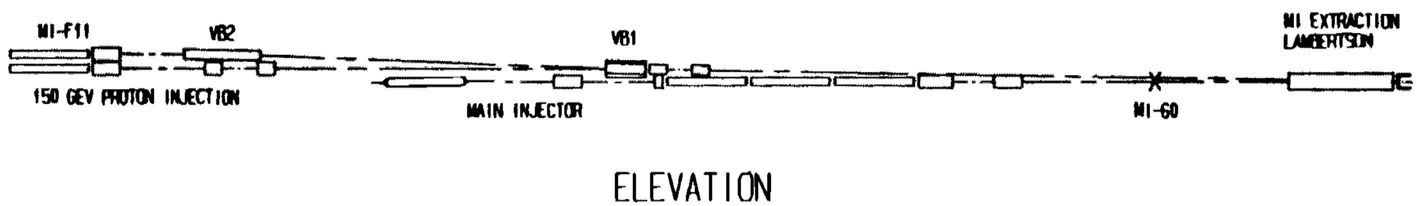


Figure 3-6: Plan and elevation views of MI-60 showing the upstream ends of the 150 GeV MI-to-Tevatron and MI-to-F11 (Antiproton production and slow spill) lines.

The most appropriate injection scheme into the Tevatron is one in which the incoming beam approaches the accelerator horizontally, the last horizontal bend being produced by a magnetic septum magnet, and closure onto the vertical orbit being produced by a kicker magnet downstream of the injection point. The nearest points on either side of the long straight section where kickers may be placed are the F17 medium straight section (for clockwise proton injection) and the E48 short straight section (for counterclockwise antiproton injection). Both of these locations have larger horizontal β functions, favoring horizontal kickers, but presently available kicker strengths are sufficient for vertical kicks.

Since the short straight section E48 is very close to the F0 region, the logical location of the injection point is at the downstream end of the straight section. This generates the largest amount of betatron phase advance between the injection magnetic septa and the kickers for the counterclockwise injected beam. The phase advance between this injection point and the F17 medium straight for the proton beam is also favorable.

<u>RF System Layout</u>

To maximize the amount of free space available for injection, the rf cavities are concentrated in the upstream end of the long straight section. To allow for independent voltage control for the proton and antiproton beams, pairs of cavities need to be separated by an odd number of quarter rf wavelengths. Each cavity is one half wavelength long, so that the entire system of eight cavities requires 4.25 wavelengths, as depicted in Figure 3-7. In this figure, the pairs of cavities P1-P3 and P2-P4 are used for proton acceleration, while A1-A3 and A2-A4 are used for antiproton acceleration. The center of cavity A4 is one half wavelength from the proton-antiproton collision point.

The cavity phasing is shown in Figure 3-8. Here, the circled arrows indicate the direction of the cavity field when the synchronous particle is present. The upper portion of the figure illustrates a synchronous proton moving left to right, while the lower portion of the figure illustrates a synchronous antiproton moving right to left.

The effect of a tripped station can be seen by studying this figure. If one of cavities P1, A1, P2, or A2 were to trip off, both proton and antiproton beams would see a reduction of rf voltage by 25%. When one of the cavities P3, A3, P4, or A4 trips off, one beam sees a decrease of 25% while the other beam will see an increase of 25%. Changes of this magnitude in the rf voltage alter the bucket area by roughly 10%. In each of the above cases, no rf phase offsets are induced by a tripped station.

<u>Injection System Layout</u>

The rf system described above occupies roughly 26 m of the 52 m straight section. In the remaining 26 m, two Lambertson magnetic septa are placed symmetrically about a point 13 m upstream (proton direction) of the end of the straight section. These Lambertsons are two of four used in the present Tevatron injection system at E0. Both the proton and antiproton beams pass

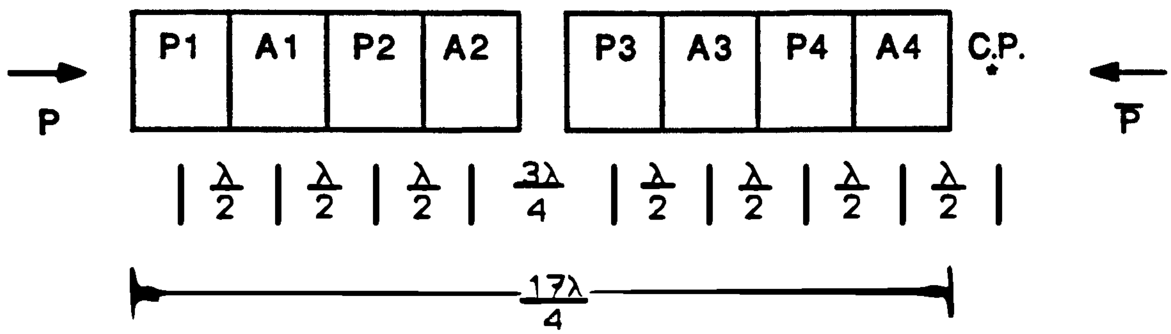


Figure 3-7: RF cavity arrangement in the Tevatron.

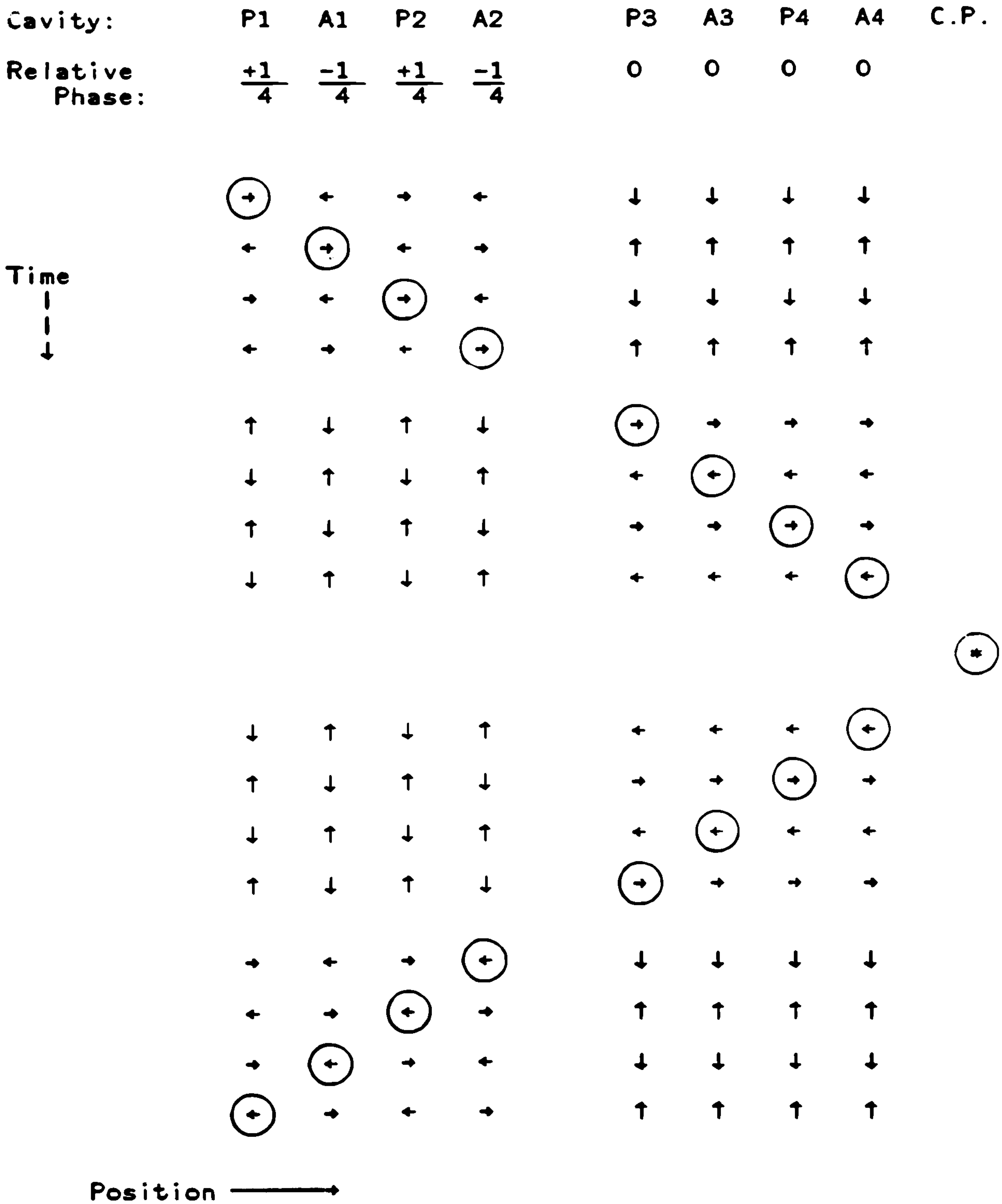


Figure 3-8: RF cavity phasing for independent proton and antiproton control in the Tevatron.

through the field region of these magnets upon injection. To provide more clearance at the ends of the free space, each of the injection lines incorporates one ''C'' style magnet just in front of the Lambertsons. As stated earlier, the vertical injection kicker magnets will be located at the E48 and F17 straight sections. These magnets will be moved into E48 and F17 from their present Tevatron locations. A plan view of the F0 region is shown in Figure 3-9.

3.3 120 GeV Antiproton Production

The existing AP-1 beamline, which is used to target 120 GeV protons for antiproton production and transport 8.9 GeV/c antiprotons back into the Main Ring, will remain intact. The Main Ring magnets from F11 to F17 will also be used in their present locations, with only minor modifications to the bus and power supplies. A new section of beamline, from the Main Injector to the old Main Ring F11 station (MI-F11 beamline), will be required to complete the beamline for antiproton production. This new section of beamline will transport 120 GeV protons to the antiproton target, transport 8.9 GeV/c antiprotons into the MI, and will also be used in the transport of 120 GeV slow extracted beams. Delivery of protons to the Switchyard is discussed in Section 3.4.

The MI-F11 beamline

This beamline lies directly above the 150 GeV proton transfer line for the majority of its length (see Figure 3-6). Since the MI-F11 and 150 Gev/c beamlines share the same extraction channel, a vertical bend is required to produce the required separation. The location and strength of this bend is driven by the elevation difference between the MI (721'6"), Tev (723'4.5"), and MR-F11 (725'6",) and the requirement of a matched vertical dispersion function in both beamlines.

Currently the second vertical bend used for the Tevatron injection is approximtely 55 meters downstream of the extraction Lambertson. If the polarity of this magnet is reversed the beam will enter the MI-F11 beamline. The second vertical bend for the MI-F11 beamline has to be suffiently far downstream (about 23 meters) to allow a minimum separation of approximately 2' for magnet installation in this region, and bring the elevation to the required 725'6" for transfer into MR F11. A single magnet string of eight Main Ring B2 magnets supplies the required 10.8 degree horizontal bend to match into F11. Newly constructed half length B3 magnets are used for the vertical bends. In addition nine quadrupole magnets are required.

Modifications to Main Ring F11 to F17 magnet string

This section of magnets will be used in their current location. Only minor modifications to the magnet bus will be required to power the dipole and quadrupole circuits. A Main Ring power supply located at F1 will be used to power the bending magnets in this section. The two quadrupole busses will be powered by new individual supplies.

Connection with the Existing AP-1 Beamline

Currently, a kicker at E17 is used to supply the required orbit

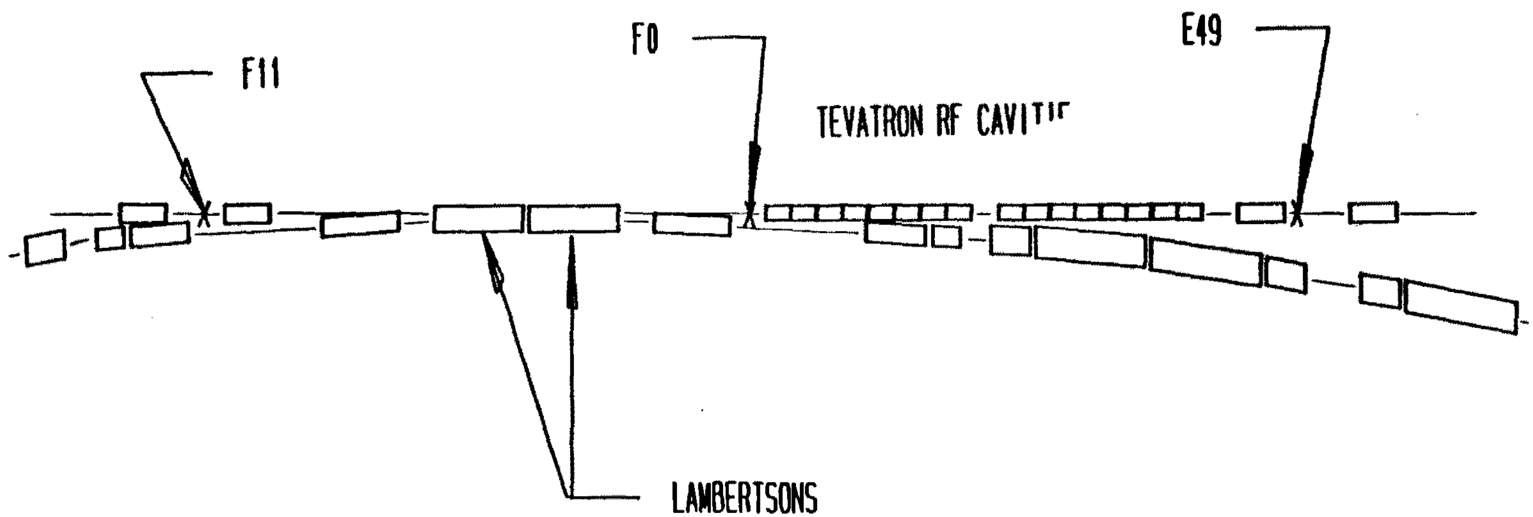


Figure 3-9: Plan view of the F0 region in the Tevatron with the 150 GeV proton and antiproton injection lines shown.

distortion necessary to place the beam in the field region of a Lambertson magnet at F17. A bump magnet at F14 will perform this function for beams from the MI. The Lambertson then bends the beam up to miss the first downstream MR dipoloe and enter the AP-1 line. The match between the MR F17 and the AP-1 line will not be altered.

3.4 The 120 GeV Slow Spill Line

The 120 GeV Slow Spill Beamline is used to transport slow and fast extracted beam from the MI to the experimental areas for a variety of purposes during collider and/or fixed target runs. This beamline uses four beamline sections: 1) MI-F11, 2) F11-F17 magnet string, 3) F18-A0 magnet string, and 4) the new section of beamline between F49 and Switchyard.

Modifications to F18-A0 Magnet String.

The magnet string will remain in its current location. Two additional bending magnets will be added to the MR bus on either side of the 7' quadrupole at F49 to move the beamline trajectory for matching into Switchyard. Minor bus work will be needed to connect the four power supplies required to ramp the bending magnets in this section. The MR power supplies at F3 and F4 will be used to power the two quad busses.

F49 to Switchyard

Approximately 130 meters of new beam transport are required to join F49 to the existing upstream end of the Switchyard without interfering with fixed target operation from the Tevatron. In addition to the two MR B2 magnets added in series with F18-A0 string, a second horizontal bend center (or 2 B2 magnets) is required for the proper horizontal trajectory. Two vertical bends located at the Switchyard interface and 40 meters upstream provide the necessary vertical trajectory for entrance into the Switchyard.

Connections to the Switchyard

Linking of the slow spill beamline to the existing Tevatron Switchyard is established in a straightforward manner with only minimal changes required at the Switchyard interface. Space for the final slow spill beamline element, a 20 ft vertical bend, is established in the Switchyard channel by shifting the proton area electrostatic septa splitting station PSEP downstream by 12.6 ft, the length of one septum module. The vertical dipole is then energized to link the Switchyard system with the new MI slow spill line, and is turned off to maintain the existing Tevatron extraction line.

As the test beam link to Switchyard is established upstream of the first Switchyard beam split, test beam capability to all Research Division fixed target experiments should be possible. A loss in splitting effectiveness of the PSEP septa of 7%, resulting from the downstream displacement of the septa string, should be inconsequential. This is one of the more conservatively designed splitting stations, readily permitting a compensating high voltage increase of this magnitude. Beam optics in the test beamline is being designed to match that of the existing Tevatron Switchyard.

3.5 Beamline Magnets and Power Supplies

Magnet requirements for all beamlines are summarized in Table 3-1. Decomissioning the Main Ring and the existing 8 GeV line will provide a major source of magnets for the beamlines.

The new 8 GeV line requires construction of new TeV I style bending magnets, SDB and SDC. The SDB is a 10 ft dipole with a sagitta of 2.5" and bend angle of 0.175 radians; the SDC is a 5 ft dipole with a sagitta of about 0.6" and a bend angle of 0.087 radians. These magnets are chosen for their reliability and low power consumption. All 54 quadrupoles in the 8 Gev line are of the SQA type. About 20 of these quadrupoles exist in the current 8 GeV line, and can be reused. The remainder (34) will be newly constructed.

The two Tev injection beamlines, the MI-F11, and the F49-SY beamlines reuse existing dipole magnets for almost all the bends. In addition about five 10' B3 style magnets need to be constructed.

The MI and beamlines use 239 3Q84 quadrupoles of which 192 exist with the remainder newly constructed.

The required trims for both the 120 GeV and 150 GeV beamlines will be constructed utilizing a current Fermilab design. These will be made using 40" of standard EPB dipole laminations.

Power Supply Requirements

The power supply requirements for all beamlines are summerized in Table 3-2. The power supplies will be located in the new MI North Service Building (MI-10), the new MI RF Service Building (MI-70), the new North Hatch Building, and in the existing Booster Gallery. All major dipole and quadrupole supplies for the 120 GeV and 150 GeV beamlines will be ramped to minimize the average power consumed. The 8 GeV line will be run DC.

Table 3-1: Beamline Magnet Requirements

	Number Required	Magnet Style	Status
MI-F11 magnet string			
Dipoles (H)	8	B2	exist
Dipoles (V)	2	B3 10'	new
Quadrupoles	9	3Q84	new
Trims (H)	3	4-2-40" EPB	new
Trims (V)	3	4-3-40" EPB	new
F11-A0 magnet string			
Dipoles (H)	129	B2	exist
Quadrupoles	34	3Q84	exist
A0-SY magnet string			
Dipoles (H)	4	B2	exist
Dipoles (V)	3	B3 10'	new
Quadrupoles	4	3Q84	new
Trims (H)	1	4-2-40" EPB	new
Trims (V)	1	4-3-40" EPB	new
150 GeV			
Lambertson	4	E0 Type	exist
Lambertson	2	F17 Type	new
C-Magnet	2	F17 Type	new
Dipoles (H)	16	B2	exist
Dipoles (V)	2	B3 10'	new
Quadrupoles	8	3Q84	new
	8	3Q84	exist
	8	3Q52	exist
	2	3Q120	new
Trims (H)	8	4-2-40" EPB	new
Trims (V)	8	4-3-40" EPB	new
8 GeV			
Dipoles (H)	12	SDB	new
	14	SDC	new
	1	Vernier	exist
	1	4' dipole	exist
Dipoles (V)	1	AP-4 bend	exist
	5	CRD	exist
Quadrupoles	20	SQA	exist
	34	SQA	new
Trims (H)	5	DTRIM	new
Trims (V)	2	DTRIM	exist
Lambertson	1	A0	exist
Kicker	4	Booster style	new

Table 3-2: Beamline Power Supply Requirements

		Number	Current(KA)	RMS Power (KW)	Status
8 GeV					
Dipole	HB1A	1	1.1	55.0	Exists
	HB1B	1	0.9	42.0	New
	HB2A/B	1	1.2	73.0	New
	HB3	1	0.9	55.0	New
	HB4	1	0.9	115.0	Exists
	HB5	1	1.0	91.0	New
	VB2/3	2	0.3	4.0	Exist
Quad	Q1	1	0.2	1.3	New
	Q5	7	0.1	0.3	New
	QF/QD	2	0.2	12.0	New
	Q3	8	0.3	3.0	Exist
Trims		7	0.02	0.2	Exist
MI-to-Tev					
Dipole	B2	1	5.0	140.0	New
	B3	1	4.3	270.0	New
Quad	Q84	4	4.6	96.0	New
	Q52	2	4.6	56.0	New
	Q120	1	0.1	24.0	Exist
Trims		16	0.6	0.7	New
MI-to-F11					
Dipole	B2	1	5.0	360.0	New
	MB1	1	2.0	7.0	New
	B3	1	3.0	16.0	New
Quad	Q84	4	4.6	96.0	New
Trims		6	0.06	0.7	
F11-to-F17					
Dipole		1	1.6	160.0	Exist
Quadrupole		2	1.6	40.0	New
Trims		2	0.06	0.7	Exist
F18-to-F49					
Dipole		2	1.6	860.0	Exist
Quadrupole		2	1.6	140.0	Exist
Trims		4	0.06	0.7	Exist
F49-to-SY					
Dipole	MB1	1	4.1	107.0	New
	B3	2	1.6	16.3	New
Quad	Q84	2	4.6	96.0	New

4. CIVIL CONSTRUCTION

4.1 Overview

The Civil Construction for the Main Injector includes all below-grade beamline enclosures, shielding, above-grade buildings, roads, parking, ponds, utilities, and services to accommodate the equipment for, and operation of, the Main Injector. The Civil Construction also includes the removal and replacement of a portion of the existing Tevatron Ring Enclosure to accommodate the new Proton and Antiproton Injection Beamline from the Main Injector into the Tevatron.

The below-grade enclosures include the Main Injector Ring Enclosure and the various Beam Transport Enclosures which provide for the following beam transport lines:

1. 8 GeV protons from the Booster to the Main Injector.

2. 150 GeV protons from the Main Injector to the Tevatron.

3. 150 GeV antiprotons from the Main Injector to the Tevatron.

4. 120 GeV protons from the Main Injector to the Antiproton Source.

5. 8 GeV antiprotons from the Antiproton Source to the Main Injector.

6. 120 GeV protons from the Main Injector directly to the Beam Extraction Lines for the Fixed Target Areas.

New construction is similar to presently used and proven construction methods at Fermilab. The architectural style of the new buildings reflects, and is harmonious with, existing adjacent buildings. Existing topography, watersheds, vegetation, natural habitat and site boundaries have been carefully observed in the layout of the new construction.

Safety provisions for radiation, fire protection and conventional safety are included in this conceptual design. Energy-efficient construction techniques will be incorporated into all new structures. Quality assurance provisions will be part of all project phases, conceptual, preliminary, and final design, construction, and construction management.

4.2 Beam Geometrics and General Layout.

Beam geometrics of the new Main Injector, the associated beam transport lines and the present Fermilab Tevatron are illustrated on Drawing No. CDR-10. Stations MI-10 through MI-80 indicate the location of the eight straight sections in the Main Injector. These geometrics are the definition about which the beam enclosures, radiation shielding, service buildings, roads and utility extensions are designed relative to the Fermilab site. Drawing Nos. CDR-1 and CDR-2 show the Main Injector on the Fermilab site relative to the present Tevatron, Experimental Areas, Industrial Area and Fermilab Village. Drawing No. CDR-3 illustrates the Main Injector on the Fermilab site as an aerial perspective. The design and general layout is compatible with the Fermilab Site Development and Utilization Plan.

4.3 Radiation Shielding and Life Safety Criteria

All new construction will provide adequate personnel shielding. Consideration has been given to various operational conditions as well as fault conditions in determining shielding designs.

Areas of specific shielding design include beam enclosures, service buildings, labyrinth accesses, stairways, drop hatches, and cable/pipe penetrations. Another area of design is access to adjacent rings or transport lines while other lines are operational.

Shielding will be done with compacted earth, regular density concrete and steel plate. Various combinations and thicknesses of these materials will be proportioned according to the limitations of economic design and space.

Life safety access control into the various beam enclosures, labyrinths, stairs, and buildings is maintained by a series of locked and interlocked barriers. Solid partitions with doors will separate the Tevatron Oxygen Deficient Hazardous (ODH) areas in the F-Zero Enclosure from the Main Injector and transport lines.

4.4 Main Injector Ring Enclosure

The Main Injector Ring Enclosure is an oval-shaped, below-grade enclosure, approximately 10,900 ft. long, with a 9'-0" wide and 8'-0" high cross-section. At utility alcoves under service buildings, heights are increased to 9'-0" and widths are broadened. The enclosure Plan and Sections are shown on Drawing Nos. CDR-6, CDR-7, CDR-10 and CDR-12. The floor of the enclosure is at Elevation 719'-6" or 13' to 25' below existing grade. The Main Injector Ring equipment is centered on Elevation 721'-6" or 2'-0" above the floor and is positioned 1'-9" to 2'-0" from the outer curved wall. The MI-70 enclosure is a 10' high enclosure and widens to 15'. Earth shielding berms over the Main Injector Enclosure provide the required 17' earth equivalent shielding.

The Main Injector Ring Enclosure is constructed on a reinforced concrete cast-in-place (CIP) base slab on 3" thick lean concrete mud slab over compacted granular fill or undisturbed glacial till. Both CIP and precast reinforced concrete wall and roof construction are used. 9,936' of the ring will be built with precast concrete inverted ''U'' wall/roof sections which are welded to the CIP base slab. Nearly 26,000' of this type precast have been economically constructed at Fermilab during the past two decades. The enclosures and alcoves beneath service buildings will be CIP base slab, walls, and roof. Underdrains, moistureproofing, and granular backfills are used to insure a dry enclosure.

Cable trays, power bus, piping, lighting, and other utilities are ceiling- or wall-mounted on outer walls. Numerous penetrations connect to the service buildings constructed above the Main Injector Enclosure's utility alcoves.

Equipment access to the Ring Enclosure is provided by an open hatch and semi-circular labyrinth from the RF/MI-70 Service Building crane bay. Personnel access stairs to the Main Injector are provided at six service buildings including the RF/MI-70 Service Building. Stairs occur at the two Abort Service Buildings. Ventilation equipment is near these stairs and is described in Section 4.11 below.

A common earth berm above the Main Injector Enclosure defines the location of the below-grade Ring Enclosure. Top of the berm is approximately 1'-0" above the service building floor.

4.5 Beam Transport Enclosures

Although there are six functionally different beam transport lines, only three distinct beam enclosures are required through the use of shared beam elements and shared enclosures. Drawing Nos. CDR-10 through CDR-18 illustrate the enclosure configurations in Plan, Section and Elevation views.

The 8 GeV Beam Enclosure is a 2,060 foot long structure, 8'-0" high and 10'-0" wide in straight sections and 11'-0" wide in arcs. The floor is slightly sloping to follow the beam elevations. Earth shielding of 19'-6" is used above this enclosure except at roads where steel shielding is used to reduce the earth requirements. In the area of Well Pond Road, existing steel shielding will be removed and replaced to maintain shielding integrity. Access is from a shielded hatch under the North Hatch Building crane bay. Earth shielding of 16'-0 is provided at the North Hatch Building.

The two 150 GeV Injection Beam Enclosures for proton and antiproton transfer from the Main Injector to the Tevatron are each 740 feet in length, 9'-0" to 20'-0" in width and 8'-0" high with level floors. Earth shielding of 17'-0" to exterior berms and 15'-0" to interior building floors is used. Access is from the Main Injector Ring Enclosure in each case. The 120 GeV protons from the Main Injector to the Antiproton Production Target and the 120 GeV Extracted Proton Test Beam to the Fixed-Target areas are also transported from the Main Injector through the Proton Injection Enclosure. These beams travel to the Tevatron Enclosure at F-Zero where both beams are injected into a beamline arc consisting of the former Main Ring accelerator components as far as either F-17 in the case of the antiproton production or to A-Zero and the start of the Switchyard for Fixed-Target beams in the case of the test beam. The 8 GeV antiprotons are transported to the Main Injector following the 120 GeV antiproton production line in reverse from F-17 to F-Zero and back into the Main Injector.

Construction details of the Beam Transport Enclosures are very similar to the Main Injector Ring Enclosure. Additional personnel stairs are provided for the 8 GeV Enclosure as well as the interrupted Antiproton Transport Enclosure.

4.6 Main Injector Service Buildings

Ten service buildings in five size configurations contain equipment, services, and utilities for the Main Injector and various beam transport lines. Other equipment for the beam transport lines will be contained in the existing Transfer Gallery. Locations of the ten service buildings are shown on Drawing No. CDR-6.

Service Buildings MI-13, MI-30, MI-50 and MI-53 are four identical buildings that are illustrated on Drawing Nos. CDR-19 and CDR-20. These buildings are located atop the shielding berm, approximately 1,800' apart. Since the buildings house the magnet power supplies, the locations occur following every 50 dipole magnets in the beam enclosure below. The buildings also contain control racks, pumps, and heat exchangers, and provide personnel stairs and equipment access to the beam enclosure. Conduits to a utility alcove off the beam enclosure below provide for dc bus, power cable, control cable, and LCW piping.

The four buildings are 34'-0" wide and 50'-0" long in plan with 10'-0" clear interior heights. Construction is insulated metal siding on a steel frame with built-up roof and concrete floor. During Title I design, precast wall panel buildings will be investigated together with precast sub-grade beams to reduce construction times and possible settlements. The electrical and mechanical systems for these buildings are described in detail in Sections 4.11 and 4.12 below.

Service Building MI-10 is similar to the above four buildings in construction, but is 50'-0" wide and 50'-0" long. The increased size is necessary to house additional power supplies for nearby 8 GeV beam transport line.

Service Buildings MI-20, MI-40 and F-17 Kicker Building are small, single-purpose buildings containing the pulsed power supplies for the Main Injector Beam Abort and Beam Transfer Kickers. These buildings are 20'-0" square with 10'-0" clear interior height. There is stair access to the beam enclosure below at MI-20 and MI-40. Construction is similar to the other service buildings.

Service Building MI-70 is a large, multi-purpose service building that is connected to the rebuilt Tevatron Service Building F-Zero. Both buildings are shown on Drawing Nos. CDR-21 and CDR-22. The construction scenario is described below in Section 4.7.

Service Building MI-70 includes a 50' by 75' by 24' high bay served by a 25-Ton crane, and low bay areas of 75' square and 25' by 300'. Within the high bay is the 8' by 30' equipment hatch and a 5-Ton freight elevator connecting to the curved access labyrinth into the Main Injector Ring Enclosure. In the low bay areas are housed Main Injector and beamline power supplies, Main Injector RF power supplies, LCW pump and deionizer equipment, HVAC equipment and access stairs.

The North Hatch Building is sited approximately midway along the 8 GeV Beam Enclosure in the immediate vicinity of the existing AP-50 Service Building. The exterior treatment is therefore similar to and consistent with, the Antiproton Source Service Buildings. This configuration is shown on Drawing No. CDR-23.

The North Hatch Building is 46' wide by 120' long with 16'-0 clear interior height. A 25-Ton crane serves the high bay area which includes a shielded access hatch 7'-2" by 24'-2". The hatch and adjacent stairs independently connect to an access enclosure leading into the 8 GeV Beam Enclosure. Power supplies, LCW pumps and control racks are located in the designated areas shown on Drawing No. CDR-23.

4.7 F-Zero Beam Enclosure and F-Zero Service Building Addition.

The F-Zero Beam Enclosure contains components from the accelerator(s) to be relocated from the existing Main Ring, as well as from several beam transport lines. Functionally these are elements of the 150 GeV Proton Injection Line, the 150 GeV Antiproton Injection Line, the 120 GeV Antiproton Production Line, the 8 GeV Antiproton Accumulator to Main Injector Line, and the 120 GeV Extracted Test Beam Line. As mentioned above, some of these lines share common elements at certain locations, or share common enclosures at other locations. In the immediate F-Zero location, a back-to-back double ''Y'' must be constructed as seen in Drawing No. CDR-11.

The existing F-Zero Enclosure has insufficient space for the new transport beams to be included in addition to provisions for the accelerator(s) to be located in the Main Ring. Hence it must be completely demolished and rebuilt. In order to do this construction work, a portion of the existing F-Zero Service Building directly above the F-Zero Enclosure must also be demolished and then rebuilt. Refer to Section 4.9 for a description of the earth retention system planned to accomplish this work, which is a three-stage process: 1) the new Main Injector Enclosure is built, and most of the MI-70 Service Building constructed, 2) The existing F-Zero Enclosure and Buildings on top are demolished, and a new F-Zero Enclosure constructed which connects to stubs left incomplete when the Main Injector was constructed, and 3) The F-Zero Service Building is rebuilt and a connecting link to the MI-70 Service Building constructed. All these steps may be seen in Drawing Nos. CDR-9, CDR-11, CDR-21 and CDR-22.

The demolished section of the existing F-Zero Enclosure will be approximately 400' long, and it will be replaced with the aforementioned double ''Y''-shaped structure as seen in Plan view in Drawing No. CDR-11. The width of the common structure varies from 17'-0" to 24'-0" and the height is either 8'-0" or 10'-0". Of the four ends in the double ''Y'', two will reconnect to the existing Main Ring tunnel, and two to the stubs left from the earlier construction of the Main Injector and the Beam Transport Lines. The floor of the enclosure under the Main Ring Accelerator(s) will be at Elevation 722'-6" and the floor of the enclosure under the Beam Transport elements will be at Elevation 719'-6" requiring a step across the width of the enclosure as seen in cross-section in Drawing No. CDR-22.

The F-Zero Enclosure is constructed of CIP reinforced concrete. Since no portion of the existing base slab can be re-used due to the increased span loads, a completely new base slab will be poured. The glacial till and the existing granular sub-base is adequate. Underdrains from the existing Tevatron/Main Ring Enclosure and the new Beam Transport Enclosures will be routed to new sump pits. Moistureproofing and granular backfills will be used similar to the Main Injector.

An existing freight elevator, stairs, and curved labyrinth from the re-used portion of the F-Zero Service Building will remain to service the new beam enclosure on the Tevatron side. Access on the opposite side will be through the beam transport lines, and stairs and freight elevators in the MI-70 building. Numerous penetrations connect the building and the enclosure below and are shown in the drawing sections.

The F-Zero Service Building Addition and the connection to the MI-70 Service Building can be built only after the F-Zero Beam Enclosure below is completed and backfilled. A 25'-0" wide, 237'-0" long, 12'-0" clear height addition is built on top and parallel to the F-Zero Enclosure for RF power and controls for the accelerator(s) in the Tevatron/Main Ring Enclosure. A 50'-0" wide, 50'-0" long, 12'-0" high addition at Elevation 745'-6" crosses the space between the two accelerator enclosures as projected to the surface, connecting the F-Zero Service Building to the MI-70 Service Building. This structure is seen in Drawing Nos. CDR-21 and CDR-22. The final connected structure encompassing MI-70 and F-Zero buildings is at three different elevations; Elevation 742'-6" for the preserved ''front or southeast'' portion of F-Zero, Elevation 745'-6" for the reconstructed Tevatron RF and connection section, and Elevation 741'-0" for the MI-70 Main Injector RF and service section.

The construction of the F-Zero addition is similar to the existing structure, with insulated metal siding over a steel frame, built-up roof and concrete floor. Equipment access doors are provided to all large equipment areas.

The co-joined F-Zero/MI-70 building contains the RF cavity power supplies for the Main Injector and the Tevatron accelerator(s), magnet power supplies, an existing helium compressor room, LCW cooling systems, control racks, test areas and small technical work areas. The space allocation is shown on the drawings.

4.8 Industrial Building No. 5

The Industrial Building No. 5 will be used for component fabrication and final assembly for many of the Main Injector magnets. The addition of this building in the Fermilab Industrial Area allows magnet production to be completed according to the schedule without impacting other Fermilab on-going magnet programs.

Industrial Building No. 5 will be located north of the present Industrial Area rear parking lot and immediately west of the present

Industrial Building No. 3. Refer to Drawing No. CDR-33. Siting the new building in this location will allow for use of the existing parking areas and will provide convenient access to the facilities and personnel in the Industrial Area. Utilities and services are available nearby for extension to the new building. Minor reworking of a drainage ditch and extension of a storm sewer are required. Based on soil borings and previous construction at the Industrial Center Building, shallow concrete caissons are an economic choice for the building foundation.

The exterior of Industrial Building No. 5 will match the appearance of the four sister Industrial Buildings No. 1 through No. 4. The steel frame building footprint is 80 feet wide by 192 feet long with a roof height of 27'-2". A 5'-1" high concrete kicker wall at grade is topped with a 2'-0" high horizontal ribbon of windows and flush metal vertical siding up to the roof. The roof is a very shallow pitched gable. Equipment access and personnel doors are provided around the building and windows on the mezzanine are provided in the north wall.

The interior of Industrial Building No. 5 is divided into a 60 foot wide crane high bay and a 20 foot wide side bay with a mezzanine above. A 50/10 ton bridge crane serves the high bay. General shop areas and heavy assembly spaces are on the ground level crane bay and side bay while light technician work spaces are on the mezzanine. An elevator is provided for personnel and light equipment access to the mezzanine. Toilet facilities are on the ground floor side bay.

All areas in Industrial Building No. 5 will be air conditioned. Lighting levels and power outlet distribution will be similar to the North Hatch Building. A 1500 kva substation will be installed near the west end of the building and will connect to a 2000 Amp switchboard for the various power needs within the new building.

4.9 Foundation Systems, Earth Retention and Active Soil Control

All base slabs and piers under Main Injector Enclosures will be founded on glacial till with high bearing capacity. Soil boring logs near the Main Injector perimeter indicate the unsuitability of shallow foundations if founded on high water bearing strata above the glacial till. Soil boring locations, elevations of glacial till, and unconfined compressive strengths are shown on Drawing No. CDR-4. During Title I, additional borings will be made to better define the sub-surface conditions.

Although the glacial till varies in depth of 4 to 21 feet below grade, the requirements for various beam enclosure structures place the base slab excavation well into the till except at a very few isolated areas. In these areas, a compacted granular backfill or lean concrete will replace the several additional feet required to reach glacial till.

The foundations for the six service buildings around the Ring may be placed on the Main Injector Enclosures below. Piers will extend above the enclosure roof and precast grade beams will support the CIP service building floors. Similar techniques have been successfully used for the Antiproton Source Service Building construction in quite similar sub-grade conditions. For portions of the Ring service buildings which extend beyond the enclosure excavation, spread footings on virgin soil will be employed. The North Hatch Building will bear on the enclosure below on drilled piers.

Earth retention systems will be used during the various construction phases in order to retain foundations for existing beam enclosure structures. In addition, the retention systems will contain and confine much of the active soil adjacent to these existing beam enclosures. With these methods, the Main Injector Ring Enclosure and much of the Beam Transport Enclosures may be built during normal accelerator operations.

Sheet piling, driven in Phase 2 beside the existing Tevatron F-Zero Enclosure and RF Service Building will allow construction of the Main Injector Ring Enclosure and MI-70 Service Building during accelerator operations. This sheet piling will be driven parallel to and 17 feet beyond the outer radius of the the Tevatron Enclosure to approximately 36 feet depth and 440 feet length. Refer to Drawing Nos. CDR-9, CDR-11, CDR-21 and CDR-22.

Another row of sheet piling will be driven in Phase 3 during the scheduled accelerator downtime. After demolition of the existing RF Service Building above the Tevatron F-Zero Enclosure, sheet piling will be driven approximately four feet away from the RF Service Building foundation to approximately 40 feet depth and 370 feet length. Between these two rows of sheet piling, the F-Zero Enclosure, MI Injection Enclosure and P-Bar Injection Enclosure will be built.

Soils excavated from areas adjacent to existing Tevatron Enclosures that exhibit low levels of activity will be carefully segregated, controlled and subsequently backfilled into areas by the reconstructed enclosures. Soil storage pits next to required excavations will be dug as a repository for all active soils removed during construction. The active soil bulk will be covered with an umbrella of clay soil for temporary protection and containment during the construction period. Surface water will be controlled and diverted away from these storage pits.

4.10 Master Substation, Primary and Secondary Power Distribution

Power is provided to the Main Injector through a new 345 KV overhead transmission line, a new outdoor 345 KV master substation and through 13.8 KV power feeders in ductbanks to various substations and secondary distribution for three Main Injector power systems. These systems as discussed in Section 2.14 above are: 1) Pulsed Power Supply Power System, 2) Conventional Power System and 3) Beamline Power System.

A new 345 KV switching station will be installed at the southeast corner of the Fermilab site along the Commonwealth Edison Co. transmission line corridor paralleling the E.J. & E. railroad tracks. Refer to Drawing No. CDR-1. Two manually-operated 1600 Amp, 345 KV switches will connect to Commonwealth Edison Co. Transmission Lines No. 11119 and No. 11120.

A new overhead transmission line, approximately 13,000 feet long will be installed along the southern boundary within the Fermilab site, at least 225 feet from Illinois Highway 56, Butterfield Road. The line will bend northward along Kautz Road and will terminate at the new Kautz Road Master Substation (KMS). Double arm steel poles at an average span of 1,000 feet will carry a single 345 KV circuit with static shield wires above.

The new Kautz Road Master Substation (KMS) will be located east of Kautz Road approximately 700 feet from nearest arc of the Main Injector, 0.2 miles from the south site boundary and 1.6 miles from the existing Master Substation (MSS) at Road A-1 and Road B. The new substation area is well drained, has been in recent cultivation and lies south of wooded areas that abut the Tevatron Ring between E-3 and E-4.

The new Master Substation (KMS) will be 400 feet by 400 feet rock base enclosed with a security fence with access gate to Kautz Road. Within this area will be the 345 KV dead-end structures, aluminum tubular bus bars and insulators, motor operated 345 KV switches, SF6 main circuit breaker, three transformers, a walk-in structure for secondary equipment and Main Injector harmonic filters and switchgear. Foundation pads and vaults, oil containment sumps, lightning and ground grid are also included.

One new transformer and two existing transformers from the present Master Substation (MSS) will be installed in the new Master Substation (KMS). Refer to Drawing No. CDR-29. The new transformer will be 40 MVA capacity (40/53/66.6 MVA-OA/FA/FOA), 345/13.8 KV, 3 phase, 60 Hz oil filled and will be used for the Main Injector Pulsed Power Supply and Beamline Power Systems. An existing 60 MVA Transformer 82B, that will be retired from Main Ring Pulsed Power Supply service, will be used for the Main Injector Conventional Power System. Another existing 40 MVA Transformer 84A, currently an MSS on-line spare, will be moved and reinstalled in the new Master Substation (KMS) as an on-line spare.

The secondary sides of the three transformers will be connected by 3,000 Amp, 13.8 KV non-segregated outdoor bus to 13.8 KV, SF-6 type main and feeder breakers with sufficient interrupting capacity for the available short circuit currents. These breakers, together with metering, relaying and communication equipment are all housed in an enclosed metal walk-in structure.

Underground concrete-encased ductbanks with precast concrete manholes will route the 13.8 feeders from the new Master Substation (KMS) to the various Main Injector power systems. Refer to Drawing No. CDR-30. Other ductbanks will connect back to the Main Ring Duct Bank near E-2 and F-2. With these connections and the use of six existing Main Ring feeders, approximately 40 MVA of primary power may be back-fed to the Master Substation (MSS).

The Pulsed Power Supply System is fed from the new 40 MVA transformer in the Master Substation (KMS) through four 13.8 KV feeders for MI Ring pulsed power and one 13.8 KV feeder for MI Beamline power. The MI Ring uses two direct-buried loop feeders, the ends of which connect through switchgear at the KMS and near the MI-70 building area. At each service building, there is a disconnect switch to supply power to the power supplies. From this switch to the power supply transformers, the feeders are routed in a ductbank. This is shown in Drawing No. CDR-19. A paralleling switch at MI-30 will enable uneven loading of each segment without overloading the feeders. This switch can also be used for feeder isolation for maintenance purposes. The power for the beamlines will require one feeder with 1500 KVA Substations at F-Zero and one 500 KVA Substation at the North Hatch Building.

The conventional power system will be fed from the relocated Transformer 82B and will consist of one 13.8 KV feeder around the Main Injector Ring, with a 500 KVA (1500 KVA at MI-70) transformer at each of the principal Ring service buildings and North Hatch Building. The conventional power will be used for building power, lights, pumps, etc. The existing Main Ring conventional power feeder will be intercepted at F-2 and will be extended to the Main Injector switchgear area located at MI-70 through an underground ductbank, as shown in Drawing No. CDR-31. From this switchgear, the feeder will continue as a direct buried feeder to the six service buildings. At each service building there will be a disconnect switch with a ductbank connection to the conventional power transformer. The conventional feeder to the North Hatch Building will be routed through ductbank.

Conventional power will be connected to power distribution panelboards in each service building. 480/277 volt, 3 phase branch circuits will power the water pumps, heating and ventilating equipment, control racks and service outlets. Step-down transformers and panelboards provide 208/120 volt power for lighting and outlets. Separate panelboards for isolating beam equipment at 480/277 volt and 208/120 volt are provided. Refer to Drawing No. CDR-19.

4.11 Primary Cooling, Distribution and Mechanical Systems.

The primary heat rejection medium for the 12 MW generated by the Main Injector is cooling pond water (PW). Drawing Nos. CDR-6 and CDR-26 show the two new interconnected cooling ponds that roughly encircle the Main Injector Road and provide 16.0 acres of cooling surface. The ponds total 11,400' in length, are 60' wide, and the average to maximum depth is 4'-6" to 7'-0". Transverse concrete dams near each service building provide intake and discharge piping separation and elevation control. Pond water level varies from Elev. 739' matching the Tevatron ponds at F-Zero down to Elev. 735'. Cross-connect piping between the Main Injector ponds and the Tevatron Ponds allow load shedding and water level control.

As described in Section 2.14 the Low Conductivity Water (LCW) system is a closed piping loop exchanging heat from the Main Injector and Beam Line magnets and power supplies to the pond water. Much of the equipment now in the present Tevatron Service Buildings will be re-installed in the new Main Injector Service Buildings and perform in a similar capacity. New LCW piping will be installed in the Main Injector Beam Enclosure. System-wide deionizers are located at the RF Building and the North Hatch Building for slip stream polishing.

Existing chilled water (CW) in the F-Zero Service Building which comes from the Central Utility Building will be retained and re-used, and extended into the attached MI-70 building. The new combined loads on the chilled water system are comparable to the present loads.

The underdrain system for all new beam enclosures is similar to the design used for the Antiproton Rings. Perforated drain piping surrounded by granular material and covered with geotextile fabric is installed on both sides of the enclosure base slabs. Duplexed pump sump pits connect to the underdrain piping and discharge into surface ditches.

The fire detection/suppression systems used for the Main Injector are similar to those systems used for the Tevatron enclosures and buildings. Industrial Cold Water (ICW) will serve fire hydrants and hose cabinets in the F-Zero, MI-70, and North Hatch Service Buildings. These buildings will also be equipped with smoke detectors which report to the site-wide FIRUS system, as will be the other service buildings. The Main Injector tunnel enclosure, and the Beam Line Enclosures will be equipped, as is the present Main Ring, with ''derivative thermal detectors'' and link to the FIRUS system.

Moderate ventilation rates with dehumidification will be used in the Main Injector Beam Enclosure. Refer to Drawing Nos. CDR-24 and CDR-25. Ventilation fans will be placed in alternate service buildings to supply/exhaust air through the stairway and alcove openings. Two air changes per hour will be used when needed during non-operating periods. Periodically placed dehumidifiers about the beam enclosure will control humidity. Also, air will be circulated through the longer beamlines by a push-pull ventilation system.

The Main Injector and North Hatch Service Buildings are equipped with a variety of HVAC equipment to accommodate the required occupancies. Local, self-contained air conditioners will be used to cool Control Rack areas. Unit heaters will heat the power supply and water system areas when operations are off. Roof fans and wall louvers will provide ventilation to these areas when the temperature requires.

4.12 Underground Utilities and Services

Power ducts, communication ducts, industrial cold water (ICW) piping and pond water (PW) piping will be extended from existing utility corridors along South Booster Road, Kautz Road, and Main Ring Road. Underground power ductbanks are described in Section 4.10 above. Utility routings and connection points are shown on Drawing Nos. CDR-8, CDR-29 and CDR-31.

A new 13.8 KV power cable corridor along the inside toe of the Main Injector berm is reserved for both direct-buried pulsed and conventional feeders. At each of the six Main Injector Service Buildings the new direct-buried feeders will connect through concrete pads with air switches to the substation foundations supporting three Main Injector power substations and one conventional power substation. The substation foundations will provide transformer oil containment reservoirs.

A new communication ductbank loop encircling the Main Injector will be installed along the outside toe of the Main Injector berm. The communication ductbank will be branched through concrete handholes into each of the six Main Injector Service Buildings. The new ductbank will extend through the North Hatch Building enroute to the Booster. The communication duct will be connected back to the Cross Gallery through a combination of new duct installation and utilization of existing routings in the South Booster and Antiproton Source areas. In some areas, where existing ductbanks are near capacity, additional ductbanks will be paralleled along the same routing. The precise routing will be determined during Title I design and will be based on the usage of the existing fiber optic links already installed into the Antiproton source.

Industrial cold water (ICW) piping will be extended along Kautz Road to the F-Zero/MI-70 Service Building and will connect to the existing ICW line on the inside of the Tevatron Ring Berm. ICW will also be extended from the existing line at the Southeast Booster Lab to the North Hatch Building. A short extension to domestic water piping connects to the rebuilt RF/MI-70 Service Building.

Existing septic systems at the existing Antiproton Target Hall and RF/F-Zero Service Building will be retained and any portions of the field damaged during construction will be replaced.

4.13 Survey and Alignment Control

A coordinated system of monuments, benchmarks and working points is planned for complete geometric control of the Main Injector during all phases of construction. Two ground isolated columns will be set into rock at construction start to define construction survey control points. This control will be extended onto enclosure base slabs as construction progresses and will be tied into control of the existing survey systems of the Tevatron, Booster and Antiproton accelerators. Provision will be made for survey sighting tubes in addition to available equipment hatches to facilitate survey checks to accelerator equipment after all construction is completed.

4.14 Roads and Landscaping

Road access to the Main Injector site is from existing Kautz Road. A new loop road around the site, Main Injector Road, will connect to Kautz Road at two places. An extension continues east of Kautz Road to the Kautz Road Master Substation. Early construction of this new road will maintain access to the existing Antiproton Target Hall and will provide direct construction access via Kautz Road from Illinois Highway 56, Butterfield Road. Refer to Drawing Nos. CDR-1 and CDR-6.

A portion of existing Kautz Road, between the Main Injector Road intersections, will be rebuilt to the alignment required by the Main Injector cooling ponds and new service buildings. Refer to Drawing No. CDR-6. Service drives with small parking areas are provided at each service building with access to either Kautz Road or the new Main Injector Road.

Special precautions will be made to protect large trees that are adjacent to the construction site. Within the construction site, topsoil will be segregated and later replaced. Crown vetch will be used on berm slopes and crests. The ring interior area will be returned to natural field grasses. Grass seed will be planted adjacent to roads and building areas.

The southwestern boundary of Fermilab abuts to an abandoned railroad right-of-way, now converted into the Illinois Prairie Path. The existing railroad berm and ditch, together with the new ponds and adjacent pond berms, create a significant barrier to any errant cyclist/hiker along the Prairie Path. In addition, appropriate shrubbery and thicket-type vegetation will be planted along the site boundary as a further visual screen and natural fence row.

4.15 Drainage and Wetlands

The construction site is mainly open cropland with approximately one-third recently removed from leased cultivation. The overall drainage pattern is to the southwest into Indian Creek. There are isolated areas of trees and fence rows, shallow ditches meander the site and abandoned agricultural tiles are in evidence.

The Federal Emergency Management Agency's National Flood Insurance Program Maps indicate that part of the construction site is within the Indian Creek floodplain for a 100-year storm. A 500-year storm would only increase the 100-year crest elevations by 18" or less. The construction area also contains wetlands, though less than 20 acres would be disturbed. The wetland areas are defined and classified in the survey data obtained from aerial photography performed in 1981 by the National Wetlands Inventory. These areas overlap the 100-year storm floodplain and occupy one or two other small areas within the construction zone. The two types of wetlands that would be affected, as defined by the Illinois State Natural History Survey Division, are in the Palustrine System. The dominant vegetation types are Emergent Herbaceous Angiosperms and Forested with Large Broad-leaved Deciduous Trees. Both types of wetlands are classified as either temporarily flooded or seasonally flooded.

The Main Injector impacts the site with three salient features; the shielding berm, the new road and the cooling ponds. The site drainage will be designed to minimize any impact according to the following design goals during both construction and operations phases:

1. <u>Maintain the Existing Watershed Characteristics</u> within the project area and the surrounding topography.

   Construction Phase:

   > The flow at Indian Creek and its tributaries will be diverted temporarily as required to keep immediate construction areas dry. The normal water courses will be restored as construction work in the Indian Creek

areas is completed. The normal flows through the center of the Main Injector will be unimpeded.

Operations Phase:

The flow at Indian Creek and its tributaries will continue unimpeded as it passes through the Main Injector area except in cases mentioned below. Special attention will be given to maintain the watershed characteristics in the center of the Main Injector Ring to maintain satisfactory environment for the resident wildlife. Any wetlands that will be disturbed during the course of the project will be restored as closely as possible to their original condition. Mitigation plans for any disturbance and/or loss of wetlands will only be finalized after consultation with the Corps of Engineers. Compensatory wetlands will be created in the vicinity of the disturbed wetlands in a ratio of 1-1/2 to 1 of existing wetlands removed from the Main Injector site.

2. Control Surface Runoff into Indian Creek so as to create no adverse impact on downstream off-site residential areas.

Construction Phase:

There will be no reduction in the retention capacity of the Indian Creek drainage basin during the construction of the project. Temporary retaining ponds will be created to counteract reduced capacity during construction. These ponds will hold only diverted excess storm water and will provide the same retention capacity as the areas temporarily disturbed by construction work. Normal flow characteristics of the basin will be not disturbed.

Operations Phase:

There will be no reduction in the retention capacity of the Indian Creek drainage basin. The Illinois State Water Survey has supplied the surface water information that will be used for the development of surface runoff control plans. The cooling ponds will be designed with an additional storage capacity in order to retain excess storm water runoff. The stored water would be released at a controlled rate in order to reduce flow peaks that most severely affect downstream sites. Compensatory 100-year floodplain areas will be created to replace areas removed from Main Injector site.

3. Provide for Collection of Surface Runoff when required into the cooling ponds using pump stations to meet project requirements for cooling loads.

4. Elevate all Buildings, Roads and Ponds above any potential high water levels.

In general, drainage structures will be placed through and under the shielding berms, road beds and ponds to maintain the normal surface water flow through the interior ring area of the Main Injector. Pump stations, control dams and weirs will be provided for seasonal adjustment of the drainage patterns needed to maintain the watershed characteristics. Operations of these controls will be coordinated with the existing Swan Lake and Booster Pond cooling systems which also connect to Indian Creek.

4.16 Construction Packages and Schedules

The Main Injector Civil Construction work has been grouped into the following four general construction phases and 13 Work Breakdown Structure (WBS) categories for the preparation of cost estimates and construction schedules.

Phase 1 - Site Preparations: (WBS 1.2.1 & 1.2.13). Site development including mobilization, fencing around habitat areas, site protection, survey control, temporary utilities, rough roads, major excavation, pond construction, site drainage and drainage controls all at Main Injector Site. Also Industrial Building No. 5.

Phase 2 - Construction During Accelerator Operations: (WBS 1.2.2-1.2.7). Main Injector ring enclosure, beam line enclosures that are shielded from the Tevatron, Service Buildings MI-10, 13, 30, 50, and 53, Abort Service Buildings MI-20 and 40, RF/MI-70 Service Building, North Hatch Building, Kautz Road Master Substation, 345 KV Transmission Line, remaining pond construction, drainage controls and various utilities and services.

Phase 3 - Construction During Accelerator Off Period: (WBS 1.2.8-1.2.11). RF/F-Zero Beam Enclosure and Service Building, all remaining beam line enclosures, modifications to Booster, Antiproton and A-Zero beam enclosures, modifications to F-17 Kicker Service Building.

Phase 4 - Landscaping and Paving: (WBS 1.2.12). Site clean-up, road regrading, paving and landscaping work to complete the project.

During development of Title I and Title II, these four categories will be divided into the actual construction packages tailored to the detailed design, operational conditions and early occupancy requirements.

5. COST ESTIMATE

The Total Estimated Cost for construction of the Main Injector, associated beamlines, and required modifications to existing facilities is $156,800,000 in then-year dollars. The cost estimate is summarized in Table 5-1. An additional $19,600,000 will be required in direct R&D, pre-operating, and capital equipment costs to support the project. The cost estimate methodology is adapted from that developed to estimate the Superconducting Super Collider (SSC). Our recent experience with the TeV I (Antiproton Source) and Main Ring overpass construction projects forms the basis for a large fraction of the cost estimate of this project.

5.1 Methodology

A Work Breakdown Structure (WBS) is set up in order to identify all required components of the Main Injector project and to insure that each component is adequately specified and incorporated into the estimate. The WBS through fourth level is shown implicitly in Table 5-1. The actual WBS used for the cost estimate extended through the seventh level.

All components are estimated at the lowest applicable level in 1989 dollars and then summed upwards. At the lowest level materials costs and labor (fabrication) hours are entered separately along with the basis for the estimate. Labor estimates are associated with a craft code specifying the type of labor to be used. When materials costs are based on previous purchases of identical components they are escalated to 1989 prices using standard DOE inflation factors. The translation of craft codes into hourly costs is based on local labor rates and is given in Table 5-2. Through this approach a categorized estimate of the total manpower required for completion of the project is created at the same time as the cost estimate. The manpower estimate is given in Table 5-3.

The cost estimate is produced in 1989 dollars. The TEC in $1989 is $126,600,000. Escalation to then year dollars is accomplished through a convolution of the cost spending profile with DOE construction project escalation rates. (See Section 5.7.)

5.2 Technical Components

The technical components of the rings and beamlines include magnets, vacuum, RF, diagnostics, controls, and safety systems. Included in the estimate are materials, fabrication, and installation costs. The total cost estimate for these components is $55,300,000 (1989). All components are similar to components already built and installed at other locations within the Fermilab complex. The only extraordinary items are the new dipole magnets. A modest R&D effort will be associated with this item.

5.3 Civil Construction

The civil construction cost estimate includes the Main Injector ring enclosure, beamline enclosures, service buildings, modifications to the Main Ring enclosure and service building at F0, and all associated utilities including primary power and water distribution. Also included are the requisite sitework and road development as well as a new industrial building required for magnet assembly. Specifically provided for are new cooling ponds, environmental restoration of impacted wetlands, and the new 345 KV Kautz Road Substation.

The total civil construction is estimated at $34,800,000 (1989). Included is $400,000 specifically targeted for environmental restoration (accounted for in WBS 1.2.1). Standard estimating guidelines (Means) are used. The cost estimate includes contractor overhead and profit at 20%.

5.4 Engineering Design Inspection & Administration (EDIA)

EDIA is estimated at the fourth level for all technical components and at the third level for civil construction components. The estimation is based upon our experience with the Tevatron I project. The estimated EDIA as a fraction of the total components cost is 17.4% (including 13.9% for ED&I, 2.6% for Project Management, and 0.7% for G&A). The G&A rate is the established **incremental** overhead on construction projects at the laboratory. EDIA is estimated at $15,600,000 (1989).

5.5 Contingency

Contingency is assigned to all technical components on the basis of the cost estimating procedure. Estimates based on previous actual purchases, on vendor quotes, or on catalog prices are assigned a 15% contingency. Estimates based on undocumented engineering estimates (approximately 25% of the total materials cost estimate for the project) are assigned a 30% contingency. An across-the-board 20% contingency is applied to all labor estimates. Civil construction contingencies are assigned at the third WBS level on the basis of previous experience with similar projects. EDIA is assigned an across-the-board 20% contingency.

The total contingency assigned to the project is $20,800,000 (1989). This represents 19.7% of all construction, installation, and EDIA costs. This level of contingency is felt to be appropriate for the conceptual design stage of a project with minimal technical risk.

5.6 Other Project Costs (R&D, Pre-operating, Capital Equipment)

Specific R&D required to support the Main Injector is limited to the areas of the dipole magnet, the 8000 Amp/1000 Volt power supply, and the special short quadrupole magents required at the MI straight sections. Dipole magnets required for one sixth of ring (50 magnets), two special quadrupole magnets and tooling, and two 8 MVA power supplies will be constructed using R&D funds. Total estimated cost of this effort is $13,800K including $4800K for the prototype dipole string, $200K for special quadrupole prototypes, $700K for magnet tooling, and $700K for the prototype power supplies. It is estimated that approximately 30 man-years of effort are required for ED&I and project management associated with the R&D program. These costs are included here as is a 37% G&A surcharge, 20% contingency, and escalation.

Pre-operating costs ($2000K) include the operation of the MI ring and beamlines during a six month commissioning period. Capital equipment required in support of R&D is estimated at $1000K.

5.7 Spending Profile

Both obligations and cost profiles have been developed based on the construction and installation schedule described in Chapter 6. The profiles are developed at WBS level 4 for technical components, level 3 for civil construction, and level 2 for EDIA and contingency. The project obligations and cost profiles are given in Table 5-4.

Table 5-1: Main Injector Cost Estimate (Dollar amounts in thousands)

WBS			Description				Total
1.			**MAIN INJECTOR CONSTRUCTION (TEC)**				**156,800**
1.1			**Technical Components**			**55,330**	
	.1		Main Injector Ring		42749		
		.1	Magnets	26809			
		.2	Vacuum	367			
		.3	Power Supplies	3991			
		.4	RF Systems	186			
		.5	Aborts	80			
		.6	Slow Extraction	17			
		.7	Instrumentation	904			
		.8	Controls	372			
		.9	Safety	329			
		.10	Utilities & Install	9695			
	.2		Beamlines		12582		
		.1	Magnets	5276			
		.2	Vacuum	214			
		.3	Power Supplies	2491			
		.4	Injection Systems	839			
		.5	Extraction Systems	237			
		.6	Instrumentation	468			
		.7	Controls	229			
		.8	Safety	269			
		.9	Utilities & Install	2559			
1.2			**Civil Construction**			**34,840**	
	.1		Site Preparation		2274		
	.2		Ring Enclosure		11767		
	.3		Beam Line Enclosures		1974		
	.4		Ring Service Buildings		1677		
	.5		MI-70 Service Building		2302		
	.6		North Hatch Building		933		
	.7		Utilities & Services		5042		
	.8		FO Enclosure		2371		
	.9		RF/FO Service Building		840		
	.10		Beamline Connections		2364		
	.11		F-17 Kicker Building		95		
	.12		Landscaping & Paving		846		
	.13		Industrial Building #5		2350		
1.3			**EDIA**			**15,650**	
1.4			**Contingency**			**20,800**	
1.5			**Escalation**			**30,210**	
2.			**OTHER PROJECT COSTS**				**19,600**
2.1			**R&D**			**16560**	
2.2			**Pre-operating**			**2000**	
2.3			**Capital Equipment**			**1000**	
			TOTAL PROJECT COST (TPC)				**176,400**

Table 5-2: Cost Estimate Labor Codes & Rates ($/hour)

Fabrication		
Technician, Conventional Magnets	T1	25.50
Technician, Accelerator Division	T2	17.20
Shops, average capability	S1	33.00*
Shops, specialized/precision	S2	37.15
Installation		
Plumber, steam fitter, sheet metal	IP	32.00
Electrician	IE	36.00
Rigger, crane operator	IG	37.00
Laborer	IL	26.00
Surveyor	IA	28.50
EDIA		
Physicist	PH	31.30
Engineer	EN	30.10
Engineer, Construction Services	CE	38.00*
Designer/drafter	DC	30.00*
Drafter, Accelerator Division	DR	17.40
Programmer	PR	25.85
Administrative Support	AD	23.50

*Fermilab Service Center chargeback rates

Table 5-3: Total Labor Effort (Man-years, R&D included)

Fabrication		
Technician, Conventional Magnets	T1	326
Technician, Accelerator Division	T2	41
Shops, average capability	S1	1
Shops, specialized/precision	S2	3
Installation		
Plumber, steam fitter, sheet metal	IP	11
Electrician	IE	49
Rigger, crane operator	IG	5
Laborer	IL	1
Surveyor	IA	1
EDIA		
Physicist	PH	39
Engineer	EN	60
Engineer, CES	CE	74
Designer/drafter	DC	38
Drafter, Accelerator Division	DR	57
Programmer	PR	0
Administrative support	AD	9
Total		**715**

Table 5-4: TEC Spending Profiles (Dollar Amounts in Thousands)

Fiscal Year	Obligations		Costs	
	1989	Then-year	1989	Then-year
1992	33730	39400	25440	29310
1993	51570	63400	50870	61910
1994	33970	44000	39700	51140
1995	7340	10020	10590	14460
Total	**126600**	**156800**	**126600**	**156800**

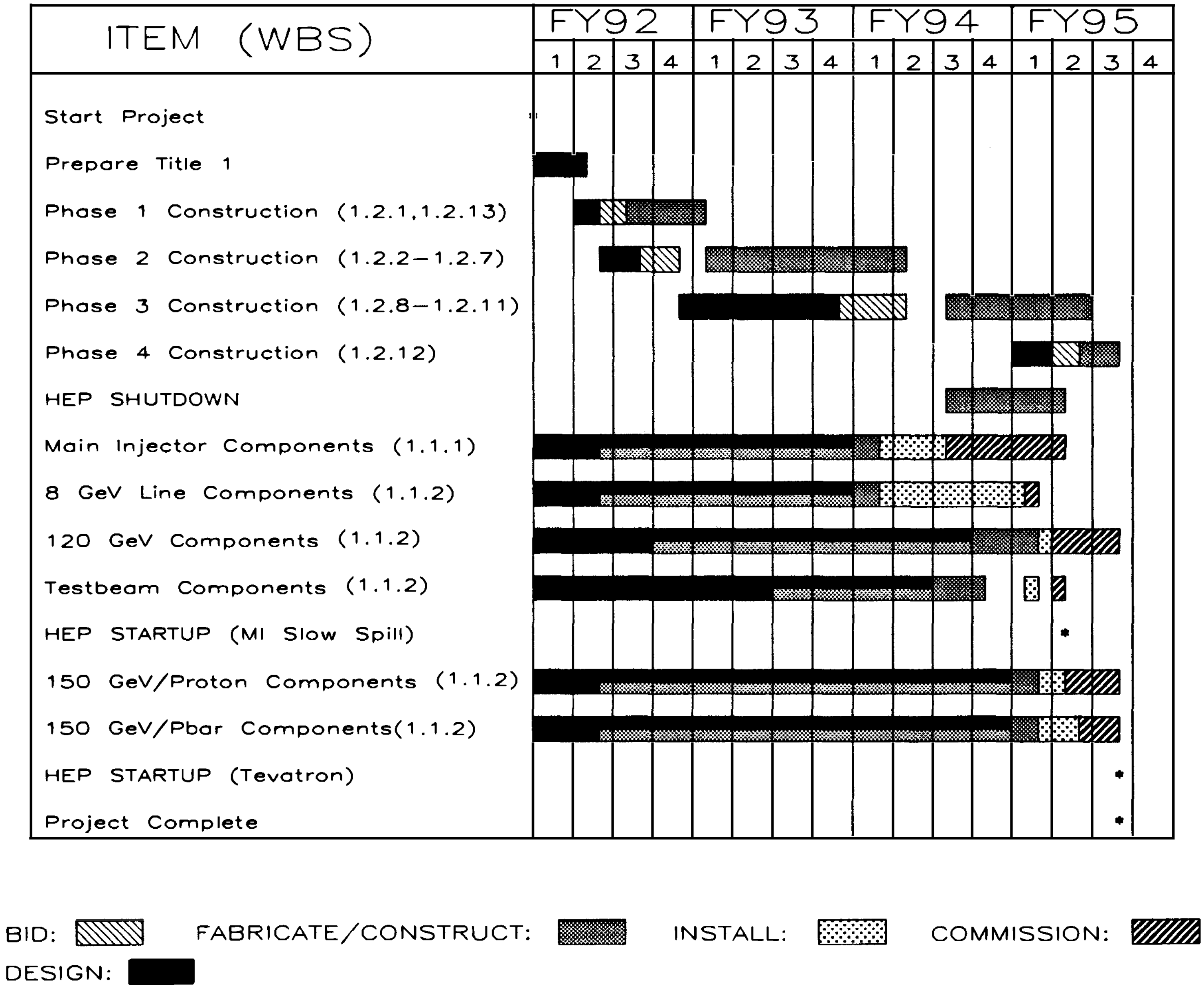
6. SCHEDULE

It is proposed that the Main Injector project be completed over the period October 1, 1991 through June 1, 1995. The schedule is shown in Figures 6-1 (project schedule) and 6-2 (civil construction schedule). The period October 1, 1989 through September 30, 1991 will be devoted to preconstruction R&D with preparatory engineering in support of construction beginning on October 1, 1991. The schedule shown reflects the spending profile given in the Construction Project Data Sheets (Appendix I) and the total manpower estimate shown in Table 5-3. The schedule results in a nine month disruption to HEP operations. This disruption will start on May 1, 1994.

A set of project milestones is given in Table 6-1. As can be seen the Main Injector ring and 8 GeV beamline can be largely installed without disturbing Tevatron operations. The length of the HEP shutdown is tied to the civil construction in the area of FO. Overall downtime has been minimized by situating the Main Injector 10 meters away from FO so that commissioning can actually begin prior to completion of construction in this area. As currently envisioned priority would be given to installing and commissioning the 150 GeV proton and 120 GeV slow spill lines so that operations in a fixed target mode with beams emanating from the MI would be initiated following the shutdown. The 120 GeV $\bar{p}$ production line and 150 GeV $\bar{p}$ transfer line would then be commissioned during the fixed target run, allowing for a collider startup in early 1995.

Table 6-1: Major Project Milestones

	Milestone	Date	Description
1989	1	October 1	Start Magnet R&D
1990	2	October 1	Complete First Dipole Prototype
1991	3	October 1	Start Project, Start Title 1 Design
1992	4	March 1	Start Magnet Production
	5	April 1	Start Civil Construction
1993	6	December 1	Beneficial Occupancy of Main Injector Enclosure, MI-70, and North Hatch Building. Start MI and 8 GeV Installation.
1994	7	February 1	Beneficial Occupancy all MI Service Buildings.
	8	May 1	Complete MI Installation. Start MI Commissioning (Power Test).
	9	May 1	**Begin HEP Shutdown.** Begin Equipment Removal at FO.
	10	May 15	Start FO Construction.
	11	August 15	Complete 8 GeV Beneficial Occupancy.
	12	November 1	Complete 8 GeV Installation. Start 8 GeV Commissioning.
	13	December 1	Beneficial Occupancy of FO and 150/120 GeV Enclosures. Start 150/120 GeV and Tevatron FO Installation.
1995	14	January 1	Start 120 GeV Slow Spill Line Commissioning.
	15	February 1	Complete Commissioning of MI and 120 GeV Slow Spill Line. **HEP Startup (MI Slow Extracted Beam).**
	16	February 1	Complete Installation of Tevatron FO Components. Begin commissioning 150 GeV, 120 GeV Lines.
	17	April 1	Beneficial Occupancy of FO Building.
	18	June 1	Finish Commissioning 120 GeV and 150 GeV Lines. **HEP Startup (Tevatron).**
	19	June 1	Paving and Landscaping Complete. **Project Complete.**


ITEM (WBS)
FY92
FY93
FY94
FY95
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Start Project
Prepare Title 1
Phase 1 Construction (1.2.1,1.2.13)
Phase 2 Construction (1.2.2–1.2.7)
Phase 3 Construction (1.2.8–1.2.11)
Phase 4 Construction (1.2.12)
HEP SHUTDOWN
Main Injector Components (1.1.1)
8 GeV Line Components (1.1.2)
120 GeV Components (1.1.2)
Testbeam Components (1.1.2)
HEP STARTUP (MI Slow Spill)
150 GeV/Proton Components (1.1.2)
150 GeV/Pbar Components(1.1.2)
HEP STARTUP (Tevatron)
Project Complete
BID:
FABRICATE/CONSTRUCT:
INSTALL:
COMMISSION:
DESIGN:

FERMILAB CONSTRUCTION SCHEDULE	PROJECT TITLE	PROJECT NO.	DATE	REVISION DATE	PAGE
	FERMILAB UPGRADE: MAIN INJECTOR CIVIL CONSTRUCTION SCHEDULE AND MILESTONES	6-6-1	Jan. 1990		1/2

DESCRIPTION CONSTRUCTION PACKAGE	1991 J F M A M J	1992 J A S O N D J F M A M J	1993 J A S O N D J F M A M J	1994 J A S O N D J F M A M J	1995 J A S O N D
TITLE 1 DESIGN & APPR.	---------[1]	--[2]		..A[11]CCELERATOR OFF..[16]STARTUP..[19]	
Phase 1: WBS 1.2.1&.13					
SITE PREPARATIONS		===[3]+++xxxxxxxxxxxxxx[5]			
INDUSTRIAL BLDG. NO.5		===[3]+++xxxxxxxxxxxxxxxxxxxxx	[6]xxxx		
Phase 2: WBS 1.2.2-.7					
M.I. RING ENCLOSURE		=========[4]+++xxxxxxxxx	xxxxxxxxxx[7]xxxxxxxxxxx[9]x	xx	
BEAM LINE ENCLOSURES		=========[4]+++xxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxx[9]x	xx	
SERV. BLDGS. # 10-53		=========[4]+++xxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxxxx	xx[10]xx	
MI-70 SERV. BLDG.		=========[4]+++xxxxxx[5]x	xxxxxxxxxxxxxxxxxxxxxx[9]x	xx	
NORTH HATCH BUILDING		=========[4]+++xxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxx[9]x	xxxx	
UTILITIES & SERVICES		=========[4]+++xxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxx[9]x	xxxxxxxxx	
Phase 3: WBS 1.2.8-.11					
F-0 ENCLOSURE		= = = = =====	==================[8]+++x	xxxxxxxxx[12]xx[13]xxxxxxx[15]	xxxx
B-0 SERV. BLDG.		= = = = =====	==================[8]+++x	xxxxxxxxx[12]xx[13]xxxxxxxxx	xxxxxx[18]xxx
BEAM LINE ENCLOSURES		= = = = =====	==================[8]+++x	xxxxxxxxxxxxxxx[14]xxxxx[15]	xxxx
F-17 KICKER SERV. BLDG.			= = = ==========[8]+++x	xxxxxxxxxxxxxxx[14]xx	
Phase 4: WBS 1.2.12					
LANDSCAPING AND PAVING				=====	==[17]++xxx[19]

(Refer to Page 2 for Milestone List)

LEGEND: 0000 ACCELERATOR OPERATIONS; - - - - CONCEPTUAL DESIGN/TITLE 1; ==== FINAL DESIGN/TITLE 2; ++++ BID & AWARD SUBCONTRACT; XXXX CONSTRUCTION & INSTALLATION; VVVV PROCUREMENT EQUIP./MAT'L.; BO BENEFICIAL OCCUPANCY; ==3++ MILESTONE NUMBER

HDFORM.OLC8

FERMILAB CONSTRUCTION SCHEDULE	PROJECT TITLE FERMILAB UPGRADE: MAIN INJECTOR CIVIL CONSTRUCTION SCHEDULE AND MILESTONES	PROJECT NO. 6-6-1	DATE Jan. 1990	REVISION DATE	PAGE 2/2

Year	No.	Date	Description
1991			
	1	Oct. 1	Start Title 1 Design Report.
1992			
	2	Feb. 1	Title 1 Design Report Reviewed and APPROVED by D.O.E.
	3	Mar. 1	Release Phase 1 Bid Packages for M.I. Site Preparations and Industrial Bldg. No. 5.
	4	July 1	Release Phase 2 Bid Packages for M.I. Beam and Ring Enclosures, Service Buildings and Utilities.
	5	Dec. 1	MI-70 Retention Wall Installed. Site Preparations Subcontract Complete.
1993			
	6	Mar. 1	Beneficial Occupancy of Industrial Bldg. No. 5.
	7	June 1	M.I. Ring Enclosure Excavation and Concrete Base Slab Complete.
	8	Oct. 15	Release Phase 3 Bid Packages for F-0 Enclosures and all Beam Line Enclosures and Modifications Requiring Shutdown.
	9	Dec. 1	Beneficial Occupancy of M.I. Ring Enclosure, MI-70 Service Building, North Hatch Building and Kautz Road Master Substation.
1994			
	10	Feb. 1	Beneficial Occupancy of all M.I. Service Buildings.

Year	No.	Date	Description
1994			
	11	May 1	ALL ACCELERATOR OPERATIONS OFF.
	12	May 15	Beam Equipment Removed and Demolition Started at F-0 Enclosure and Service Building. START DOUBLE SHIFT CONSTRUCTION AT F-0.
	13	July 15	F-0 Retention Wall Installed and F-0 Service Building Addition and Enclosure Demolished.
	14	Aug. 15	Beneficial Occupancy of all 8 GeV Beam Enclosures and F-17 Kicker Service Building.
	15	Dec. 1	Beneficial Occupancy of F-0 Beam Enclosure & 150/120 GeV Beam and Beam Enclosures.
1995			
	16	Feb. 1	MAIN INJECTOR STARTUP for Slow Extracted Beam.
	17	Feb. 15	Release Phase 4 Construction Bid Package for Paving and Landscaping.
	18	Apr. 1	Beneficial Occupancy of F-0 Service Building.
	19	June 1	TEVATRON STARTUP. Landscaping and Paving Complete at all Main Injector Areas. MAIN INJECTOR PROJECT COMPLETE.

(Refer to Page 1 for Construction Schedule)

HDFORM.OB88

APPENDIX A

Schedule 44

DEPARTMENT OF ENERGY
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
FY 1992 BUDGET REQUEST
(TABULAR DOLLARS IN THOUSANDS. NARRATIVE MATERIAL IN WHOLE DOLLARS.)
CONSTRUCTION PROJECT DATA SHEET

CHICAGO OPERATIONS
Field Office

HIGH ENERGY PHYSICS
FERMI NATIONAL ACCELERATOR

1. Title and location of Project:
Fermilab Main Injector
Fermi National Accelerator Laboratory, Batavia, Illinois

2. Project No. 92-CH-400

3. Date A-E work initiated: 1st Quarter FY 1992

3a. Date physical construction starts: 3rd Quarter FY 1992

4. Date construction ends: 3rd Quarter FY 1995

5. Previous cost estimate: $129,400

6. Current cost estimate: $156,800
Date: January 1989

7. Financial Schedule:

Fiscal Year	Authorization	Appropriation	Obligation	Costs
1992	$156,800	$39,400	$39,400	$29,300
1993		63,400	63,400	61,900
1994		44,000	44,000	51,100
1995		10,000	10,000	14,500
Total	$156,800	$156,800	$156,800	$156,800

8. Brief Physical Description of Project

This project provides for the construction of a new replacement accelerator, designated the Main Injector, to provide particles for injection into the existing Fermilab superconducting Tevatron accelerator and for direct delivery to the existing fixed target experimental areas. The accelerator is 3.3 km in circumference and is capable of accelerating protons to 150 GeV. It is constructed using conventional iron core magnets. Also provided are five new beamlines required to tie the Main Injector into the existing accelerator complex and to provide slow extracted beam to the A0 Transfer Hall, from where it can be directed toward the fixed target experimental areas. The accelerator will recycle many technical components from the existing Main Ring, including quadrupole magnets, some power supplies and correction magnets, RF systems, some controls components, and diagnostic devices. Following commissioning of the Main Injector, operation of the Main Ring will cease.

9. Purpose, Justification of Need for, and Scope of Project

The purpose of this project is to increase the luminosity available at the Fermilab Proton-Antiproton Collider, to improve data collection efficiency in the CDF and D-ZERO detectors through elimination of the Main Ring background, to increase the number of protons which can be delivered to the Tevatron for acceleration and delivery to the fixed target experimental areas, and to provide 120 GeV protons to these experimental areas during Collider operation.

The Fermilab Proton-Antiproton Collider is presently running with a peak luminosity of 2×10^{30}. The primary programmatic goal at Fermilab is to increase the luminosity delivered to the experimental detectors by at least a factor of 30. Increasing the luminosity is intimately related to increasing the number of antiprotons available. Measures are currently being taken to increase the antiproton production rate by a factor of about 3. However, following implementation of these improvements the 20-year old Main Ring accelerator will remain the primary bottleneck restricting further production rate improvements. The Main Injector is designed to remove this bottleneck.

Substantially improved performance is expected to result from the improved aperture of the Main Injector and its increased cycle rate. Protons are presently delivered to the Main Ring, and will be delivered to the Main Injector, from the 8 GeV Booster. The Booster currently has an aperture which is significantly larger than that of the Main Ring, hence the bottleneck. The aperture of the Main Injector is designed to be 30% larger than the aperture of the 8 GeV Booster. The improvement arises from tighter focussing, improved field quality, and the elimination of overpasses. It is anticipated that the Main Injector will be capable of accelerating as many as 3×10^{13} protons when filled with six Booster batches. For antiproton production, the ring is designed to cycle to 120 GeV in 1.5 seconds as compared to 2.6 seconds with the existing Main Ring. As a result we expect the total number of protons per cycle deliverable from the Main Injector to be up to a factor of three higher, and the number of protons per second deliverable to the antiproton production target as great as a factor of 5 higher, than achieved from the present Main Ring operation.

Specifically provided for in the scope of the project are:

a. Construction of the enclosure (~10,900 linear feet), service buildings (~27,400 square feet), utilities, and new technical components required to implement the Main Injector accelerator. New technical components required include dipole magnets, power supplies, and vacuum systems.

b. Construction of beamline enclosures (~4,100 linear feet), service buildings (~5,800 square feet), utilites, and technical components required to implement the 8 GeV Booster-to-Main Injector beamline, the 150 GeV proton and antiproton Main Injector-to-Tevatron transfer lines, and the 120 GeV Main Injector-to-Antiproton Production Target beamline.

c. Construction of technical components required to implement the delivery of 120 GeV beam from the Main Injector to the A0 Transfer Hall.

d. Modifications to the F0 area of the Tevatron (~5,900 square feet) required for installation of the 150 GeV proton and antiproton transfer lines.

e. Construction of a new Industrial Building, IB-5 (~19,200 square feet), required for assembly of magnets.

f. Construction of a new sub-station and 345KV power lines for delivery of power to the MI site.

10. Details of Cost Estimate

	Item Cost	Total Cost
a. EDI&A at 16.9% of construction costs (G&A included)		$18,900
b. Main Injector construction costs		111,500
1. Conventional construction	$43,000	
2. Special facilities	68,600	
c. Contingency at 20.2% of above cost		26,400
Total		$156,800

11. Method of Performance

Design of facilities will be by the operating contractor and subcontractors as appropriate. To the extent feasible construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids.

12. Schedule of Project Funding and Other Related Funding Requirements

	FY 1992	FY 1993	FY 1994	FY 1995	TOTAL
a. Total project cost					
1. Total facility costs					
(a) Construction line item	$29,300	$61,900	$51,100	$14,500	$156,800
Total facility cost	$29,300	$61,900	$51,100	$14,500	$156,800
2. Other project costs					
(a) R&D costs necessary to complete construction (G&A included)	$7,800	$5,600	$2,600	$600	$16,600
(b) Pre-operating costs	$0	$0	$1,000	$1,000	$2,000
(c) Capital equipment	$400	$400	$200	$0	$1,000
Total other project costs	$8,200	$6,000	$3,800	$1,600	$19,600
Total project costs	$37,500	$67,900	$54,900	$16,100	$176,400

b. Total related incremental annual funding requirements (estimated life of project: 20 years)

1. Facility operating costs for Main Injector power	$4,300
2. Facility operating costs for 120 GeV slow spill operation	$1,200
Total incremental annual funding	$5,500

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

a. Total project costs
   1. Total facility cost
      (a) Construction line item - explained in items 8, 9, 10.
   2. Other project costs
      (a) Direct R&D operating costs - This will provide for the design and development of critical new components and for the fabrication and testing of prototypes. R&D on all elements of the project to optimize performance and minimize costs will continue through early stages of the project. Specifically included are development of the high current dipole magnet/power supply system and special length quadrupoles required in the Main Injector and beamlines. A subsection of the ring magnet/power supply system will be developed and tested in-situ in order to assure complete system development prior to cessation of Main Ring operations.
      (b) Pre-operating costs - Includes personnel and power costs for a six month commissioning period.
      (c) Capital equipment - Includes test instruments, electronics, and other general equipment to support 12.1.1.(a) and (b).

b. Total incremental funding requirements - It is assumed that the Fermilab Tevatron complex will continue to operate both the fixed target and collider programs, with each running about 40% of the time. It is further assumed that during both modes of running the Main Injector is supplying 120 GeV slow spill beams to the experimental areas. The Main Injector replaces the existing Main Ring in all its functional roles. The Main Injector and associated beamlines are designed to require nearly the same amount of power to operate as the existing Main Ring for antiproton production. However the slow spill cycle expends considerably more power. For 120 GeV slow spill operation of the Main Injector, assumed to be 80% of the time, there will be an increase in power costs of about $4.3M annually. The beamlines will require supplemental funding for M&S and personnel for these 120 GeV operations. This is estimated to be an additional $2M annual increment. The increase in operating costs in 12.b reflects solely the demands of delivering 120 GeV protons to the fixed target experimental areas during Tevatron collider and fixed targer runs.

14. Incorporation of Fallout Shelters in Future Federal Buildings

Not applicable.

15. Incorporation of Measure for the Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities.

The total estimated cost of this project includes the cost of those measures necessary to assure the facility will comply with Executive Order 12088.

16. Evaluation of Flood Hazard

This project will be partially located in the flood plain of Indian Creek, which originates on the Fermilab site. An active drainage system will allow the control of water levels within the region encompassed by the Main Injector ring. Measures will be taken to insure that the water retention capacity of the Indian Creek drainage basin is maintained both during the construction and operational phases of the project. Components installed in the underground Main Injector ring and beamline enclosures will be protected by pumps, as are all existing underground enclosures on the Fermilab site. Service buildings and enclosure access points will be located well above the floodplain. Construction will be in accordance with Executive Order 11988. An Army Corps of Engineers permit will be required prior to initiation of civil construction.

17. Environmental Impact

An Environmental Assessment is being prepared for this project. Any wetlands that will be disturbed during the course of the project will be restored as closely as possible to their original condition. Mitigation plans for any disturbance and/or loss of wetlands will only be finalized after consultation with the Corps of Engineers. Compensatory wetlands will be created in the vicinity of the disturbed wetlands in a ratio of 1-1/2 to 1 of existing wetlands removed from the Main Injector site. The project will be in compliance with the National Environmental Policy Act.

18. Accessibility to the Handicapped

Not applicable.

APPENDIX B

Project Basic Data and Validation Checklist

PROJECT BASIC DATA
for
FY92 VALIDATIONS

Program:	High Energy Physics/ Fermi National Accelerator	Status of Design:
Project:	Fermilab Upgrade: Main Injector	Conceptual - 100%
		Title I - 0%
		Title II - 0%
Project No:	BAKALIA 92-CH-400	

(Program Office Assigned number only, if available)

TEC:

The TEC is $ 156.8M
ED&I is 14.7% of Construction Cost
(Excluding construction management and project management at 2.6%)
Contingency: 20% of Design and Construction Cost.

Project Description and Background:

This project provides for the construction and installation of a new Main Injector Accelerator to replace the 150 GeV Fermilab Main Ring conventional accelerator. The purpose of this part of the project is to increase collider luminosity, to increase fixed target intensity, improve collider detector performance by the removal of a major source of background, and to provide a fixed target test beam at approximately 120 GeV during collider operation. An additional possible benefit is a future high duty factor Kaon production capability. A new tunnel for the 150 GeV Main Injector, with associated beamlines, extraction systems and an abort system will be constructed adjacent to the existing Tevatron Tunnel.

About 15,000 ft of tunnel and 58,300 (net 49,600) sq ft of service and industrial buildings will be constructed. Technical components for the Main Injector and the beamlines and beam transfers include conventional magnets and accelerator components. Some reuse of technical components from the existing Main Ring is included in the design of the Main Injector and extracted beam lines. The project includes service building, industrial building, and tunnel construction, standard and accelerator utilities, and new conventional magnets, expecially the main bending dipoles for the Main Injector.

An Environmental Assessment will be prepared, and approvals received prior to the start of the project.

FY92 Budget Authority (B/A):

The request is for $ 39.4M for FY92.
This request is to cover initial procurement for long term magnet and accelerator systems components for the conventional Main Injector accelerator.

This request also covers authority to release the bid package for the Main Injector, site prep, beam enclosures, and service buildings, and to start site prep construction.

The FY91 request was $30M; prior year funding was $0M.

Technical/R&D:

There is no particularly unusual construction in the beamlines and Main Injector. The Main Injector dipoles are a new, conventional, design however, and R&D will be carried out to obtain tooling and to prototype the new magnets and accelerator components. The Main Injector and the beamlines make extensive use of existing accelerator magnets and technical components.

Additional R&D costs are associated with power supplies for the new high current main dipoles and special length quadrupoles.

The risk of this project is low for a project of this type. The Fermilab staff is experienced in all aspects of this project; it is similar to the recently completed TeV I project in technical scope and detail.

Schedule:

Title I design start scheduled 1QFY92.
Title I and II design duration: 33 months total.
Procurement and construction start scheduled:
1QFY92, 3QFY92.
Procurement and construction complete: 3QFY95

Status of Documentation: (For major projects and major systems acquisitions only)

Justification for New Start:	Approved __/__/__	(mm/dd/yy)
Project charter:	Approved __/__/__	(mm/dd/yy)
Project Plan:	Approved __/__/__	(mm/dd/yy)

Additional Information:

Environmental Assessment will be required.

Contingency factor used is 20%. This is an overall factor and has been split for varying degrees of certainty in the different components of the work breakdown structure. The analysis has been carried to the 4th level for the technical components and to the third level for the civil construction. This overall contingency is appropriate for the present level of the conceptual design. As the design continues, it will probably become appropriate to allocate additional varying contingency factors as certainties become better determined.

FY92 FERMILAB UPGRADE: MAIN INJECTOR

PROJECT VALIDATION CHECKLIST

I. OBJECTIVES

Fermilab Upgrade: Main Injector project objectives and performance parameters have been developed to support the programmatic needs and goals of the laboratory. These have been defined in the light of much experience and a number of studies which have been made to understand the current limitations of the accelerator and how to improve the performance and utilization of the accelerator in order to support the High Energy Physics program in future years. Additional information has been supplied to the Validation Review Committee.

II. SCOPE

A. REQUIREMENTS

1. Facility Performance Requirements

Fermilab has kept both the High Energy Physics Program Office and the Batavia Area Office fully informed of the goals for the Fermilab Upgrade: Main Injector and the improvements expected. There is a mutual understanding of the programmatic needs for the Fermilab Upgrade: Main Injector project.

2. Facility Requirements

The general requirements for the facility both in terms of real property, buildings and hardware have been defined at the conceptual level of design. Materials documenting these requirements have been distributed to the Validation Review Committee.

3. Evaluation of Seismic and Tornado Hazards

The total estimated cost of the project includes the cost of those measures necessary to assure the facility will comply with DOE 6430.1. The project is located in an area of low seismic and tornado activity. The site is equipped with a tornado warning system. The underground enclosures will provide an adequate tornado shelter area.

4. Safeguards and Security Requirements

Advice and guidance from cognizant safeguards and security personnel will be utilized during the project planning and design stages. Any radiation hazards that are known to exist will be treated in the same manner as the hazards are now treated in the present operating complex under Accelerator Division control. The facility does not involve items of a classified nature. Physical security will be provided in the same manner as that currently existing in the accelerator facility.

5. Location

Location is determined, to a large extent, by the existing beam lines and accelerator enclosures and technical requirements. Basically, three alternative locations were considered for the Main Injector. The area selected best fits both the technical requirements and provides the best site from a civil engineering perspective. The project is in compliance with the overall Site Development and Facilities Utilization Plan. Land acquisition is not required.

6. Function Definitions

Functions of all major structures, systems and components are defined to the extent appropriate for a conceptual design.

7. Matching of Existing Facilities to Demands

To the largest extent possible, available utilities, roads and accesses and other support facilities will be used. In particular, extensive use will be made in the Main Injector of utilities relocated from the present Main Ring, such as transformers, and heat exchangers, as well as some of the technical components.

8. Initial Complement of Equipment

The requirements for the initial complement of equipment for the Main Injector Accelerator have been defined. Cost estimates for this accelerator equipment have been made based on similar equipment installed at Fermilab.

9. Quality Levels and Program Requirements

The quality levels and program requirements have been defined by many years of operation of the present facility. The levels and requirements have been incorporated into the conceptual design and cost estimate.

10. Emissions and Wastes

Emissions and wastes will be no different than those occurring in the presently operating accelerator. Total compliance with Federal and State emission and waste regulations will not be a problem.

11. Codes and Standards

The facility will operate within applicable local, state and national codes and standards. Compliance with DOE general design criteria

6430.1A will be maintained.

12. Office space

Office space is not required for the Main Injector project.

13. Space Requirements

Space for tunnel and equipment enclosures is in addition to current space. Where possible current equipment and tunnel enclosures will be utilized.

At the F0 (RF) straight section part of the rf building must be demolished in order to construct the modified tunnel enclosure at the injection point for 150 GeV protons and antiprotons to be delivered from the Main Injector to the Tevatron. Also, beamlines carrying 120 Gev protons to the antiproton target at AP-0 and to the Test Beam Line, and 8 GeV antiprotons from the Accumulator to the Main Injector traverse this region. When completed, two connected buildings, the rebuilt F0 rf building and a Main Injector Service Building MI-70 will house the rf systems for accelerators in both enclosures, and also beam transfer and extraction equipment for equipment to be located in the F0 and MI-70 locations in the respective tunnels.

B. DESIGN (Conceptual)

1. Design Status

All designs, at this point, are at the conceptual level. Studies have been made based upon current experience, and general civil engineering practices. All major items have been scoped. The scope has been well defined from the programmatic requirements of the Laboratory. The Fermilab Upgrade: Main Injector project has been included in the current Fermilab Site Development and Facility Utilization Plans. The schedule has been developed using time estimates based on similar work performed at Fermilab on projects of comparable nature. The Main Injector involves the construction of some new components and the relocation of some existing Main Ring components, and is similar in nature to numerous modifications made to the Main Ring in recent years. The Main Injector dipoles will be designed and prototyped starting in FY90. This work is similar to the production of conventional magnets for the Antiproton Source. Cost and schedule projections are based heavily on similar recent experience.

2. Site Conditions

Soil borings are available for areas in close proximity to the site considered. Recent nearby construction experience (TeV I) has been used to prepare cost estimates.

3. Safety hazards and Risks

Hazards and risks are characteristic of those already encountered in the accelerator complex and its construction. No new unique hazards are expected.

4. Solar Energy Applications

Solar energy applications were considered but no application was found to be appropriate.

5. Design Cost Effectiveness

The design is cost effective at a conceptual design level. Further studies to minimize cost and lifecycle costs will be carried out in parallel with the Title I design. In particular, specific attention will be paid to the design of the area where the proton and antiproton injection lines into the Tevatron from the Main Injector connect to the Tevatron at F0. Optimization of beam transport line design will also continue.

6. Environmental Assessment

The environment surrounding the proposed construction site has been characterized to the extent that the entire Laboratory site is characterized. Topology and hydrology are documented. The impact of the proposed facility on the environment will be no different from the existing facility; no unique hazards are expected. To be noted is the flow of Indian Creek through the proposed site of the Main Injector. Care will be taken to provide proper creek drainage.

Both wetlands and water retention areas in locations classified as floodplains will be preserved in quantity and character as required.

Sites classified as of archeological interest will be taken into account in the final design.

A Core of Engineers permit will be required and obtained.

7. Prerequisite R&D

The necessary R&D required to design and specify the basic system has been done. Additional R&D is in progress to refine the design. R&D will be required to work out detailed designs and to support prototype fabrication of the Main Injector main dipoles and of special components. These activities will continue to help refine the requirements that are necessary for specifying and accomplishing the construction of special facilities.

Some R&D may be necessary to support fabrication of the Main Injector main dipoles in quantity after prototyping is complete. A schedule for all the required R&D costs so far identified has been provided in the project data sheets. R&D funding will be required for detailed design, tooling, prototype fabrication, and production development for the Main Injector main dipoles and other necessary special components.

8. Participants

The conceptual designs presented to the Validation Review Committee have been prepared by Fermilab staff members. In particular, members of the Accelerator Division, Technical Support Section, and Construction Engineering Services have participated in the designs for the Main Injector Accelerator.

9. Uncertainties.

The Main Injector main dipole magnets are conventional, not superconducting, magnets. Their fabrication should be similar to recently constructed TeV I magnets. The civil construction techniques are similar to previous work on the Fermilab site. Thus, there are no unique aspects to this proposal. The 8,000 Ampere power supplies necessary for the Main Injector dipole bend bus might be classified as unusual, but are not regarded as technically unique.

10. Energy Conservation Report

An Energy Conservation Report will be prepared during Title I/II.

III. SCHEDULE

All of the following factors have been considered at a depth appropriate at this conceptual design level in developing the schedule.

- budget cycle timing
- contractor selection duration
- Headquarters review and approvals
- prerequisite R&D schedule constraints
- dependency upon timing and amount of operating funds
- historical experience on design, procurement, and construction durations
- procurement lead times for equipment (particularly reflecting vendor quotes)
- logical sequence of design, procurement, and construction
- reasonable manpower levels, buildup and rampdown
- reasonable obligation and costing rates
- shift work or overtime work requirements
- work space constraints
- exposure constraints

The construction schedule falls into three distinct phases. In the first phase, site preparation and the construction of Industrial Building #5 will be completed.

In the second phase, the large majority, if not all, of the Main Injector main dipoles will be fabricated, and the entire Main Injector ring tunnel enclosure constructed, as well as most of the beam transport lines. This conventional construction will include all of the Main Injector above ground facilities as well, with the exception of the work on the Tevatron side at FO. As occupancy becomes possible, the main dipoles may be set in place in the Main Injector. During this phase the fabrication of the new main dipoles will be the critical path.

During the above two phases, the existing accelerator complex will be maintained fully operational.

During the third phase the accelerator complex will be shut down. Civil construction of the FO tunnel enclosure, following demolition and removal of the existing enclosures, will be the critical path item. Main dipole fabrication will conclude, and installation of the main dipoles will be completed. Civil construction of those portions of the beam transport lines left unfinished in the first phase will be undertaken and completed. Installation of technical components to be removed from the existing Main Ring conventional accelerator can proceed in parallel in the Main Injector tunnel enclosure and Service Buildings. Reinstallation of components in the Tevatron FO area, and the completion of installation of components in the FO connecting and adjacent beam transport lines must await completion of the conventional construction. Since the Main Injector itself can be operated entirely within the new Main Injector tunnel enclosure, commissioning of the Main Injector can begin upon completion of installation of Main Injector components but prior to completion of the Tevatron FO reinstallation.

IV. Estimate

A. General

1. Estimate Preparation

The estimates presented were prepared in December 1988, and refined in August 1989 and January 1990. The cost estimate is done in FY89 base year dollars with the escalation shown in "year of expenditure" dollars.

2. Estimate Basis

Estimates are based upon conceptual design layouts, preliminary engineering calculations, and experience with similar projects done at Fermilab. Our recent experience with the TeV I construction project forms the basis for a large fraction of the cost estimate for this project. For construction, estimates are based on quantity takeoffs where available and square foot estimates. Cost comparisons have been made with specific portions of recent similar Fermilab construction such as Transfer Hall Addition, Booster Laboratories, Industrial Center Building, and several of the Tevatron I and II buildings. The cost estimate methodology is adapted from that used to estimate the Superconducting Super Collider (SSC) Injection System as incorporated into the SSC Conceptual Design Report. Manpower estimates where appropriate have been derived from the TeV I project, and recent experience (1988) on modification and reinstallation of Main Ring components has also been considered.

3. Support of Estimates

Vendor quotes are not appropriate at the conceptual level for this design. Catalogue prices have been used for components where appropriate. Manpower rates are based on present Fermilab Accelerator tech experience, Fermilab chargeback rates, or T&M trade rates. Commercially published construction data bases such as R. S. Means, have been used very successfully at Fermilab for cost estimation.

4. Contingency

The contingency reflects the degree of confidence in the scope of work, development features, pricing methodology, and complexity of the project. The contingency analysis provides for and is presently using a varying degree of uncertainty in the different components of the Work Breakdown Structure.

5. Escalation Rates

Escalation rates provided by DOE were used. The most recent information obtainable was dated August 1989.

6. Project Reviews

This is the second cost estimate submitted to DOE for this project and is a bottoms up estimate. It has been reviewed by knowledgeable Fermilab staff and management.

7. Uniqueness

The technical components and civil construction are similar to work that has already been done at Fermilab and are therefore not unique. The 8000 Ampere power supplies for the Main Injector dipole bus are unusual, however.

8. Estimating Guides

Conventional construction items and standard equipment estimates were made using standard estimating guides. Square foot estimating data available from commercial publishers (Means & Richardson) have been used where applicable.

9. Indirect Costs

All known indirect costs have been included in the estimate.

10. Title I/Title II Estimates

Not applicable.

11. Experimental Components

Experimental detector improvement costs for the CDF and D-Zero detectors are not included in the estimate. Detector upgrades are usually incorporated in the ongoing laboratory capital equipment expenditure profile.

12. Procurement Strategy

To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids. As presently planned, final magnet assembly will take place at Fermilab, as in the case of the TeV I project.

B. Construction

1. Bulk Materials

Both engineering drawings and past experience were used to estimate the bulk material quantities.

2. Quantity Growth

Normal estimating methods for conceptual estimates allow for quantity growth.

3. Bulk Material Pricing

The bulk material costs are current and reflect local conditions.

4. Labor Costs

Labor estimates are based on (Davis-Bacon) local rates where applicable and at actual average rate for component fabrication and include applicable fringe and other hidden costs. Costs have been derived from the Tevatron I Project. The local labor market has critical skill construction labor available.

5. Equipment Pricing

Equipment Pricing is based upon actual experience in the Tevatron I Project, other Fermilab construction, and on commercially published cost data.

6. Special Process Spares

Not applicable.

7. Indirect Costs

Indirect construction costs have been included.

8. Labor Productivity

Labor productivity is based on much local experience.

9. Labor Availability

All necessary craft labor is available in the Chicago area.

10. Pricing variants

To the extent required for the conceptual design, the cost estimate reflects code, QA, scheduling, climatic, geographic, and other unique specification requirements.

11. Unitized Pricing

Not applicable.

C. Engineering and Management

1. Contractor Project Management

Contractor project management and engineering costs are included in the EDIA.

2. EDIA Estimate

EDIA costs are estimated at the same percentage of construction costs as those for the recently completed Tevatron I Project at Fermilab.

3. Inspection

Inspection, QA, and QC costs have been included. Magnetic measurements and magnet assembly inspection are provided in the laboratory through G&A.

4. Management

FNAL has considerable experience with Program Management Control systems as used in TeV I and II. We consider the management system responsible for this activity to be mature and reasonable. Adequate personnel will be made available.

V. Funding and Costs Status

1. Basis for the Planned Authorization, Appropriation, and Cost Schedule.

The programmatic goal of the Fermilab Upgrade: Main Injector project is to achieve an improvement in Collider luminosity, an improvement in Fixed Target intensity, and to provide for the operation of test beams in approximately one half of the fixed target areas during Collider operation. This goal has been set by the demands of the physics experimental program. Increased luminosity in the mid 1990's time scale is crucial to productive utilization of the Tevatron. This increased potential is necessary for a viable national high energy physics program in the pre-SSC era. The test beam capability is vital to the development of detector technology for the SSC era. The authorization of the proposal at the earliest possible time is urged. The appropriation and obligation schedule is predicated on issuing the long-lead contracts at the earliest possible time. The costing is based on an estimate of the effort done as a function of time. The schedule calls for a shutdown of the order of one year for moving those Main Ring components to be reused into the Main Injector, and to accomplish the civil construction in the F0 area. In order for this shutdown to be utilized effectively all the civil construction for the Main Injector Ring and almost all of the beam transport line civil construction, and almost all of the Main Injector main dipoles must be complete prior to the shutdown. Thus, a significant fraction of the funding is required prior to shutdown. Any delay in authorization or appropriation will result in extending the time to operation.

2. Other Associated Project Costs

Other associated project costs include $ 19.6M R&D, preoperation, and capital equipment costs. When the project is complete there is expected to be a related annual funding increase for operating and improvement costs. These include cryogenic (in the test beams) and power costs, personnel and M&S costs totaling $ 4.3M, of which $ 1.2M is directly related to the operation of the test beam in the fixed target area. It is estimated that no additional people will be required to maintain and operate the facility.

3. Funding Consistency

The annual funding proposed is consistent with the project schedule. The schedule has been developed on the basis of a preliminary Critical Path Network (CPN). The CPN will be revised, updated, and expanded as the R&D, design, and project advances.

4. Continuing Resolution Alternatives

In the event of a continuing resolution, the project will be delayed proportionally.

5. Contributing Funding

External contributory funding is not considered for this project.

6. Incrementally Funded Construction Contracts

None.

7. Funding by Client or Consultant Agencies

Not applicable.

APPENDIX C

Environmental and Shielding Considerations

C. ENVIRONMENTAL AND SHIELDING CONSIDERATIONS

C.1 Environment

The proposed construction of the MI lies in approximately 400 acres southwest of the existing Main Ring tunnel, between the F0 building and the site boundary. Access to the construction project will be via the existing Kautz Road. Efforts will be made throughout the construction period to protect and enhance the local conditions. The need for an Environmental Assesment has been determined and such a document will be prepared over the next six months.

The area is a floodplain fed by Indian Creek, which originates on the Fermilab site and gives rise to a wetland region encircled by the proposed ring. The tree cover directly in the path of the tunnel, roads, and cooling ponds represents a small percentage of the total tree cover in the region. The affected wooded areas are previously disturbed regions of young immature trees and do not need to be avoided. The higher quality forested regions will be undisturbed and protected from construction traffic and debris.

The tunnel with its underdrain system will affect the water levels inside the ring. In order to maintain the character of the site an active drainage system to allow active control of the water level will be installed. Changes of water levels over a long time period affect the area; the dead trees in the rookery are the result of such changes. The ability to control the water level will ensure that existing flow patterns will be maintained inside and outside the ring. The project will add approximately 16 acres of surface water through the cooling pond system.

The construction goes through prairie plot #12. At the present time this plot does not contain any threatened or endangered plant species. Fifty acres of corn leases lie inside the proposed ring. These leases will be retired and the area could be used to enhance the prairie project acreage.

The construction area contains no known archaeological sites; however, some of the land adjacent to Indian Creek has not been surveyed. A study of this region will be completed by the end of 1988. There is sufficient time available in the schedule to allow any new sites uncovered by this survey to be examined, if desired. The Lorentz site does lie within the new ring but will be unaffected by the construction. Any topsoil disturbed by the construction will be replaced, graded, and reseeded as part of the project. The visual impact of the project will be minimal. The highest item will be the tunnel berm, which is not expected to exceed 20 ft. Existing vegetation next to the bicycle path will be augmented to reduce the visual impact and restrict access.

C.2 Shielding

Calculations of radiation dose near the tunnel are mode for two conditions: when beam is lost on the magnets, and when it is dumped intentionally. The dose is estimated both on the surface of the earth berm covering the tunnel and at the site boundary at the point of closest approach (approximately 75 m) to the MI. These represent the expected maximum exposure conditions respectively for Fermilab personnel (in areas of unrestricted access) and the general public. A constant berm thickness of 17 ft, corresponding to that of the present Main Ring, is assumed. For each location estimates are made assuming two beam loss scenarios: an integrated dose when the full beam is lost accidentally at one point, and a dose rate (rem/year) under normal operating conditions. The dose rate in the vicinity of the abort dump (sec. 2.10) is also investigated. It is convenient to treat hadron dose separately from muon dose. The dose per proton lost is calculated using the Monte Carlo code CASIM.[5] The result is then converted, assuming certain loss mechanisms and loss rates, to a give a final estimate of dose.

CASIM results compare well with dose measurements for a variety of hadron and muon shielding arrangements under known beam loss conditions. The tunnel geometry in CASIM consists of a close approximation to a continuous dipole centered in a 1.5 m radius tunnel of circular cross section. The arc radius of the tunnel is 400 m and the continuous dipole field is chosen at 1.25 Tesla so as to accommodate 150 GeV protons in the aperture. The field outside the dipole gap is supplied numerically. The tunnel is completely and uniformly surrounded by soil with a (Fermilab standard) density of 2.24 g/cm^3.

The operating scenario assumes either a 150 GeV ramp at a 3 sec cycle with an operating intensity of 3×10^{13} protons per pulse, or a 120 GeV ramp at a 1.5 sec cycle with 4×10^{12} protons per pulse. These cycle times represent the fastest possible rates. The MI is assumed to run 60% of the time, divided equally between 150 GeV and 120 GeV operation. Under these conditions, about 1.2×10^{20} protons are accelerated per year. For the worst case accidental loss scenario the full 150 GeV beam is assumed lost at one point in the ring for 10 successive machine cycles (i.e., 3×10^{14} protons). To establish dose rates under normal operation it is assumed that each cycle loses 20% of the protons at low energy (8-20 GeV) and 1% at high energy (120 or 150 GeV), spread uniformly around the ring. The low energy losses are anticipated to occur but no measurable beam loss is expected at high energy. The 1% figure is strictly for the purpose of establishing safety criteria and should be regarded as an upper limit.

<u>Hadron Dose</u>

A loss point is assumed to occur in the middle of the beampipe. Since the hadron dose in the soil is mainly due to neutrons, it is quite insensitive to the lateral position of the loss point within the beampipe. For the same reason it is acceptable to average the dose over the tunnel azimuth. Figures C-1 and C-2 show isodose contours due to hadrons in the soil outside the tunnel for injection and high energy, respectively. The abscissa is the distance along the tunnel arc from the loss point. The curves are normalized to a single proton lost.

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5. A. Van Ginneken, Fermilab publication FN-272 (1985).

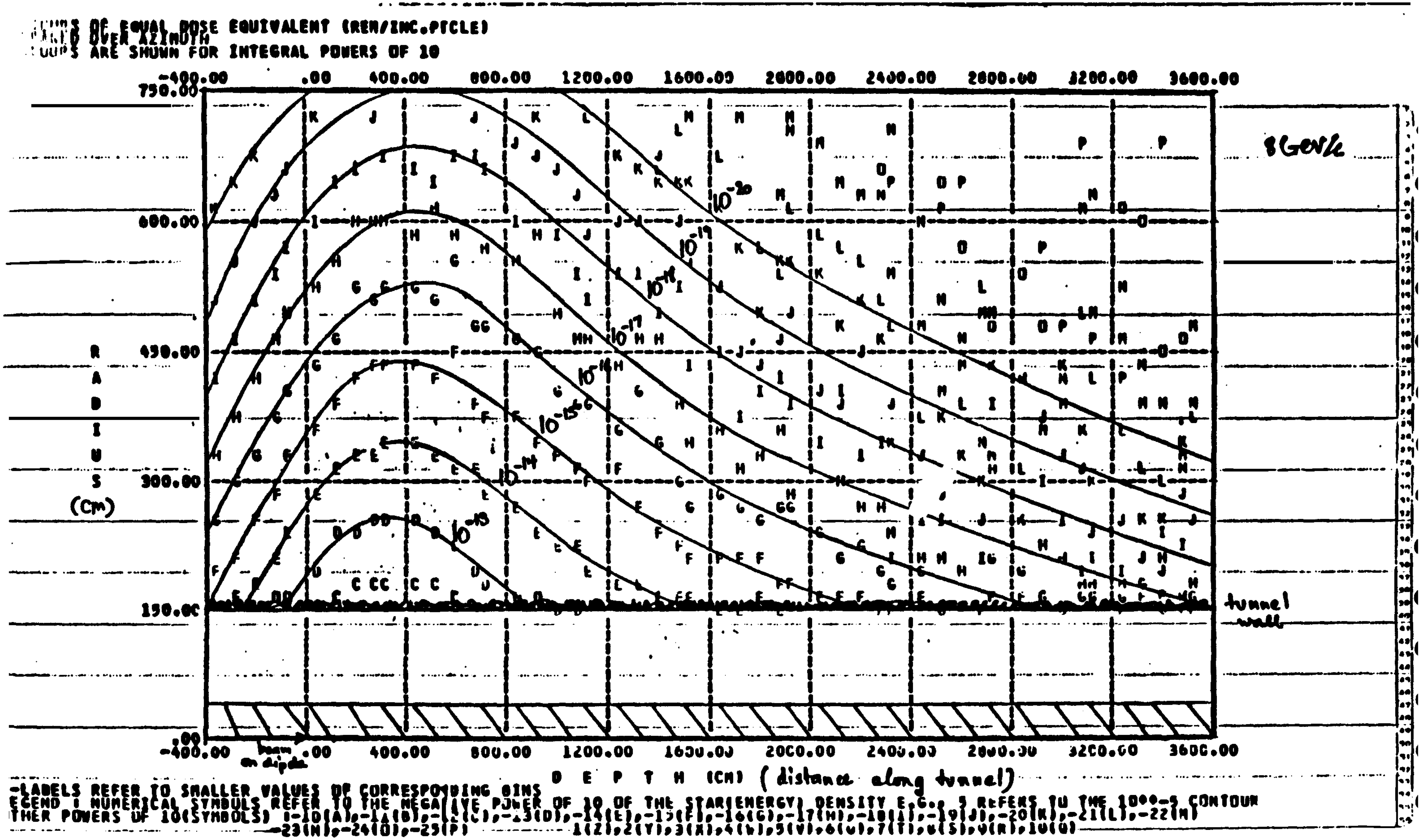


Figure C-1: Isodose contours due to hadrons in the MI berm per 8.9 GeV/c proton lost. All distances are in centimeters.

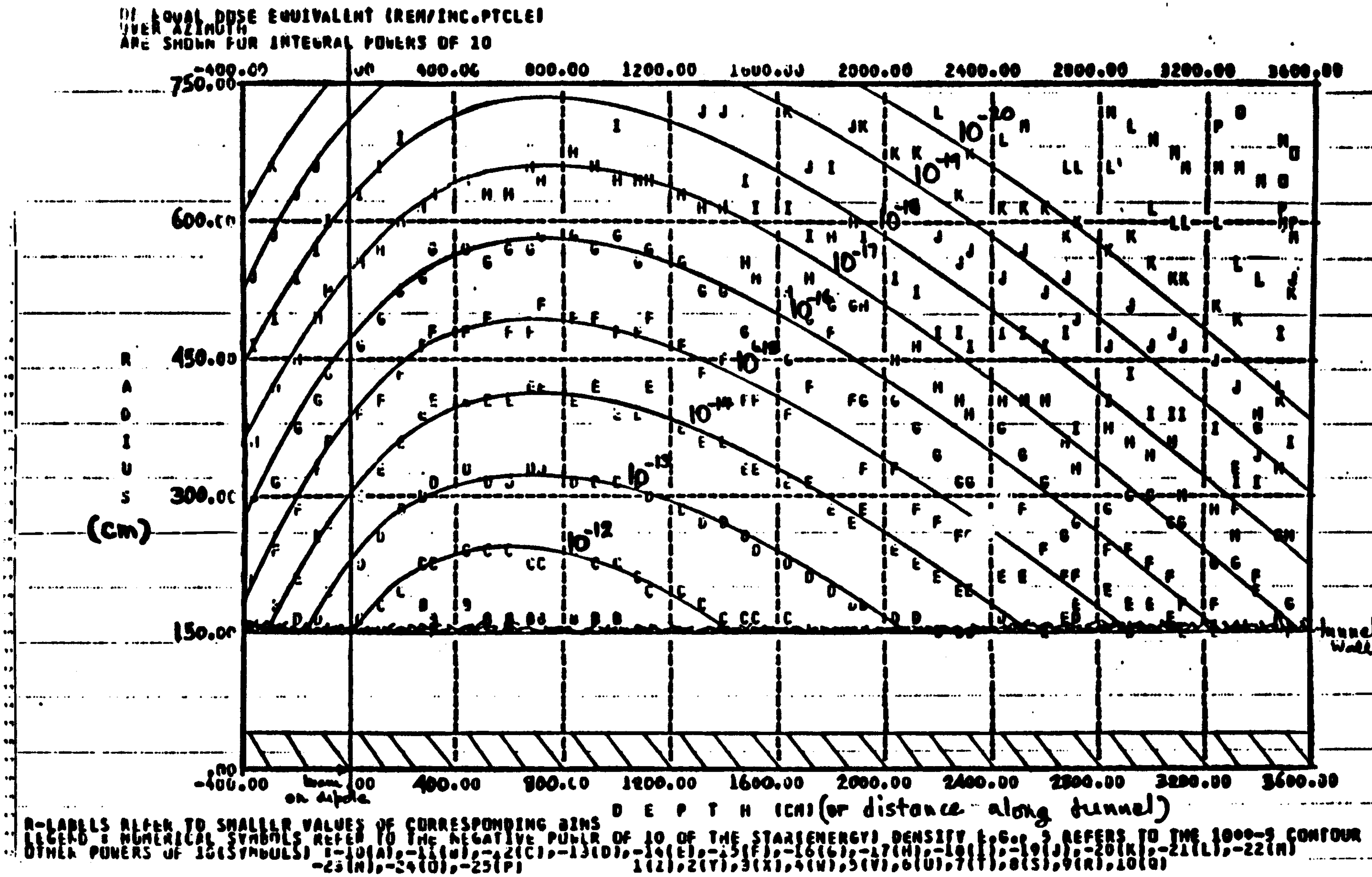


Figure C-2: Isodose contours due to hadrons in the MI berm per 150 GeV/c proton lost.

For the accidental loss scenario Figures C-1 and C-2 predict an exposure of about 3 mR at the surface of the berm. Fermilab radiation criteria require this area to be defined as minimal occupancy, i.e., unrestricted but no continual occupancy (equipment but not offices). Clearly, there is no intention of constructing any permanently occupied buildings directly on top of the berm. Further from the berm, the dose diminishes at least as fast as the inverse of the distance from the loss point, so that at about 60 ft from the berm the dose falls below the level where minimal occupancy regulations apply (1 mR). At the site boundary (about 75 m), the dose from such accidental losses is reduced further by at least a factor of four. Under the scenario for routine operation the annual exposure rate at the surface of the berm is 50 mR/year from 150 GeV beam and 250 mR/year from lower energies. The combined value is below the 500 mR/year limit for permanent occupancy. Since the distance of closest approach to the site boundary is reasonably small compared to the dimensions of the MI it is acceptable to use 1/r scaling which extrapolates to an off-site dose rate of 20 mR/year due to routine operation. Because of the relatively short distance, the surrounding air can be ignored in calculating the maximum off-site dose rate.

Muon Dose

For a circular ring the muon dose is maximum close to a line tangent to the loss point. Averaging over azimuth is no longer justified since the worst muon penetration is expected in the median plane, though up-down symmetry still holds. Beam loss on the inside of the beampipe produces a larger muon flux by providing a relatively long pion decay length along the tangent inside the beampipe.

Figures C-3 and C-4 show isodose contours in the median plane for beam loss on the radial inside and radial outside of the beampipe, respectively. Because the ring elevation is between 10 ft and 20 ft below grade, the isodose contours of Figures C-5 and C-6, which represent averages over top and bottom quadrants, are more relevant in calculating muon dose rates at the surface. Since 8 GeV muons range out in less than 20 m, only the high energy component warrants consideration. Under the worst case loss condition the highest muon dose is only 0.3 mR and occurs about 70 m downstream of the loss point, where the berm meets grade level (assumed to be 10 ft above the center of the tunnel). The average exposure rate during routine operation at the surface of the berm is also small and amounts to approximately 12 mR/year. The dose at the site boundary is estimated at 0.3 mR for the worst case scenario and at 10 mR per year for routine operation. Clearly muons do not pose a problem.

Abort Dump

The abort dump described in Section 2-10 is patterned after the dump currently in use in the Tevatron/Main Ring complex. The trajectory of the beam line to the dump slants downward by 10 mrad, which results in 6 m of soil coverage at the dump location from the existing grade level. The maximum number of protons accelerated per year in the MI is expected to be about 2.5 times the number typical for the Main Ring. This means that approximately 2.5×10^{18} protons/year will strike the MI abort dump. The high density construction of the beam dump ensures that the hadron dose in the immediate vicinity of the dump is negligible. The major radiation problem associated

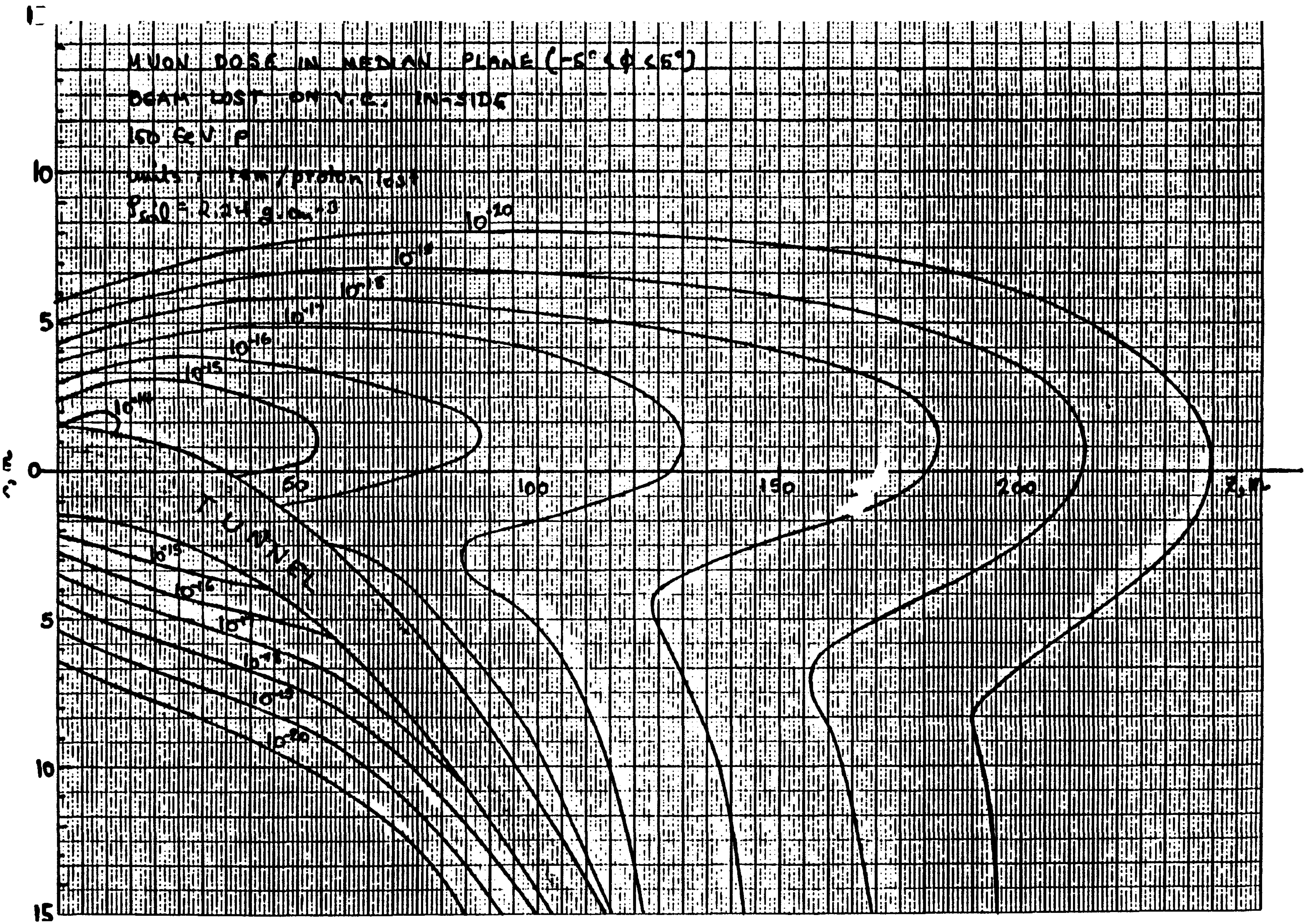


Figure C-3: Isodose contours due to muons in the median plane for a 150 GeV proton lost on the radial inside of the MI beampipe.

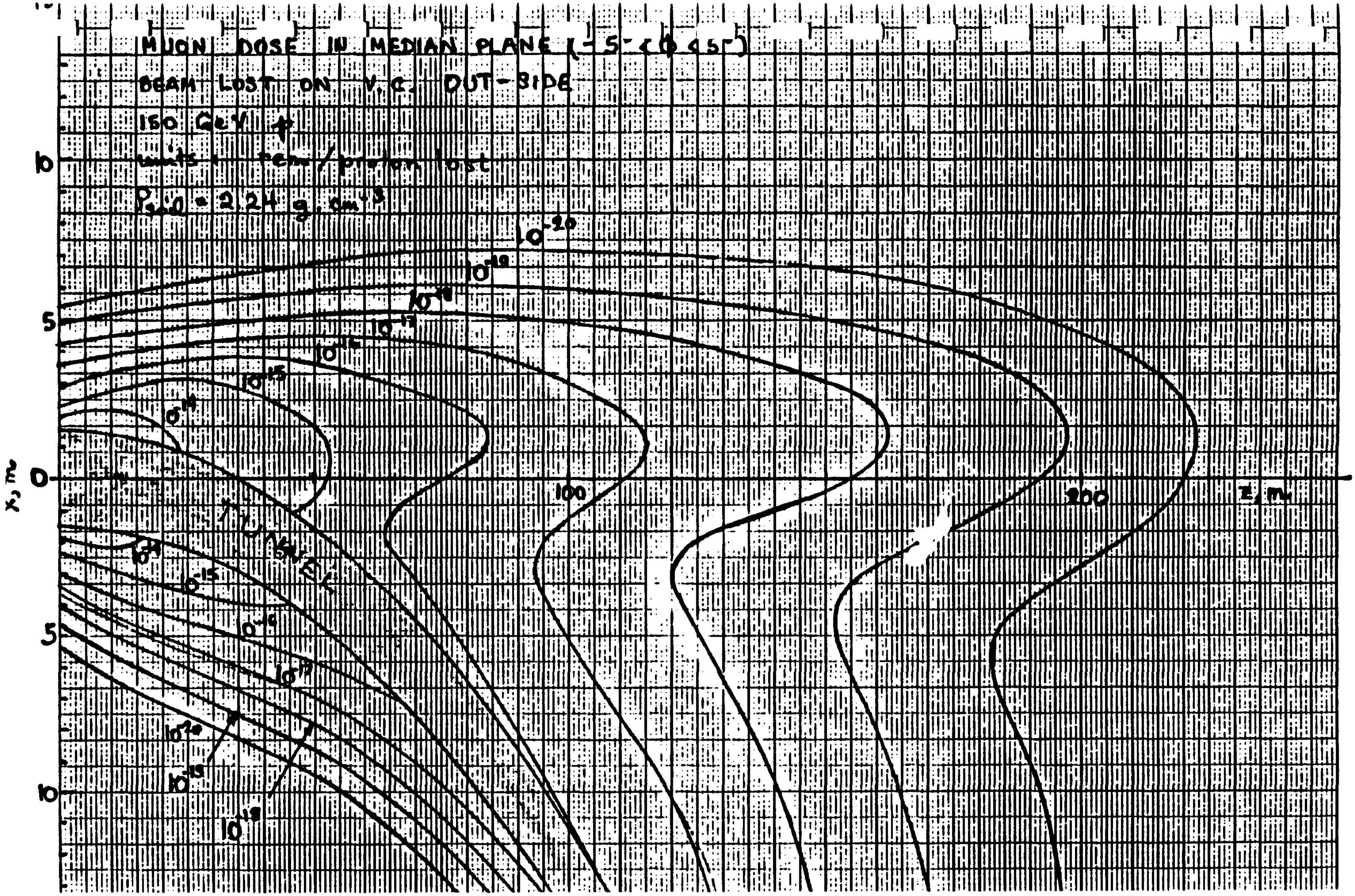


Figure C-4: Isodose contours due to muons in the median plane for a 150 GeV proton lost on the radial outside of the MI beampipe.

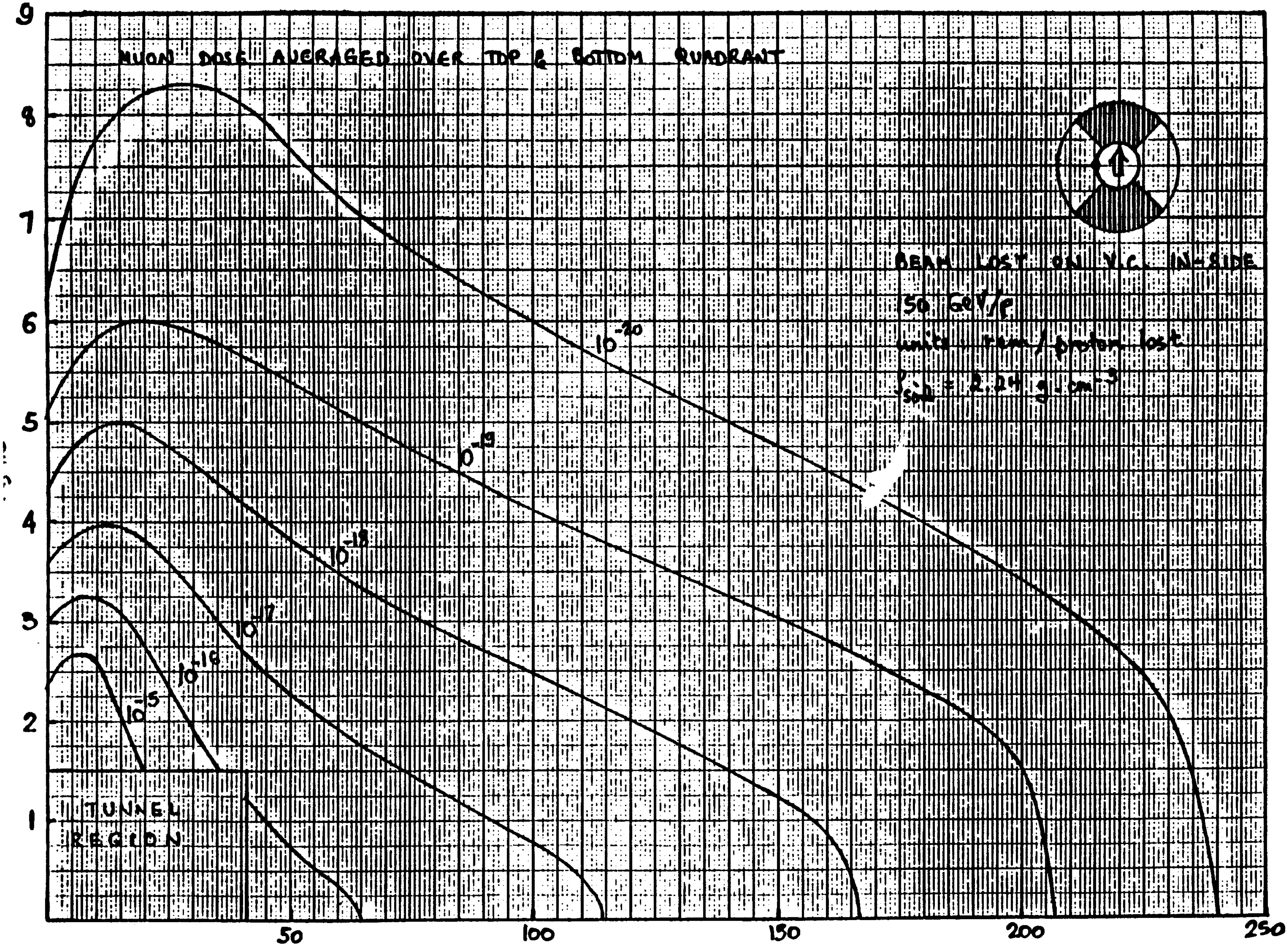


Figure C-5: Isodose contours averaged over top and bottom azimuths for muons produced under the same conditions as C-3.

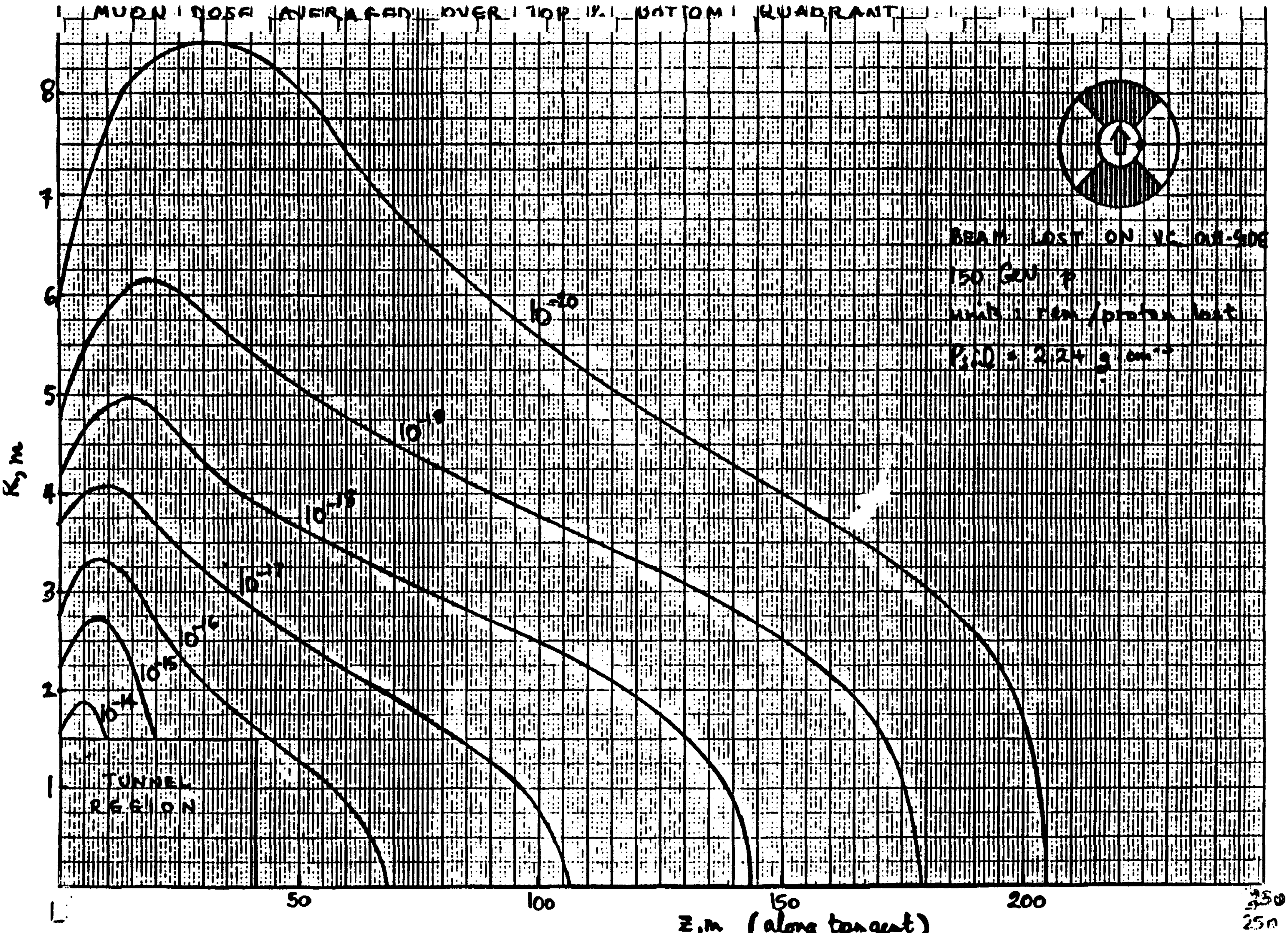


Figure C-6: Isodose contours averaged over top and bottom azimuths for muons produced under the same conditions as C-4.

with hadrons is ground water activation. The current Tevatron dump, which has been in continuous operation for the last six years, was desgined to deal with this problem, along with questions of radiation heating and material integrity of its components.[6] The ground water is frequently monitored and results show that water immediately adjacent to the Tevatron dump meets EPA release limits for unrestricted use.

Estimated muon isodose contours for the abort dump are shown in Figure C-7. From these results the maximum dose rate on the surface is 250 mR per year at 5 m downstream of the dump location, which is below permanent occupancy limits. Continuous maximum intensity running to the dump produces an exposure rate of 4 mR/hour in the same place. The trajectory of the abort line intercepts the site boundary 1300 m downstream of the dump. At this point the beam is 15 m beneath the surface and the distance is sufficient to range out all the muons.

Discussion

The largest uncertainties in the above estimates result from assumptions made regarding beam losses, i.e., in converting the CASIM results to dose for a single accident and to an annual dose rate for routine operation. The above calculations and assumptions regarding beam loss establish that no gross radiation problems are expected to accompany operation of the MI. This conclusion could also have been anticipated from similarities with the present Main Ring, and the absence of any such problems with it The only difference is the proximity of the MI to the site boundary.

The maximum off-site dose for a single accident is expected to be quite small (<0.25 mR), but the dose rate from routine operation is estimated to be twice the Fermilab limit unless the berm is gradually enlarged near the point of closest approach. An extra 3 ft reduces the off-site dose by about an order of magnitude (see Figs. C-1 and C-2). Conformance to the off-site limit can easily be ensured by monitoring the radiation either at the site boundary or at selected on-site locations from which one can confidently extrapolate to the boundary.

6. J. Kidd et al., IEEE Transactions on Nuclear Science, NS-28, 2774 (1981).

CONTOURS ARE SHOWN FOR INTEGRAL POWERS OF 10

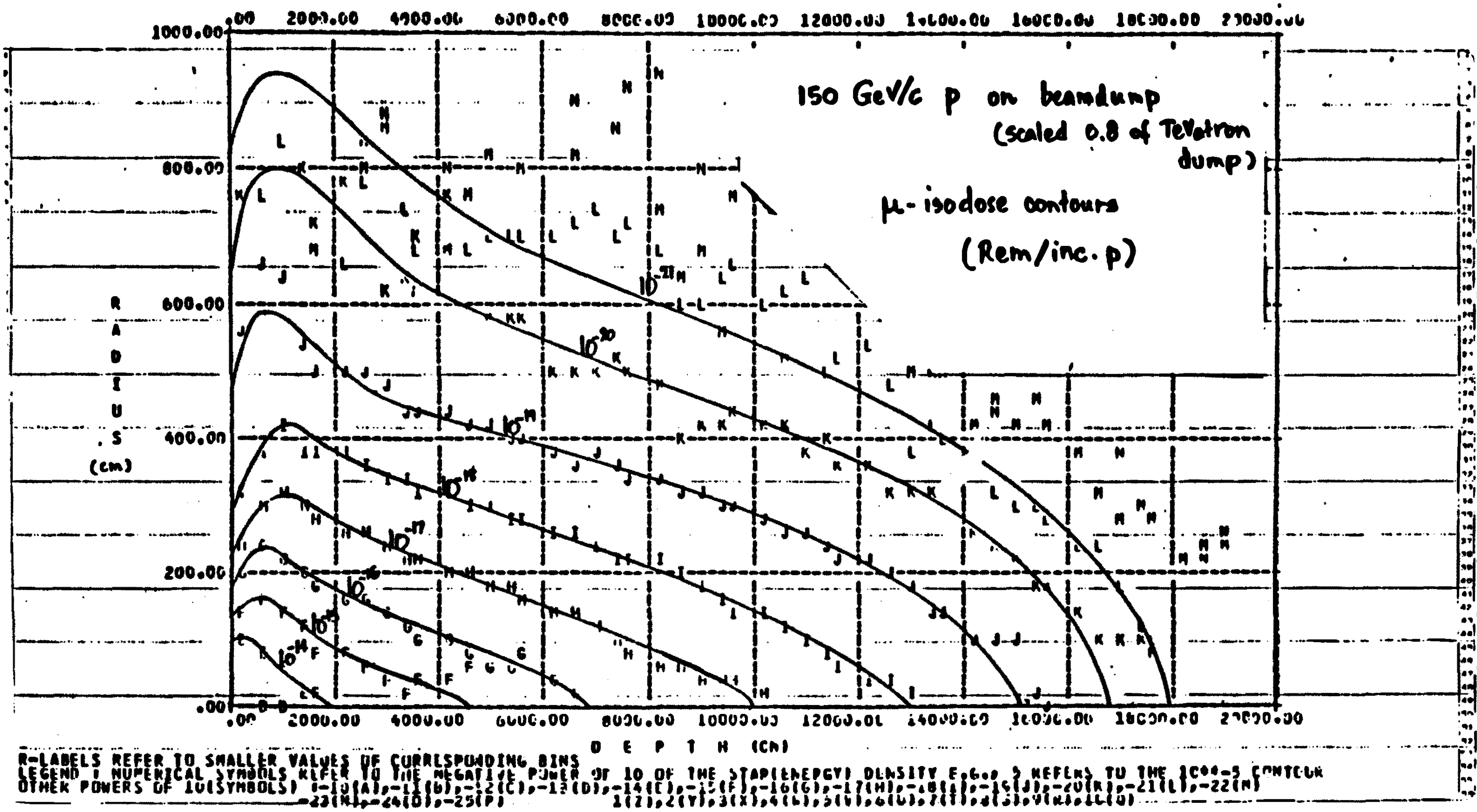


Figure C-7: Estimated muon isodose contours for the MI abort dump.

APPENDIX D

Lattice Functions

BETATRON FUNCTIONS OF

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
0	0.0000	0.00000	0.00000	56.51174	11.61313	-0.22122	0.00000	0.0000	-0.00126	0.00284	0.00078	0.00000
1 QF2	1.0668	0.00305	0.01437	54.04332	12.23373	-0.21546	0.00000	0.0000	2.28051	-0.59323	0.00997	0.00000
2 RFO	1.3576	0.00392	0.01810	52.72668	12.58810	-0.21257	0.00000	0.0000	2.24714	-0.62537	0.00997	0.00000
3 000	2.4658	0.00743	0.03135	47.88702	14.10987	-0.20152	0.00000	0.0000	2.11999	-0.74783	0.00997	0.00080
4 SB	8.5364	0.03475	0.08143	26.37605	27.26189	-0.14100	0.00000	0.0000	1.42348	-1.41868	0.00997	0.00000
5 O	8.9114	0.03706	0.08358	25.32458	28.34144	-0.13727	0.00000	0.0000	1.38045	-1.46012	0.00997	0.00000
6 SB	14.9820	0.09181	0.10932	12.79254	50.14150	-0.07675	0.00000	0.0000	0.68393	-2.13097	0.00997	0.00000
7 O	15.3570	0.09657	0.11049	12.29573	51.75527	-0.07301	0.00000	0.0000	0.64091	-2.17241	0.00997	0.00000
8 QD2	16.4238	0.11093	0.11368	11.57348	54.11659	-0.06392	0.00000	0.0000	0.04609	-0.00823	0.00713	0.00000
9 QD2	17.4906	0.12540	0.11686	12.09318	51.78937	-0.05768	0.00000	0.0000	-0.54043	2.15738	0.00461	0.00000
10 RFO	17.7814	0.12918	0.11777	12.41653	50.54387	-0.05634	0.00000	0.0000	-0.57150	2.12563	0.00461	0.00000
11 000	18.8896	0.14266	0.12143	13.81440	45.96670	-0.05123	0.00000	0.0000	-0.68990	2.00464	0.00461	0.00000
12 SB	24.9602	0.19443	0.14971	26.12797	25.65142	-0.02322	0.00000	0.0000	-1.33849	1.34186	0.00461	0.00000
13 O	25.3352	0.19667	0.15209	27.14686	24.66038	-0.02149	0.00000	0.0000	-1.37856	1.30092	0.00461	0.00000
14 SB	31.4058	0.22361	0.20738	47.82160	12.88914	0.00652	0.00000	0.0000	-2.02716	0.63814	0.00461	0.00000
15 O	31.7808	0.22484	0.21210	49.35699	12.42589	0.00825	0.00000	0.0000	-2.06722	0.59720	0.00461	0.00000
16 QF2	32.8476	0.22818	0.22624	51.58151	11.80376	0.01295	0.00000	0.0000	0.01319	-0.00535	0.00417	0.00000
17 QF2	33.9144	0.23152	0.24037	49.30237	12.44942	0.01707	0.00000	0.0000	2.09128	-0.60887	0.00354	0.00000
18 FUG	34.8144	0.23454	0.25138	45.62636	13.63457	0.02026	0.00000	0.0000	1.99318	-0.70797	0.00354	0.00000
19 OOL	38.7788	0.25121	0.28903	31.53572	20.97835	0.03427	0.00000	0.0000	1.56111	-1.14446	0.00354	0.00000
20 B2	44.8494	0.29394	0.32311	16.59930	38.91883	0.11930	0.00000	0.0014	0.89953	-1.81019	0.02448	0.00000
21 OOL	48.8138	0.34094	0.33676	11.18007	54.99857	0.21635	0.00000	0.0014	0.46745	-2.24584	0.02448	0.00000
22 QD2	49.8806	0.35654	0.33976	10.78210	57.36955	0.24748	0.00000	0.0014	-0.08890	0.05628	0.03409	0.00000
23 QD2	50.9474	0.37188	0.34277	11.57075	54.76543	0.28962	0.00000	0.0014	-0.66126	2.34857	0.04521	0.00000
24 FUG	51.8474	0.38363	0.34549	12.86163	50.63437	0.33031	0.00000	0.0014	-0.77305	2.24149	0.04521	0.00000
25 OOL	55.8118	0.42246	0.36056	20.94323	34.73190	0.50954	0.00000	0.0014	-1.26549	1.76982	0.04521	0.00000
26 B2	61.8824	0.45572	0.47002	40.88362	17.61814	0.84755	0.00000	0.0154	-2.01950	1.04868	0.06616	0.00000
27 OOL	65.8468	0.46860	0.44560	58.84803	11.17645	1.10982	0.00000	0.0154	-2.51194	0.57620	0.06616	0.00000
28 QF2	66.9136	0.47140	0.46138	61.59448	10.55527	1.15514	0.00000	0.0154	-0.02403	0.01473	0.01848	0.00000
29 QF2	67.9804	0.47419	0.47720	58.94754	11.11168	1.14896	0.00000	0.0154	2.46811	-0.54406	-0.03001	0.00000
30 FUG	68.8804	0.47672	0.48952	54.60238	12.18546	1.12195	0.00000	0.0154	2.35984	-0.64903	-0.03001	0.00000
31 OOL	72.8448	0.49063	0.53129	37.78243	19.16456	1.00296	0.00000	0.0154	1.88291	-1.11141	-0.03001	0.00000
32 B2	78.9154	0.52666	0.56792	19.35611	36.94530	0.88435	0.00000	0.0349	1.15265	-1.81694	-0.00907	0.00000
33 OOL	82.8798	0.56835	0.58217	12.10772	53.18118	0.84839	0.00000	0.0349	0.67572	-2.27848	-0.00907	0.00000
34 QD2	83.9466	0.58299	0.58527	11.30695	55.70650	0.85753	0.00000	0.0349	0.08597	-0.05361	0.02626	0.00000
35 QD2	85.0134	0.59786	0.58836	11.72992	53.40325	0.90485	0.00000	0.0349	-0.48830	2.18063	0.06277	0.00000
36 FUG	85.9134	0.60961	0.59114	12.69437	49.56541	0.96134	0.00000	0.0349	-0.58332	2.08364	0.06277	0.00000
37 OOL	89.8778	0.65072	0.60637	18.97872	34.73838	1.21016	0.00000	0.0349	-1.00188	1.65640	0.06277	0.00000
38 B2	95.9484	0.68854	0.64476	35.03208	18.58830	1.65473	0.00000	0.0647	-1.64276	1.00339	0.08371	0.00000
39 OOL	99.9128	0.70368	0.68693	49.71651	12.32937	1.98659	0.00000	0.0647	-2.06132	0.57539	0.08371	0.00000
40 QF2	100.9796	0.70700	0.70117	51.91154	11.74937	2.03096	0.00000	0.0647	0.03451	-0.02363	-0.00085	0.00000
41 QF2	102.0464	0.71032	0.71534	49.57359	12.43323	1.98479	0.00000	0.0647	2.12426	-0.62694	-0.08537	0.00000
42 FUG	102.9464	0.71332	0.72634	45.83999	13.65247	1.90796	0.00000	0.0647	2.02418	-0.72778	-0.08537	0.00000
43 000	104.0546	0.71737	0.73851	41.49016	15.40312	1.81334	0.00000	0.0647	1.90095	-0.85194	-0.08537	0.00000
44 B2	110.1252	0.74919	0.78418	22.50931	29.86672	1.35868	0.00000	0.0977	1.22596	-1.53010	-0.06443	0.00000

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
45	O	110.5002	0.75190	0.78614	21.60547	31.03003	1.33452	0.00000	0.0977	1.18426	-1.57205	-0.06443	0.00000
46	SB	116.5708	0.81533	0.80978	11.32497	54.23930	0.94339	0.00000	0.0977	0.50923	-2.25117	-0.06443	0.00000
47	O	116.9458	0.82069	0.81087	10.95868	55.94341	0.91923	0.00000	0.0977	0.46753	-2.29312	-0.06443	0.00000
48	QD2	118.0126	0.83662	0.81382	10.55313	58.37324	0.87045	0.00000	0.0977	-0.08176	0.04922	-0.02736	0.00000
49	QD2	119.0794	0.85230	0.81677	11.31799	55.73955	0.86042	0.00000	0.0977	-0.64577	2.38295	0.00849	0.00000
50	FUG	119.9794	0.86431	0.81944	12.58180	51.54729	0.86806	0.00000	0.0977	-0.75846	2.27512	0.00849	0.00000
51	OOO	121.0876	0.87742	0.82304	14.41660	46.65186	0.87746	0.00000	0.0977	-0.89720	2.14234	0.00849	0.00000
52	B2	127.1582	0.92463	0.85146	29.92219	25.04199	0.99255	0.00000	0.1171	-1.65719	1.41664	0.02943	0.00000
53	O	127.5332	0.92658	0.85389	31.18269	23.99640	1.00359	0.00000	0.1171	-1.70414	1.37161	0.02943	0.00000
54	SB	133.6038	0.94968	0.91272	56.48698	11.76835	1.18225	0.00000	0.1171	-2.46419	0.64270	0.02943	0.00000
55	D	133.9788	0.95072	0.91789	58.35273	11.30321	1.19329	0.00000	0.1171	-2.51114	0.59767	0.02943	0.00000
56	QF2	135.0456	0.95355	0.93351	61.12047	10.64164	1.19786	0.00000	0.1171	-0.04448	0.03169	-0.02090	0.00000
57	Q1	136.1124	0.95636	0.94923	58.53694	11.16390	1.14904	0.00000	0.1171	2.43002	-0.52853	-0.07029	0.00000
58	XO	141.6978	0.97603	1.00920	35.07166	20.64301	0.75641	0.00000	0.1171	1.77117	-1.16859	-0.07029	0.00000
59	QOO	142.2911	0.97879	1.01364	33.47577	21.77527	0.71981	0.00000	0.1171	0.93097	-0.73108	-0.05325	0.00000
60	O	142.6661	0.98060	1.01635	32.78539	22.33348	0.69984	0.00000	0.1171	0.91006	-0.75750	-0.05325	0.00000
61	B2	148.7367	1.01547	1.05164	23.79168	34.11561	0.44019	0.00000	0.1288	0.57157	-1.18292	-0.03230	0.00000
62	O	149.1117	1.01800	1.05337	23.37085	35.01269	0.42808	0.00000	0.1288	0.55066	-1.20929	-0.03230	0.00000
63	B2	155.1823	1.06483	1.07603	18.74037	52.26814	0.29557	0.00000	0.1361	0.21217	-1.63255	-0.01136	0.00000
64	O	155.5573	1.06803	1.07716	18.58908	53.50241	0.29131	0.00000	0.1361	0.19126	-1.65884	-0.01136	0.00000
65	B2	161.6279	1.12137	1.09231	18.32183	76.19906	0.28593	0.00000	0.1420	-0.14723	-2.07912	0.00959	0.00000
66	O	162.0029	1.12462	1.09309	18.44010	77.76822	0.28953	0.00000	0.1420	-0.16814	-2.10531	0.00959	0.00000
67	QO	164.5855	1.14462	1.09847	25.09578	68.75729	0.35383	0.00000	0.1420	-2.62851	5.28671	0.04128	0.00000
68	XI	167.7155	1.15952	1.10800	44.63780	39.78734	0.48304	0.00000	0.1420	-3.61494	3.96887	0.04128	0.00000
69	QI	169.8491	1.16636	1.11807	52.11581	30.34643	0.52593	0.00000	0.1420	0.32168	0.71687	-0.00168	0.00000
70	LS	184.3491	1.21356	1.21809	47.23873	20.04598	0.50162	0.00000	0.1420	0.01467	-0.00650	-0.00168	0.00000
71	LS	198.8491	1.26116	1.31741	51.26517	30.72319	0.47731	0.00000	0.1420	-0.29235	-0.72986	-0.00168	0.00000
72	QI	200.9827	1.26811	1.32735	43.81976	40.29794	0.43177	0.00000	0.1420	3.57125	-4.02230	-0.04038	0.00000
73	XI	204.1127	1.28333	1.33676	24.53870	69.65395	0.30537	0.00000	0.1420	2.58883	-5.35661	-0.04038	0.00000
74	QO	206.6953	1.30383	1.34207	17.95826	78.78513	0.23706	0.00000	0.1420	0.17620	2.13276	-0.01366	0.00000
75	O	207.0703	1.30716	1.34284	17.83418	77.19546	0.23194	0.00000	0.1420	0.15467	2.10635	-0.01366	0.00000
76	B2	213.1409	1.36206	1.35780	18.07190	54.18903	0.21260	0.00000	0.1464	-0.19384	1.68263	0.00729	0.00000
77	O	213.5159	1.36534	1.35891	18.22535	52.93700	0.21533	0.00000	0.1464	-0.21537	1.65612	0.00729	0.00000
78	B2	219.5865	1.41330	1.38130	22.95546	35.41642	0.32312	0.00000	0.1518	-0.56387	1.22938	0.02823	0.00000
79	O	219.9615	1.41588	1.38301	23.38644	34.50435	0.33371	0.00000	0.1518	-0.58540	1.20279	0.02823	0.00000
80	B2	226.0321	1.45115	1.41796	32.60894	22.50228	0.56864	0.00000	0.1610	-0.93391	0.77386	0.04918	0.00000
81	O	226.4071	1.45296	1.42065	33.31745	21.93188	0.58708	0.00000	0.1610	-0.95544	0.74721	0.04918	0.00000
82	QOO	227.0004	1.45573	1.42506	34.94105	20.77872	0.62036	0.00000	0.1610	-1.79361	1.18753	0.06312	0.00000
83	XO	232.5858	1.47540	1.48491	58.74223	11.13171	0.97290	0.00000	0.1610	-2.46771	0.53965	0.06312	0.00000
84	Q1	233.6526	1.47821	1.50070	61.39782	10.58515	1.01805	0.00000	0.1610	0.01564	-0.01970	0.02121	0.00000
85	QF2	234.7194	1.48102	1.51642	58.67747	11.21832	1.01782	0.00000	0.1610	2.49623	-0.58264	-0.02164	0.00000
86	FUG	235.6194	1.48356	1.52859	54.28407	12.36378	0.99835	0.00000	0.1610	2.38532	-0.69010	-0.02164	0.00000
87	OOO	236.7276	1.48697	1.54200	49.14859	14.03995	0.97437	0.00000	0.1610	2.24875	-0.82242	-0.02164	0.00000
88	SB	242.7982	1.51393	1.59114	26.38759	28.42526	0.84302	0.00000	0.1610	1.50063	-1.54725	-0.02164	0.00000
89	O	243.1732	1.51624	1.59320	25.27944	29.60248	0.83490	0.00000	0.1610	1.45442	-1.59202	-0.02164	0.00000

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
90	B2	249.2438	1.57250	1.61761	12.16318	53.31450	0.76713	0.00000	0.1776	0.70636	-2.31316	-0.00069	0.00000
91	0	249.6188	1.57751	1.61871	11.65074	55.06612	0.76687	0.00000	0.1776	0.66014	-2.35783	-0.00069	0.00000
92	QD2	250.6856	1.59274	1.62170	10.86702	57.67643	0.78319	0.00000	0.1776	0.08534	-0.05274	0.03141	0.00000
93	QD2	251.7524	1.60821	1.62469	11.27573	55.28459	0.83438	0.00000	0.1776	-0.47410	2.26156	0.06491	0.00000
94	FUG	252.6524	1.62043	1.62738	12.21709	51.30337	0.89281	0.00000	0.1776	-0.57186	2.16202	0.06491	0.00000
95	000	253.7606	1.63412	1.63098	13.61796	46.64730	0.96474	0.00000	0.1776	-0.69223	2.03945	0.06491	0.00000
96	B2	259.8312	1.68637	1.65890	26.02422	25.94690	1.42235	0.00000	0.2024	-1.35158	1.36975	0.08586	0.00000
97	0	260.2062	1.68862	1.66124	27.05318	24.93518	1.45455	0.00000	0.2024	-1.39231	1.32818	0.08586	0.00000
98	SB	266.2768	1.71557	1.71621	47.96039	12.89455	1.97576	0.00000	0.2024	-2.05170	0.65525	0.08586	0.00000
99	0	266.6518	1.71680	1.72093	49.51444	12.41870	2.00796	0.00000	0.2024	-2.09243	0.61369	0.08586	0.00000
100	QF2	267.7186	1.72013	1.73510	51.78621	11.76194	2.05412	0.00000	0.2024	-0.00523	0.01111	0.00036	0.00000
101	QF2	268.7854	1.72345	1.74930	49.53611	12.36988	2.00872	0.00000	0.2024	2.08289	-0.58945	-0.08515	0.00000
102	FUG	269.6854	1.72646	1.76039	45.87420	13.51912	1.93208	0.00000	0.2024	1.98590	-0.68749	-0.08515	0.00000
103	000	270.7936	1.73050	1.77271	41.60501	15.17665	1.83771	0.00000	0.2024	1.86647	-0.80820	-0.08515	0.00000
104	B2	276.8642	1.76199	1.81944	22.91641	28.99473	1.38438	0.00000	0.2359	1.21230	-1.46753	-0.06421	0.00000
105	0	277.2392	1.76465	1.82146	22.02234	30.11067	1.36030	0.00000	0.2359	1.17188	-1.50831	-0.06421	0.00000
106	B2	283.3098	1.82618	1.84587	11.76621	52.41444	1.03411	0.00000	0.2607	0.51771	-2.16494	-0.04326	0.00000
107	0	283.6848	1.83134	1.84700	11.39308	54.05340	1.01789	0.00000	0.2607	0.47730	-2.20563	-0.04326	0.00000
108	QD2	284.7516	1.84666	1.85005	10.98165	56.38085	0.99405	0.00000	0.2607	-0.08594	0.05628	-0.00159	0.00000
109	QD2	285.8184	1.86172	1.85311	11.77076	53.82030	1.01446	0.00000	0.2607	-0.66466	2.30835	0.04001	0.00000
110	FUG	286.7184	1.87328	1.85588	13.06636	49.76052	1.05046	0.00000	0.2607	-0.77490	2.20252	0.04001	0.00000
111	000	287.8266	1.88592	1.85960	14.93427	45.02327	1.09480	0.00000	0.2607	-0.91064	2.07221	0.04001	0.00000
112	B2	293.8972	1.93182	1.88905	30.50297	24.18317	1.40120	0.00000	0.2867	-1.65416	1.35999	0.06095	0.00000
113	0	294.2722	1.93374	1.89157	31.76082	23.17975	1.42406	0.00000	0.2867	-1.70009	1.31580	0.06095	0.00000
114	B2	300.3428	1.95654	1.95209	56.91371	11.54006	1.85761	0.00000	0.3208	-2.44361	0.60116	0.08189	0.00000
115	0	300.7178	1.95757	1.95737	58.76364	11.10577	1.88832	0.00000	0.3208	-2.48954	0.55692	0.08189	0.00000
116	QF2	301.7846	1.96037	1.97322	61.46551	10.52236	1.93295	0.00000	0.3208	-0.00526	-0.00191	0.00146	0.00000
117	QF2	302.8514	1.96318	1.98906	58.78540	11.11419	1.89142	0.00000	0.3208	2.47996	-0.56110	-0.07903	0.00000
118	FUG	303.7514	1.96571	2.00136	54.42001	12.21999	1.82029	0.00000	0.3208	2.37049	-0.66757	-0.07903	0.00000
119	000	304.8596	1.96912	2.01494	49.31543	13.84489	1.73271	0.00000	0.3208	2.23570	-0.79868	-0.07903	0.00000
120	B2	310.9302	1.99589	2.06492	26.65514	27.89327	1.31655	0.00000	0.3525	1.49737	-1.51498	-0.05809	0.00000
121	0	311.3052	1.99818	2.06702	25.54922	29.04612	1.29477	0.00000	0.3525	1.45176	-1.55928	-0.05809	0.00000
122	B2	317.3758	2.05355	2.09191	12.40617	52.31434	1.00575	0.00000	0.3764	0.71343	-2.27281	-0.03714	0.00000
123	0	317.7508	2.05847	2.09303	11.88820	54.03552	0.99182	0.00000	0.3764	0.66782	-2.31701	-0.03714	0.00000
124	QD2	318.8176	2.07338	2.09608	11.09644	56.60491	0.97398	0.00000	0.3764	0.08530	-0.05578	0.00357	0.00000
125	QD2	319.8844	2.08853	2.09912	11.51335	54.26657	0.99950	0.00000	0.3764	-0.48186	2.21520	0.04445	0.00000
126	FUG	320.7844	2.10050	2.10186	12.46738	50.36738	1.03951	0.00000	0.3764	-0.57818	2.11723	0.04445	0.00000
127	000	321.8926	2.11393	2.10553	13.88030	45.80843	1.08877	0.00000	0.3764	-0.69678	1.99660	0.04445	0.00000
128	B2	327.9632	2.16540	2.13391	26.28292	25.56401	1.42215	0.00000	0.4025	-1.34643	1.33750	0.06539	0.00000
129	0	328.3382	2.16763	2.13629	27.30779	24.57623	1.44667	0.00000	0.4025	-1.38656	1.29659	0.06539	0.00000
130	B2	334.4088	2.19441	2.19179	48.08454	12.84717	1.90718	0.00000	0.4374	-2.03621	0.63510	0.08634	0.00000
131	0	334.7838	2.19564	2.19652	49.62674	12.38621	1.93956	0.00000	0.4374	-2.07634	0.59414	0.08634	0.00000
132	QF2	335.8506	2.19896	2.21070	51.85845	11.76907	1.98775	0.00000	0.4374	0.01567	-0.00704	0.00368	0.00000
133	QF2	336.9174	2.20228	2.22487	49.56187	12.41714	1.94735	0.00000	0.4374	2.10491	-0.60949	-0.07915	0.00000
134	FUG	337.8174	2.20529	2.23590	45.86179	13.60369	1.87611	0.00000	0.4374	2.00629	-0.70889	-0.07915	0.00000

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
135	OOO	338.9256	2.20933	2.24814	41.54960	15.31052	1.78840	0.00000	0.4374	1.88487	-0.83130	-0.07915	0.00000
136	B2	344.9962	2.24099	2.29427	22.70416	29.46486	1.37151	0.00000	0.4702	1.21974	-1.49981	-0.05821	0.00000
137	O	345.3712	2.24367	2.29626	21.80477	30.60523	1.34969	0.00000	0.4702	1.17865	-1.54117	-0.05821	0.00000
138	B2	351.4418	2.30619	2.32025	11.53300	53.36347	1.05994	0.00000	0.4952	0.51352	-2.20694	-0.03726	0.00000
139	O	351.8168	2.31145	2.32136	11.16327	55.03414	1.04597	0.00000	0.4952	0.47243	-2.24819	-0.03726	0.00000
140	QD2	352.8836	2.32709	2.32435	10.75427	57.40856	1.02921	0.00000	0.4952	-0.08339	0.05545	0.00572	0.00000
141	QD2	353.9504	2.34247	2.32736	11.52972	54.80445	1.05826	0.00000	0.4952	-0.65423	2.34940	0.04896	0.00000
142	FUG	354.8504	2.35427	2.33008	12.80765	50.67189	1.10232	0.00000	0.4952	-0.76570	2.24233	0.04896	0.00000
143	OOO	355.9586	2.36716	2.33374	14.65685	45.84807	1.15657	0.00000	0.4952	-0.90295	2.11050	0.04896	0.00000
144	B2	362.0292	2.41375	2.36267	30.18262	24.59361	1.51731	0.00000	0.5230	-1.65477	1.38994	0.06990	0.00000
145	O	362.4042	2.41569	2.36515	31.44112	23.56792	1.54352	0.00000	0.5230	-1.70122	1.34524	0.06990	0.00000
146	B2	368.4748	2.43866	2.42492	56.65806	11.62172	2.03139	0.00000	0.5602	-2.45303	0.62221	0.09084	0.00000
147	O	368.8498	2.43970	2.43016	58.51525	11.17184	2.06546	0.00000	0.5602	-2.49948	0.57745	0.09084	0.00000
148	QF2	369.9166	2.44251	2.44594	61.25018	10.54793	2.11562	0.00000	0.5602	-0.02584	0.01610	0.00284	0.00000
149	QF2	370.9834	2.44532	2.46178	58.62227	11.10109	2.07148	0.00000	0.5602	2.45235	-0.54233	-0.08529	0.00000
150	FUG	371.8834	2.44786	2.47411	54.30495	12.17171	1.99472	0.00000	0.5602	2.34467	-0.64725	-0.08529	0.00000
151	OOO	372.9916	2.45127	2.48776	49.25517	13.74945	1.90020	0.00000	0.5602	2.21207	-0.77644	-0.08529	0.00000
152	B2	379.0622	2.47798	2.53833	26.80854	27.46435	1.44605	0.00000	0.5951	1.48579	-1.48230	-0.06434	0.00000
153	O	379.4372	2.48026	2.54046	25.71102	28.59245	1.42192	0.00000	0.5951	1.44093	-1.52595	-0.06434	0.00000
154	B2	385.5078	2.53495	2.56577	12.62637	51.39282	1.09492	0.00000	0.6212	0.71464	-2.22909	-0.04340	0.00000
155	O	385.8828	2.53977	2.56691	12.10722	53.08097	1.07864	0.00000	0.6212	0.66978	-2.27264	-0.04340	0.00000
156	QD2	386.9496	2.55441	2.57002	11.31873	55.59827	1.05601	0.00000	0.6212	0.08024	-0.05204	0.00081	0.00000
157	QD2	388.0164	2.56926	2.57311	11.75462	53.29652	1.08039	0.00000	0.6212	-0.49486	2.17766	0.04506	0.00000
158	FUG	388.9164	2.58098	2.57590	12.73116	49.46400	1.12094	0.00000	0.6212	-0.59018	2.08070	0.04506	0.00000
159	OOO	390.0246	2.59412	2.57964	14.16929	44.98466	1.17088	0.00000	0.6212	-0.70754	1.96130	0.04506	0.00000
160	B2	396.0952	2.64467	2.60854	26.66136	25.12813	1.50798	0.00000	0.6490	-1.35041	1.30892	0.06601	0.00000
161	O	396.4702	2.64687	2.61096	27.68906	24.16162	1.53273	0.00000	0.6490	-1.39012	1.26843	0.06601	0.00000
162	B2	402.5408	2.67337	2.66721	48.46788	12.73338	1.99697	0.00000	0.6858	-2.03299	0.61372	0.08695	0.00000
163	O	402.9158	2.67458	2.67198	50.00752	12.28829	2.02958	0.00000	0.6858	-2.07270	0.57317	0.08695	0.00000
164	QF2	403.9826	2.67788	2.68626	52.21366	11.71148	2.07641	0.00000	0.6858	0.03563	-0.02444	0.00053	0.00000
165	QF2	405.0494	2.68118	2.70047	49.85995	12.39573	2.03070	0.00000	0.6858	2.13769	-0.62650	-0.08592	0.00000
166	FUG	405.9494	2.68417	2.71151	46.10259	13.61442	1.95337	0.00000	0.6858	2.03715	-0.72760	-0.08592	0.00000
167	OOO	407.0576	2.68819	2.72371	41.72463	15.36503	1.85816	0.00000	0.6858	1.91336	-0.85209	-0.08592	0.00000
168	B2	413.1282	2.71985	2.76946	22.61189	29.84132	1.40019	0.00000	0.7197	1.23528	-1.53204	-0.06497	0.00000
169	O	413.5032	2.72254	2.77142	21.70114	31.00612	1.37582	0.00000	0.7197	1.19339	-1.57410	-0.06497	0.00000
170	B2	419.5738	2.78581	2.79507	11.32909	54.23331	1.04499	0.00000	0.7448	0.51531	-2.25124	-0.04403	0.00000
171	O	419.9488	2.79117	2.79615	10.95831	55.93747	1.02848	0.00000	0.7448	0.47342	-2.29320	-0.04403	0.00000
172	QD2	421.0156	2.80711	2.79910	10.54039	58.36773	1.00406	0.00000	0.7448	-0.07589	0.04889	-0.00193	0.00000
173	QD2	422.0824	2.82281	2.80206	11.29179	55.73495	1.02433	0.00000	0.7448	-0.63885	2.38244	0.04008	0.00000
174	FUG	422.9824	2.83486	2.80473	12.54274	51.54359	1.06040	0.00000	0.7448	-0.75109	2.27463	0.04008	0.00000
175	OOO	424.0906	2.84802	2.80833	14.36060	46.64920	1.10482	0.00000	0.7448	-0.88928	2.14189	0.04008	0.00000
176	B2	430.1612	2.89546	2.83675	29.75174	25.04351	1.41168	0.00000	0.7709	-1.64626	1.41640	0.06102	0.00000
177	O	430.5362	2.89742	2.83918	31.00397	23.99810	1.43456	0.00000	0.7709	-1.69302	1.37138	0.06102	0.00000
178	B2	436.6068	2.92066	2.89801	56.15273	11.76466	1.86856	0.00000	0.8053	-2.45000	0.64337	0.08197	0.00000
179	O	436.9818	2.92170	2.90319	58.00776	11.29904	1.89930	0.00000	0.8053	-2.49676	0.59830	0.08197	0.00000

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
180	QF2	438.0486	2.92454	2.91882	60.76038	10.63602	1.94377	0.00000	0.8053	-0.04490	0.03244	0.00108	0.00000
181	QF2	439.1154	2.92738	2.93455	58.19368	11.15645	1.90159	0.00000	0.8053	2.41488	-0.52753	-0.07986	0.00000
182	FUG	440.0154	2.92993	2.94684	53.94198	12.19881	1.82972	0.00000	0.8053	2.30923	-0.63065	-0.07986	0.00000
183	000	441.1236	2.93337	2.96048	48.96798	13.73730	1.74122	0.00000	0.8053	2.17913	-0.75763	-0.07986	0.00000
184	B2	447.1942	2.96014	3.01137	26.83830	27.15022	1.32005	0.00000	0.8371	1.46652	-1.45138	-0.05891	0.00000
185	0	447.5692	2.96241	3.01353	25.75492	28.25485	1.29796	0.00000	0.8371	1.42250	-1.49428	-0.05891	0.00000
186	B2	453.6398	3.01664	3.03919	12.81097	50.59746	1.00393	0.00000	0.8610	0.70989	-2.18537	-0.03797	0.00000
187	0	454.0148	3.02140	3.04035	12.29506	52.25254	0.98969	0.00000	0.8610	0.66587	-2.22818	-0.03797	0.00000
188	QD2	455.0816	3.03579	3.04350	11.52101	54.71172	0.97091	0.00000	0.8610	0.07041	-0.04283	0.00264	0.00000
189	QD2	456.1484	3.05036	3.04665	11.98566	52.42996	0.99536	0.00000	0.8610	-0.51238	2.15000	0.04337	0.00000
190	FUG	457.0484	3.06185	3.04949	12.99326	48.64683	1.03439	0.00000	0.8610	-0.60718	2.05349	0.04337	0.00000
191	000	458.1566	3.07473	3.05329	14.46838	44.22718	1.08245	0.00000	0.8610	-0.72392	1.93464	0.04337	0.00000
192	B2	464.2272	3.12428	3.08270	27.13827	24.67601	1.40925	0.00000	0.8869	-1.36333	1.28528	0.06431	0.00000
193	0	464.6022	3.12644	3.08517	28.17558	23.72716	1.43337	0.00000	0.8869	-1.40283	1.24498	0.06431	0.00000
194	B2	470.6728	3.15253	3.14235	49.08767	12.56503	1.88731	0.00000	0.9214	-2.04224	0.59333	0.08525	0.00000
195	0	471.0478	3.15373	3.14718	50.63416	12.13516	1.91928	0.00000	0.9214	-2.08174	0.55298	0.08525	0.00000
196	QF2	472.1146	3.15699	3.16162	52.83076	11.59518	1.96678	0.00000	0.9214	0.05349	-0.03929	0.00346	0.00000
197	QF2	473.1814	3.16026	3.17596	50.41266	12.30787	1.92661	0.00000	0.9214	2.17929	-0.63870	-0.07849	0.00000
198	FUG	474.0814	3.16321	3.18706	46.58232	13.55020	1.85597	0.00000	0.9214	2.07665	-0.74166	-0.07849	0.00000
199	000	475.1896	3.16719	3.19931	42.11970	15.33449	1.76900	0.00000	0.9214	1.95026	-0.86843	-0.07849	0.00000
200	B2	481.2602	3.19868	3.24491	22.64508	30.08488	1.35614	0.00000	0.9539	1.25799	-1.56084	-0.05754	0.00000
201	0	481.6352	3.20137	3.24686	21.71762	31.27157	1.33456	0.00000	0.9539	1.21523	-1.60368	-0.05754	0.00000
202	B2	487.7058	3.26510	3.27025	11.16656	54.93333	1.04884	0.00000	0.9787	0.52296	-2.29323	-0.03660	0.00000
203	0	488.0808	3.27054	3.27132	10.79038	56.66927	1.03511	0.00000	0.9787	0.48019	-2.33596	-0.03660	0.00000
204	QD2	489.1476	3.28675	3.27423	10.35271	59.15841	1.01882	0.00000	0.9787	-0.06388	0.03728	0.00594	0.00000
205	QD2	490.2144	3.30275	3.27715	11.07110	56.51485	1.04789	0.00000	0.9787	-0.61945	2.40400	0.04875	0.00000
206	FUG	491.1144	3.31505	3.27978	12.28735	52.28480	1.09176	0.00000	0.9787	-0.73194	2.29605	0.04875	0.00000
207	000	492.2226	3.32848	3.28333	14.06311	47.34316	1.14578	0.00000	0.9787	-0.87045	2.16311	0.04875	0.00000
208	B2	498.2932	3.37687	3.31129	29.23590	25.48600	1.50526	0.00000	1.0062	-1.62913	1.43659	0.06969	0.00000
209	0	498.6682	3.37887	3.31368	30.47532	24.42546	1.53139	0.00000	1.0062	-1.67599	1.39151	0.06969	0.00000
210	B2	504.7388	3.40246	3.37148	55.42771	11.95400	2.01801	0.00000	1.0432	-2.43467	0.66244	0.09064	0.00000
211	0	505.1138	3.40352	3.37658	57.27129	11.47409	2.05200	0.00000	1.0432	-2.48154	0.61730	0.09064	0.00000
212	QF2	506.1806	3.40639	3.39199	60.02518	10.77747	2.10224	0.00000	1.0432	-0.06128	0.04541	0.00320	0.00000
213	QF2	507.2474	3.40926	3.40753	57.52508	11.27450	2.05877	0.00000	1.0432	2.36978	-0.51824	-0.08438	0.00000
214	FUG	508.1474	3.41185	3.41971	53.35263	12.29847	1.98283	0.00000	1.0432	2.26627	-0.61951	-0.08438	0.00000
215	000	509.2556	3.41531	3.43326	48.47091	13.80972	1.88932	0.00000	1.0432	2.13882	-0.74420	-0.08438	0.00000
216	B2	515.3262	3.44228	3.48417	26.74266	26.98362	1.44068	0.00000	1.0778	1.44070	-1.42544	-0.06344	0.00000
217	0	515.7012	3.44455	3.48634	25.67831	28.06850	1.41689	0.00000	1.0778	1.39757	-1.46758	-0.06344	0.00000
218	B2	521.7718	3.49857	3.51224	12.94900	50.01114	1.09538	0.00000	1.1039	0.69946	-2.14621	-0.04249	0.00000
219	0	522.1468	3.50327	3.51342	12.44058	51.63656	1.07945	0.00000	1.1039	0.65633	-2.18824	-0.04249	0.00000
220	QD2	523.2136	3.51747	3.51661	11.69129	54.03765	1.05781	0.00000	1.1039	0.05640	-0.02912	0.00177	0.00000
221	QD2	524.2804	3.53182	3.51979	12.19274	51.75718	1.08326	0.00000	1.1039	-0.53337	2.13509	0.04612	0.00000
222	FUG	525.1804	3.54310	3.52267	13.23814	48.00101	1.12477	0.00000	1.1039	-0.62819	2.03843	0.04612	0.00000
223	000	526.2886	3.55573	3.52652	14.75984	43.61493	1.17588	0.00000	1.1039	-0.74494	1.91941	0.04612	0.00000
224	B2	532.3592	3.60427	3.55640	27.68535	24.25476	1.51940	0.00000	1.1319	-1.38442	1.26905	0.06706	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
225 0	532.7342	3.60639	3.55891	28.73848	23.31811	1.54455	0.00000	1.1319	-1.42392	1.22869	0.06706	0.00000
226 B2	538.8048	3.63201	3.61711	49.90712	12.35967	2.01521	0.00000	1.1690	-2.06341	0.57608	0.08801	0.00000
227 0	539.1798	3.63319	3.62203	51.46949	11.94277	2.04821	0.00000	1.1690	-2.10291	0.53567	0.08801	0.00000
228 QF2	540.2466	3.63639	3.63669	53.67312	11.43229	2.09575	0.00000	1.1690	0.06817	-0.05004	0.00079	0.00000
229 QF2	541.3134	3.63961	3.65121	51.18720	12.16272	2.04988	0.00000	1.1690	2.22723	-0.64484	-0.08647	0.00000
230 FUG	542.2134	3.64252	3.66243	47.27251	13.41772	1.97206	0.00000	1.1690	2.12243	-0.74960	-0.08647	0.00000
231 000	543.3216	3.64645	3.67479	42.71137	15.22209	1.87623	0.00000	1.1690	1.99338	-0.87860	-0.08647	0.00000
232 B2	549.3922	3.67760	3.72050	22.80175	30.17016	1.41491	0.00000	1.2032	1.28654	-1.58323	-0.06553	0.00000
233 0	549.7672	3.68028	3.72244	21.85323	31.37393	1.39034	0.00000	1.2032	1.24287	-1.62682	-0.06553	0.00000
234 B2	555.8378	3.74413	3.74570	11.05508	55.39058	1.05615	0.00000	1.2286	0.53602	-2.32854	-0.04458	0.00000
235 0	556.2128	3.74963	3.74676	10.66943	57.15329	1.03944	0.00000	1.2286	0.49236	-2.37202	-0.04458	0.00000
236 QD2	557.2796	3.76605	3.74964	10.20237	59.69821	1.01466	0.00000	1.2286	-0.04808	0.02183	-0.00204	0.00000
237 QD2	558.3464	3.78231	3.75253	10.88072	57.06287	1.03506	0.00000	1.2286	-0.59717	2.41186	0.04042	0.00000
238 FUG	559.2464	3.79483	3.75514	12.05663	52.81829	1.07143	0.00000	1.2286	-0.70939	2.30434	0.04042	0.00000
239 000	560.3546	3.80853	3.75865	13.78203	47.85766	1.11622	0.00000	1.2286	-0.84756	2.17195	0.04042	0.00000
240 B2	566.4252	3.85793	3.78624	28.66573	25.87496	1.42512	0.00000	1.2550	-1.60439	1.44843	0.06136	0.00000
241 0	566.8002	3.85996	3.78860	29.88655	24.80547	1.44813	0.00000	1.2550	-1.65114	1.40353	0.06136	0.00000
242 B2	572.8708	3.88399	3.84540	54.52604	12.16999	1.88417	0.00000	1.2897	-2.40798	0.67743	0.08231	0.00000
243 0	573.2458	3.88506	3.85041	56.34956	11.67877	1.91504	0.00000	1.2897	-2.45473	0.63248	0.08231	0.00000
244 QF2	574.3126	3.88798	3.86556	59.08821	10.95753	1.95951	0.00000	1.2897	-0.07404	0.05365	0.00075	0.00000
245 QF2	575.3794	3.89090	3.88086	56.65614	11.44294	1.91663	0.00000	1.2897	2.31971	-0.61543	-0.08083	0.00000
246 FUG	576.2794	3.89352	3.89286	52.57189	12.46030	1.84389	0.00000	1.2897	2.21835	-0.61497	-0.08083	0.00000
247 000	577.3876	3.89704	3.90625	47.79346	13.95916	1.75431	0.00000	1.2897	2.09353	-0.73755	-0.08083	0.00000
248 B2	583.4582	3.92431	3.95689	26.52729	26.98189	1.32722	0.00000	1.3217	1.40986	-1.40719	-0.05989	0.00000
249 0	583.8332	3.92660	3.95905	25.48573	28.05282	1.30477	0.00000	1.3217	1.36763	-1.44861	-0.05989	0.00000
250 B2	589.9038	3.98065	3.98505	13.03228	49.69495	1.00482	0.00000	1.3457	0.68396	-2.11568	-0.03894	0.00000
251 0	590.2788	3.98532	3.98623	12.53515	51.29720	0.99022	0.00000	1.3457	0.64172	-2.15700	-0.03894	0.00000
252 QD2	591.3456	3.99939	3.98944	11.81946	53.64628	0.97041	0.00000	1.3457	0.03905	-0.01233	0.00167	0.00000
253 QD2	592.4124	4.01365	3.99265	12.36357	51.34829	0.99380	0.00000	1.3457	-0.55660	2.13449	0.04235	0.00000
254 FUG	593.3124	4.02467	3.99555	13.45126	47.59385	1.03191	0.00000	1.3457	-0.65195	2.03711	0.04235	0.00000
255 000	594.4206	4.03709	3.99944	15.02635	43.21169	1.07884	0.00000	1.3457	-0.76935	1.91720	0.04235	0.00000
256 B2	600.4912	4.08467	4.02968	28.27012	23.90829	1.39947	0.00000	1.3714	-1.41243	1.26192	0.06329	0.00000
257 0	600.8662	4.08674	4.03223	29.34434	22.97710	1.42321	0.00000	1.3714	-1.45216	1.22126	0.06329	0.00000
258 B2	606.9368	4.11185	4.09144	50.87759	12.13870	1.87098	0.00000	1.4057	-2.09524	0.56374	0.08424	0.00000
259 0	607.3118	4.11300	4.09644	52.46391	11.73116	1.90257	0.00000	1.4057	-2.13496	0.52303	0.08424	0.00000
260 QF2	608.3786	4.11615	4.11136	54.69073	11.23978	1.94936	0.00000	1.4057	0.07880	-0.05557	0.00316	0.00000
261 QF2	609.4454	4.11931	4.12612	52.13759	11.97541	1.90927	0.00000	1.4057	2.27867	-0.64425	-0.07805	0.00000
262 FUG	610.3454	4.12217	4.13751	48.13219	13.23078	1.83902	0.00000	1.4057	2.17178	-0.75060	-0.07805	0.00000
263 000	611.4536	4.12602	4.15003	43.46452	15.03953	1.75252	0.00000	1.4057	2.04016	-0.88155	-0.07805	0.00000
264 B2	617.5242	4.15672	4.19609	23.07261	30.08829	1.34229	0.00000	1.4379	1.31921	-1.59686	-0.05711	0.00000
265 0	617.8992	4.15936	4.19803	22.09990	31.30252	1.32087	0.00000	1.4379	1.27467	-1.64111	-0.05711	0.00000
266 B2	623.9698	4.22300	4.22128	11.00125	55.55742	1.03778	0.00000	1.4624	0.55372	-2.35349	-0.03616	0.00000
267 0	624.3448	4.22853	4.22234	10.60266	57.33908	1.02422	0.00000	1.4624	0.50919	-2.39762	-0.03616	0.00000
268 QD2	625.4116	4.24509	4.22521	10.09829	59.93088	1.00815	0.00000	1.4624	-0.02943	0.00414	0.00593	0.00000
269 QD2	626.4784	4.26155	4.22809	10.73198	57.32192	1.03697	0.00000	1.4624	-0.57334	2.40519	0.04829	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
270 FUG	627.3784	4.27426	4.23069	11.86428	53.08845	1.08043	0.00000	1.4624	-0.68477	2.29866	0.04829	0.00000
271 000	628.4866	4.28819	4.23418	13.53405	48.13907	1.13394	0.00000	1.4624	-0.82197	2.16749	0.04829	0.00000
272 B2	634.5572	4.33859	4.26153	28.07506	26.16986	1.49062	0.00000	1.4896	-1.57352	1.45067	0.06923	0.00000
273 0	634.9322	4.34068	4.26386	29.27261	25.09854	1.51659	0.00000	1.4896	-1.61995	1.40619	0.06923	0.00000
274 B2	641.0028	4.36519	4.31979	53.50123	12.39014	2.00041	0.00000	1.5262	-2.37149	0.68679	0.09018	0.00000
275 0	641.3778	4.36628	4.32471	55.29726	11.89175	2.03422	0.00000	1.5262	-2.41792	0.64225	0.09018	0.00000
276 QF2	642.4446	4.36926	4.33958	58.00509	11.15745	2.08437	0.00000	1.5262	-0.08239	0.05631	0.00349	0.00000
277 QF2	643.5114	4.37223	4.35461	55.63845	11.64421	2.04161	0.00000	1.5262	2.26766	-0.51939	-0.08335	0.00000
278 FUG	644.4114	4.37490	4.36642	51.64609	12.66744	1.96659	0.00000	1.5262	2.16830	-0.61753	-0.08335	0.00000
279 000	645.5196	4.37848	4.37960	46.97584	14.17005	1.87422	0.00000	1.5262	2.04596	-0.73837	-0.08335	0.00000
280 B2	651.5902	4.40615	4.42968	26.20498	27.14522	1.43181	0.00000	1.5606	1.37584	-1.39854	-0.06241	0.00000
281 0	651.9652	4.40848	4.43184	25.18863	28.20944	1.40841	0.00000	1.5606	1.33444	-1.43937	-0.06241	0.00000
282 B2	658.0358	4.46280	4.45776	13.05586	49.68184	1.09314	0.00000	1.5866	0.66432	-2.09697	-0.04147	0.00000
283 0	658.4108	4.46746	4.45894	12.57314	51.26984	1.07759	0.00000	1.5866	0.62292	-2.13771	-0.04147	0.00000
284 QD2	659.4776	4.48146	4.46216	11.89790	53.57841	1.05702	0.00000	1.5866	0.01937	0.00578	0.00275	0.00000
285 QD2	660.5444	4.49551	4.46538	12.48801	51.24588	1.08350	0.00000	1.5866	-0.58069	2.14826	0.04708	0.00000
286 FUG	661.4444	4.50650	4.46828	13.61998	47.46776	1.12587	0.00000	1.5866	-0.67706	2.04965	0.04708	0.00000
287 000	662.5526	4.51875	4.47218	15.25211	43.05948	1.17804	0.00000	1.5866	-0.79572	1.92822	0.04708	0.00000
288 B2	668.6232	4.56547	4.50263	28.85788	23.67269	1.52740	0.00000	1.6147	-1.44570	1.26463	0.06802	0.00000
289 0	668.9982	4.56750	4.50520	29.95722	22.73966	1.55290	0.00000	1.6147	-1.48586	1.22345	0.06802	0.00000
290 B2	675.0688	4.59209	4.56529	51.94147	11.92515	2.02940	0.00000	1.6520	-2.13584	0.55761	0.08897	0.00000
291 0	675.4438	4.59322	4.57038	53.55841	11.52240	2.06276	0.00000	1.6520	-2.17599	0.51639	0.08897	0.00000
292 QF2	676.5106	4.59630	4.58557	55.82321	11.03771	2.11099	0.00000	1.6520	0.08476	-0.05529	0.00112	0.00000
293 QF2	677.5774	4.59939	4.60061	53.20743	11.76545	2.06513	0.00000	1.6520	2.33056	-0.63702	-0.08678	0.00000
294 FUG	678.4774	4.60220	4.61220	49.11032	13.00887	1.98703	0.00000	1.6520	2.22177	-0.74456	-0.08678	0.00000
295 000	679.5856	4.60598	4.62492	44.33443	14.80585	1.89086	0.00000	1.6520	2.08782	-0.87697	-0.08678	0.00000
296 B2	685.6562	4.63613	4.67154	23.44158	29.84778	1.42767	0.00000	1.6866	1.35408	-1.60032	-0.06583	0.00000
297 0	686.0312	4.63873	4.67350	22.44301	31.06479	1.40299	0.00000	1.6866	1.30875	-1.64506	-0.06583	0.00000
298 B2	692.1018	4.70183	4.69687	11.00827	55.41646	1.06693	0.00000	1.7122	0.57501	-2.36547	-0.04489	0.00000
299 0	692.4768	4.70736	4.69793	10.59401	57.20730	1.05010	0.00000	1.7122	0.52968	-2.41010	-0.04489	0.00000
300 QD2	693.5436	4.72397	4.70081	10.04664	59.83218	1.02523	0.00000	1.7122	-0.00903	-0.01393	-0.00191	0.00000
301 QD2	694.6104	4.74055	4.70369	10.63369	57.26499	1.04601	0.00000	1.7122	-0.54937	2.38468	0.04099	0.00000
302 FUG	695.5104	4.75339	4.70629	11.72171	53.06715	1.08290	0.00000	1.7122	-0.65955	2.27959	0.04099	0.00000
303 000	696.6186	4.76752	4.70978	13.33388	48.15807	1.12833	0.00000	1.7122	-0.79522	2.15019	0.04099	0.00000
304 B2	702.6892	4.81886	4.73704	27.49896	26.33997	1.44073	0.00000	1.7389	-1.53834	1.44309	0.06194	0.00000
305 0	703.0642	4.82098	4.73935	28.66993	25.27412	1.46396	0.00000	1.7389	-1.58425	1.39920	0.06194	0.00000
306 B2	709.1348	4.84601	4.79462	52.41412	12.59150	1.90351	0.00000	1.7739	-2.32738	0.68953	0.08288	0.00000
307 0	709.5098	4.84713	4.79945	54.17687	12.09083	1.93459	0.00000	1.7739	-2.37328	0.64559	0.08288	0.00000
308 QF2	710.5766	4.85016	4.81407	56.84012	11.35638	1.97923	0.00000	1.7739	-0.08586	0.05312	0.00051	0.00000
309 QF2	711.6434	4.85319	4.82883	54.53241	11.85735	1.93566	0.00000	1.7739	2.21671	-0.52970	-0.08190	0.00000
310 FUG	712.5434	4.85592	4.84043	50.63018	12.89830	1.86195	0.00000	1.7739	2.11910	-0.62690	-0.08190	0.00000
311 000	713.6516	4.85957	4.85337	46.06658	14.42041	1.77119	0.00000	1.7739	1.99893	-0.74659	-0.08190	0.00000
312 B2	719.7222	4.88774	4.90272	25.79486	27.45660	1.33764	0.00000	1.8063	1.34065	-1.40037	-0.06095	0.00000
313 0	720.0972	4.89010	4.90485	24.80462	28.52204	1.31479	0.00000	1.8063	1.29998	-1.44081	-0.06095	0.00000
314 B2	726.1678	4.94494	4.93055	13.01834	49.97318	1.00838	0.00000	1.8304	0.64170	-2.09202	-0.04001	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
315 O	726.5428	4.94961	4.93173	12.55231	51.55733	0.99337	0.00000	1.8304	0.60103	-2.13237	-0.04001	0.00000
316 QD2	727.6096	4.96361	4.93493	11.92197	53.84110	0.97249	0.00000	1.8304	-0.00145	0.02334	0.00071	0.00000
317 QD2	728.6764	4.97761	4.93813	12.55868	51.46064	0.99490	0.00000	1.8304	-0.60419	2.17497	0.04146	0.00000
318 FUG	729.5764	4.98852	4.94102	13.73427	47.63589	1.03221	0.00000	1.8304	-0.70202	2.07475	0.04146	0.00000
319 000	730.6846	5.00065	4.94491	15.42370	43.17417	1.07816	0.00000	1.8304	-0.82247	1.95134	0.04146	0.00000
320 B2	736.7552	5.04665	4.97538	29.41375	23.57252	1.39339	0.00000	1.8560	-1.48226	1.27690	0.06240	0.00000
321 O	737.1302	5.04864	4.97797	30.54072	22.63054	1.41679	0.00000	1.8560	-1.52302	1.23505	0.06240	0.00000
322 B2	743.2008	5.07274	5.03870	53.03563	11.74126	1.85915	0.00000	1.8901	-2.18280	0.55833	0.08335	0.00000
323 O	743.5758	5.07385	5.04388	54.68801	11.33822	1.89041	0.00000	1.8901	-2.22356	0.51643	0.08335	0.00000
324 QF2	744.6426	5.07686	5.05933	57.00334	10.84713	1.93653	0.00000	1.8901	0.08568	-0.04925	0.00280	0.00000
325 QF2	745.7094	5.07989	5.07463	54.33320	11.55472	1.89633	0.00000	1.8901	2.37982	-0.62389	-0.07788	0.00000
326 FUG	746.6094	5.08264	5.08643	50.14887	12.77511	1.82625	0.00000	1.8901	2.26944	-0.73210	-0.07788	0.00000
327 000	747.7176	5.08634	5.09938	45.26949	14.54538	1.73995	0.00000	1.8901	2.13353	-0.86534	-0.07788	0.00000
328 B2	753.7882	5.11589	5.14674	23.88675	29.47370	1.33080	0.00000	1.9221	1.38907	-1.59324	-0.05693	0.00000
329 O	754.1632	5.11844	5.14872	22.86219	30.68551	1.30945	0.00000	1.9221	1.34308	-1.63826	-0.05693	0.00000
330 B2	760.2338	5.18073	5.17233	11.07573	54.98238	1.02744	0.00000	1.9463	0.59862	-2.36324	-0.03599	0.00000
331 O	760.6088	5.18623	5.17340	10.64401	56.77166	1.01394	0.00000	1.9463	0.55263	-2.40816	-0.03599	0.00000
332 QD2	761.6756	5.20280	5.17630	10.05051	59.41238	0.99784	0.00000	1.9463	0.01191	-0.03051	0.00568	0.00000
333 QD2	762.7424	5.21940	5.17920	10.59169	56.89803	1.02616	0.00000	1.9463	-0.52668	2.35247	0.04760	0.00000
334 FUG	763.6424	5.23232	5.18182	11.63740	52.75660	1.06900	0.00000	1.9463	-0.63522	2.24912	0.04760	0.00000
335 000	764.7506	5.24657	5.18533	13.19342	47.91269	1.12175	0.00000	1.9463	-0.76887	2.12185	0.04760	0.00000
336 B2	770.8212	5.29872	5.21264	26.97161	26.36758	1.47427	0.00000	1.9733	-1.50095	1.42646	0.06855	0.00000
337 O	771.1962	5.30088	5.21495	28.11429	25.31392	1.49997	0.00000	1.9733	-1.54618	1.38330	0.06855	0.00000
338 B2	777.2668	5.32642	5.26980	51.32922	12.75309	1.97963	0.00000	2.0095	-2.27826	0.68537	0.08949	0.00000
339 O	777.6418	5.32757	5.27458	53.05487	12.25527	2.01319	0.00000	2.0095	-2.32348	0.64215	0.08949	0.00000
340 QF2	778.7086	5.33067	5.28899	55.66242	11.53360	2.06308	0.00000	2.0095	-0.08423	0.04439	0.00369	0.00000
341 QF2	779.7754	5.33376	5.30351	53.40367	12.06015	2.02101	0.00000	2.0095	2.16988	-0.54531	-0.08227	0.00000
342 FUG	780.6754	5.33654	5.31490	49.58447	13.12883	1.94697	0.00000	2.0095	2.07368	-0.64212	-0.08227	0.00000
343 000	781.7836	5.34027	5.32762	45.11965	14.68415	1.85580	0.00000	2.0095	1.95522	-0.76134	-0.08227	0.00000
344 B2	787.8542	5.36901	5.37611	25.32126	27.88357	1.41999	0.00000	2.0436	1.30637	-1.41250	-0.06132	0.00000
345 O	788.2292	5.37141	5.37821	24.35651	28.95805	1.39700	0.00000	2.0436	1.26629	-1.45279	-0.06132	0.00000
346 B2	794.2998	5.42699	5.40358	12.92194	50.53860	1.08832	0.00000	2.0694	0.61745	-2.10136	-0.04038	0.00000
347 O	794.6748	5.43170	5.40474	12.47389	52.12969	1.07318	0.00000	2.0694	0.57736	-2.14155	-0.04038	0.00000
348 QD2	795.7416	5.44576	5.40791	11.89023	54.40699	1.05367	0.00000	2.0694	-0.02219	0.03851	0.00367	0.00000
349 QD2	796.8084	5.45977	5.41107	12.57138	51.97019	1.08107	0.00000	2.0694	-0.62573	2.21183	0.04789	0.00000
350 FUG	797.7084	5.47066	5.41394	13.78735	48.08072	1.12417	0.00000	2.0694	-0.72535	2.10979	0.04789	0.00000
351 000	798.8166	5.48272	5.41780	15.53095	43.54381	1.17724	0.00000	2.0694	-0.84802	1.98415	0.04789	0.00000
352 B2	804.8872	5.52816	5.44811	29.90472	23.61820	1.53149	0.00000	2.0975	-1.51992	1.29744	0.06883	0.00000
353 O	805.2622	5.53012	5.45069	31.06023	22.66110	1.55730	0.00000	2.0975	-1.56143	1.25484	0.06883	0.00000
354 B2	811.3328	5.55378	5.51175	54.09511	11.60620	2.03869	0.00000	2.1350	-2.23334	0.56582	0.08978	0.00000
355 O	811.7078	5.55486	5.51698	55.78568	11.19783	2.07235	0.00000	2.1350	-2.27485	0.52317	0.08978	0.00000
356 QF2	812.7746	5.55782	5.53265	58.16106	10.68791	2.12123	0.00000	2.1350	0.08152	-0.03807	0.00151	0.00000
357 QF2	813.8414	5.56079	5.54819	55.44810	11.36518	2.07555	0.00000	2.1350	2.42352	-0.60623	-0.08682	0.00000
358 FUG	814.7414	5.56348	5.56019	51.18617	12.55385	1.99741	0.00000	2.1350	2.31195	-0.71452	-0.08682	0.00000
359 000	815.8496	5.56711	5.57338	46.21419	14.28528	1.90119	0.00000	2.1350	2.17458	-0.84786	-0.08682	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
360 B2	821.9202	5.59605	5.62158	24.38171	29.00503	1.43772	0.00000	2.1697	1.42211	-1.57637	-0.06588	0.00000
361 O	822.2952	5.59855	5.62359	23.33256	30.20420	1.41302	0.00000	2.1697	1.37563	-1.62142	-0.06588	0.00000
362 B2	828.3658	5.65981	5.64754	11.19962	54.30043	1.07669	0.00000	2.1955	0.62316	-2.34704	-0.04493	0.00000
363 O	828.7408	5.66525	5.64862	10.74969	56.07757	1.05984	0.00000	2.1955	0.57667	-2.39199	-0.04493	0.00000
364 QD2	829.8076	5.68169	5.65156	10.10965	58.71525	1.03514	0.00000	2.1955	0.03213	-0.04387	-0.00154	0.00000
365 QD2	830.8744	5.69824	5.65449	10.60847	56.25927	1.05652	0.00000	2.1955	-0.50662	2.31192	0.04178	0.00000
366 FUG	831.7744	5.71115	5.65714	11.61634	52.18916	1.09412	0.00000	2.1955	-0.61323	2.21042	0.04178	0.00000
367 OOO	832.8826	5.72546	5.66068	13.12098	47.42850	1.14042	0.00000	2.1955	-0.74451	2.08543	0.04178	0.00000
368 B2	838.9532	5.77821	5.68820	26.52433	26.24980	1.45759	0.00000	2.2225	-1.46357	1.40253	0.06272	0.00000
369 O	839.3282	5.78041	5.69052	27.63866	25.21379	1.48111	0.00000	2.2225	-1.50799	1.36015	0.06272	0.00000
370 B2	845.3988	5.80643	5.74525	50.31093	12.85808	1.92542	0.00000	2.2580	-2.22705	0.67474	0.08367	0.00000
371 O	845.7738	5.80760	5.74999	51.99788	12.36794	1.95679	0.00000	2.2580	-2.27147	0.63230	0.08367	0.00000
372 QF2	846.8406	5.81077	5.76424	54.54192	11.67064	2.00177	0.00000	2.2580	-0.07760	0.03105	0.00035	0.00000
373 QF2	847.9074	5.81392	5.77858	52.31922	12.23146	1.95753	0.00000	2.2580	2.12995	-0.56457	-0.08299	0.00000
374 FUG	848.8074	5.81676	5.78980	48.57102	13.33501	1.88284	0.00000	2.2580	2.03471	-0.66160	-0.08299	0.00000
375 OOO	849.9156	5.82057	5.80232	44.19125	14.93379	1.79087	0.00000	2.2580	1.91744	-0.78108	-0.08299	0.00000
376 B2	855.9862	5.84991	5.84995	24.81231	28.38164	1.35069	0.00000	2.2907	1.27506	-1.43368	-0.06204	0.00000
377 O	856.3612	5.85236	5.85202	23.87090	29.47204	1.32743	0.00000	2.2907	1.23537	-1.47405	-0.06204	0.00000
378 B2	862.4318	5.90887	5.87696	12.77240	51.31920	1.01439	0.00000	2.3150	0.59300	-2.12401	-0.04110	0.00000
379 O	862.8068	5.91363	5.87811	12.34253	52.92731	0.99897	0.00000	2.3150	0.55331	-2.16428	-0.04110	0.00000
380 QD2	863.8736	5.92782	5.88123	11.80457	55.21709	0.97704	0.00000	2.3150	-0.04160	0.04971	-0.00017	0.00000
381 QD2	864.9404	5.94190	5.88435	12.52536	52.72142	0.99861	0.00000	2.3150	-0.64401	2.25501	0.04075	0.00000
382 FUG	865.8404	5.95281	5.88717	13.77608	48.75589	1.03528	0.00000	2.3150	-0.74567	2.15113	0.04075	0.00000
383 OOO	866.9486	5.96487	5.89098	15.56749	44.12987	1.08044	0.00000	2.3150	-0.87084	2.02322	0.04075	0.00000
384 B2	873.0192	6.00995	5.92096	30.30165	23.80499	1.39135	0.00000	2.3406	-1.55647	1.32413	0.06169	0.00000
385 O	873.3942	6.01188	5.92352	31.48489	22.82816	1.41448	0.00000	2.3406	-1.59883	1.28075	0.06169	0.00000
386 B2	879.4648	6.03517	5.98455	55.05704	11.53404	1.85254	0.00000	2.3746	-2.28446	0.57930	0.08264	0.00000
387 O	879.8398	6.03624	5.98982	56.78626	11.11585	1.88353	0.00000	2.3746	-2.32681	0.53588	0.08264	0.00000
388 QF2	880.9066	6.03914	6.00562	59.22766	10.57664	1.92905	0.00000	2.3746	0.07252	-0.02292	0.00239	0.00000
389 QF2	881.9734	6.04206	6.02135	56.48595	11.21658	1.88859	0.00000	2.3746	2.45907	-0.58587	-0.07796	0.00000
390 FUG	882.8734	6.04470	6.03353	52.16067	12.36815	1.81842	0.00000	2.3746	2.34679	-0.69365	-0.07796	0.00000
391 OOO	883.9816	6.04825	6.04692	47.11246	14.05264	1.73202	0.00000	2.3746	2.20853	-0.82637	-0.07796	0.00000
392 B2	890.0522	6.07661	6.09598	24.89708	28.49061	1.32234	0.00000	2.4064	1.45124	-1.55146	-0.05702	0.00000
393 O	890.4272	6.07906	6.09803	23.82619	29.67102	1.30096	0.00000	2.4064	1.40445	-1.59630	-0.05702	0.00000
394 B2	896.4978	6.13917	6.12239	11.37259	53.44166	1.01842	0.00000	2.4305	0.64716	-2.31854	-0.03607	0.00000
395 O	896.8728	6.14453	6.12349	10.90477	55.19734	1.00489	0.00000	2.4305	0.60037	-2.36328	-0.03607	0.00000
396 QD2	897.9396	6.16076	6.12647	10.22055	57.81341	0.98849	0.00000	2.4305	0.05046	-0.05261	0.00521	0.00000
397 QD2	899.0064	6.17716	6.12945	10.68304	55.41526	1.01609	0.00000	2.4305	-0.49038	2.26725	0.04673	0.00000
398 FUG	899.9064	6.19001	6.13214	11.65978	51.42396	1.05815	0.00000	2.4305	-0.59488	2.16753	0.04673	0.00000
399 OOO	901.0146	6.20429	6.13573	13.12088	46.75593	1.10994	0.00000	2.4305	-0.72356	2.04473	0.04673	0.00000
400 B2	907.0852	6.25739	6.16359	26.18365	25.99890	1.45717	0.00000	2.4571	-1.42840	1.37379	0.06768	0.00000
401 O	907.4602	6.25962	6.16593	27.27129	24.98417	1.48254	0.00000	2.4571	-1.47195	1.33215	0.06768	0.00000
402 B2	913.5308	6.28606	6.22084	49.41969	12.89552	1.95691	0.00000	2.4929	-2.17679	0.65876	0.08862	0.00000
403 O	913.9058	6.28725	6.22556	51.06862	12.41709	1.99014	0.00000	2.4929	-2.22033	0.61706	0.08862	0.00000
404 QF2	914.9726	6.29047	6.23973	53.54511	11.75323	2.03963	0.00000	2.4929	-0.06636	0.01448	0.00380	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
405 QF2	916.0394	6.29369	6.25395	51.34343	12.35345	1.99819	0.00000	2.4929	2.09931	-0.58548	-0.08119	0.00000
406 FUG	916.9394	6.29658	6.26505	47.64999	13.49536	1.92513	0.00000	2.4929	2.00452	-0.68331	-0.08119	0.00000
407 000	918.0476	6.30046	6.27740	43.33649	15.14333	1.83516	0.00000	2.4929	1.88782	-0.80376	-0.08119	0.00000
408 B2	924.1182	6.33041	6.32426	24.29820	28.89892	1.40591	0.00000	2.5266	1.24856	-1.46168	-0.06024	0.00000
409 0	924.4932	6.33292	6.32629	23.37660	30.01044	1.38332	0.00000	2.5266	1.20907	-1.50238	-0.06024	0.00000
410 B2	930.5638	6.39050	6.35079	12.57858	52.23362	1.08121	0.00000	2.5522	0.56980	-2.15761	-0.03930	0.00000
411 0	930.9388	6.39533	6.35191	12.16604	53.86706	1.06647	0.00000	2.5522	0.53031	-2.19821	-0.03930	0.00000
412 QD2	932.0056	6.40970	6.35498	11.67008	56.18702	1.04798	0.00000	2.5522	-0.05855	0.05577	0.00450	0.00000
413 QD2	933.0724	6.42393	6.35805	12.42336	53.63606	1.07614	0.00000	2.5522	-0.65796	2.30000	0.04849	0.00000
414 FUG	933.9724	6.43492	6.36082	13.70112	49.59106	1.11978	0.00000	2.5522	-0.76177	2.19445	0.04849	0.00000
415 000	935.0806	6.44702	6.36456	15.53115	44.87130	1.17352	0.00000	2.5522	-0.88959	2.06449	0.04849	0.00000
416 B2	941.1512	6.49194	6.39410	30.58099	24.11342	1.53144	0.00000	2.5803	-1.58973	1.35417	0.06944	0.00000
417 0	941.5262	6.49386	6.39663	31.78951	23.11432	1.55747	0.00000	2.5803	-1.63298	1.31010	0.06944	0.00000
418 B2	947.5968	6.51686	6.45727	55.86431	11.53230	2.04253	0.00000	2.6178	-2.33311	0.59737	0.09038	0.00000
419 0	947.9718	6.51791	6.46254	57.63036	11.10082	2.07642	0.00000	2.6178	-2.37637	0.55325	0.09038	0.00000
420 QF2	949.0386	6.52078	6.47839	60.13983	10.52490	2.12585	0.00000	2.6178	0.05922	-0.00536	0.00193	0.00000
421 QF2	950.1054	6.52364	6.49423	57.38514	11.12440	2.08051	0.00000	2.6178	2.48436	-0.56495	-0.08660	0.00000
422 FUG	951.0054	6.52624	6.50652	53.01452	12.23737	2.00257	0.00000	2.6178	2.37188	-0.67168	-0.08660	0.00000
423 000	952.1136	6.52974	6.52007	47.91098	13.87171	1.90659	0.00000	2.6178	2.23337	-0.80309	-0.08660	0.00000
424 B2	958.1842	6.55758	6.56992	25.40226	27.98404	1.44446	0.00000	2.6527	1.47472	-1.52110	-0.06566	0.00000
425 0	958.5592	6.55998	6.57201	24.31380	29.14152	1.41984	0.00000	2.6527	1.42785	-1.56551	-0.06566	0.00000
426 B2	964.6298	6.61888	6.59681	11.58437	52.49556	1.08485	0.00000	2.6787	0.66920	-2.28072	-0.04471	0.00000
427 0	965.0048	6.62414	6.59793	11.10005	54.22271	1.06808	0.00000	2.6787	0.62233	-2.32502	-0.04471	0.00000
428 QD2	966.0716	6.64011	6.60097	10.37663	56.80084	1.04380	0.00000	2.6787	0.06578	-0.05583	-0.00097	0.00000
429 QD2	967.1384	6.65628	6.60400	10.81097	54.45397	1.06598	0.00000	2.6787	-0.47892	2.22313	0.04272	0.00000
430 FUG	968.0384	6.66900	6.60673	11.76514	50.54073	1.10443	0.00000	2.6787	-0.58127	2.12491	0.04272	0.00000
431 000	969.1466	6.68317	6.61039	13.19312	45.96509	1.15178	0.00000	2.6787	-0.70729	2.00398	0.04272	0.00000
432 B2	975.2172	6.73635	6.63868	25.96981	25.64103	1.47469	0.00000	2.7060	-1.39755	1.34323	0.06367	0.00000
433 0	975.5922	6.73860	6.64105	27.03396	24.64898	1.49856	0.00000	2.7060	-1.44020	1.30222	0.06367	0.00000
434 B2	981.6628	6.76535	6.69643	48.70841	12.86151	1.94860	0.00000	2.7418	-2.13046	0.63908	0.08461	0.00000
435 0	982.0378	6.76656	6.70115	50.32225	12.39760	1.98033	0.00000	2.7418	-2.17310	0.59802	0.08461	0.00000
436 QF2	983.1046	6.76983	6.71533	52.73116	11.77276	2.02579	0.00000	2.7418	-0.05119	-0.00360	0.00029	0.00000
437 QF2	984.1714	6.77309	6.72950	50.53423	12.41340	1.98095	0.00000	2.7418	2.07975	-0.60586	-0.08404	0.00000
438 FUG	985.0714	6.77604	6.74054	46.87603	13.59316	1.90531	0.00000	2.7418	1.98491	-0.70498	-0.08404	0.00000
439 000	986.1796	6.77998	6.75278	42.60611	15.29092	1.81218	0.00000	2.7418	1.86812	-0.82702	-0.08404	0.00000
440 B2	992.2502	6.81050	6.79901	23.80946	29.38151	1.36560	0.00000	2.7749	1.22844	-1.49359	-0.06310	0.00000
441 0	992.6252	6.81306	6.80101	22.90295	30.51716	1.34194	0.00000	2.7749	1.18892	-1.53483	-0.06310	0.00000
442 SB	998.6958	6.87183	6.82507	12.35151	53.20407	0.95890	0.00000	2.7749	0.54920	-2.20235	-0.06310	0.00000
443 0	999.0708	6.87674	6.82618	11.95443	54.87130	0.93524	0.00000	2.7749	0.50968	-2.24359	-0.06310	0.00000
444 QD2	1000.1376	6.89135	6.82919	11.49436	57.24325	0.88824	0.00000	2.7749	-0.07206	0.05313	-0.02533	0.00000
445 QD2	1001.2044	6.90578	6.83220	12.27110	54.65121	0.88079	0.00000	2.7749	-0.66677	2.34057	0.01131	0.00000
446 FUG	1002.1044	6.91689	6.83493	13.56665	50.53421	0.89097	0.00000	2.7749	-0.77273	2.23388	0.01131	0.00000
447 000	1003.2126	6.92909	6.83859	15.42389	45.72861	0.90350	0.00000	2.7749	-0.90319	2.10252	0.01131	0.00000
448 B2	1009.2832	6.97407	6.86759	30.72656	24.55546	1.03572	0.00000	2.7950	-1.61778	1.38454	0.03225	0.00000
449 0	1009.6582	6.97597	6.87007	31.95645	23.53376	1.04782	0.00000	2.7950	-1.66193	1.33999	0.03225	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
450 SB	1015.7288	6.99879	6.92983	56.47259	11.64233	1.24362	0.00000	2.7950	-2.37658	0.61886	0.03225	0.00000
451 O	1016.1038	6.99983	6.93506	58.27158	11.19489	1.25572	0.00000	2.7950	-2.42072	0.57432	0.03225	0.00000
452 QF2	1017.1706	7.00266	6.95081	60.84730	10.57824	1.26189	0.00000	2.7950	0.04240	0.01231	-0.02074	0.00000
453 Q1	1018.2374	7.00550	6.96659	58.09599	11.14078	1.21181	0.00000	2.7950	2.49805	-0.54746	-0.07280	0.00000
454 XO	1023.8228	7.02553	7.02624	34.07866	20.89587	0.80518	0.00000	2.7950	1.80197	-1.19907	-0.07280	0.00000
455 QOO	1024.4161	7.02837	7.03063	32.43457	22.06124	0.76741	0.00000	2.7950	0.98180	-0.75615	-0.05464	0.00000
456 O	1024.7911	7.03024	7.03330	31.70673	22.63837	0.74692	0.00000	2.7950	0.95909	-0.78286	-0.05464	0.00000
457 B2	1030.8617	7.06690	7.06802	22.29415	34.75677	0.47881	0.00000	2.8076	0.59154	-1.21295	-0.03370	0.00000
458 O	1031.2367	7.06960	7.06971	21.85901	35.67648	0.46617	0.00000	2.8076	0.56883	-1.23961	-0.03370	0.00000
459 B2	1037.3073	7.12030	7.09193	17.18427	53.32809	0.32519	0.00000	2.8157	0.20128	-1.66747	-0.01275	0.00000
460 O	1037.6823	7.12379	7.09304	17.04182	54.58866	0.32041	0.00000	2.8157	0.17858	-1.69406	-0.01275	0.00000
461 B2	1043.7529	7.18164	7.10789	17.10492	77.74059	0.30657	0.00000	2.8220	-0.18897	-2.11888	0.00819	0.00000
462 O	1044.1279	7.18511	7.10865	17.25516	79.33968	0.30964	0.00000	2.8220	-0.21168	-2.14536	0.00819	0.00000
463 QO	1046.7105	7.20631	7.11393	23.87593	70.13195	0.37285	0.00000	2.8220	-2.57030	5.39624	0.04181	0.00000
464 XI	1049.8405	7.22187	7.12327	43.08711	40.55893	0.50373	0.00000	2.8220	-3.56746	4.05201	0.04181	0.00000
465 QI	1051.9741	7.22893	7.13316	50.66185	30.90662	0.54591	0.00000	2.8220	0.23160	0.73865	-0.00287	0.00000
466 LS	1066.4741	7.27627	7.23226	48.31818	20.00009	0.50422	0.00000	2.8220	-0.06997	0.01352	-0.00287	0.00000
467 LS	1080.9741	7.32176	7.33285	54.71984	30.12231	0.46254	0.00000	2.8220	-0.37153	-0.71161	-0.00287	0.00000
468 QI	1083.1077	7.32826	7.34300	46.98956	39.49600	0.41581	0.00000	2.8220	3.77589	-3.94077	-0.04027	0.00000
469 XI	1086.2377	7.34239	7.35260	26.53350	68.26538	0.28976	0.00000	2.8220	2.75959	-5.25072	-0.04027	0.00000
470 QO	1088.8203	7.36127	7.35802	19.55378	77.22276	0.21968	0.00000	2.8220	0.17322	2.08823	-0.01517	0.00000
471 O	1089.1953	7.36433	7.35880	19.43127	75.66635	0.21399	0.00000	2.8220	0.15347	2.06220	-0.01517	0.00000
472 B2	1095.2659	7.41479	7.37405	19.50906	53.15933	0.18545	0.00000	2.8260	-0.16628	1.64453	0.00577	0.00000
473 O	1095.6409	7.41784	7.37519	19.64118	51.93573	0.18761	0.00000	2.8260	-0.18604	1.61840	0.00577	0.00000
474 B2	1101.7115	7.46310	7.39798	23.84063	34.83603	0.28621	0.00000	2.8307	-0.50578	1.19779	0.02672	0.00000
475 O	1102.0865	7.46558	7.39972	24.22737	33.94752	0.29623	0.00000	2.8307	-0.52554	1.17158	0.02672	0.00000
476 B2	1108.1571	7.50026	7.43513	32.54848	22.28699	0.52196	0.00000	2.8391	-0.84529	0.74882	0.04766	0.00000
477 O	1108.5321	7.50207	7.43785	33.18985	21.73522	0.53983	0.00000	2.8391	-0.86504	0.72256	0.04766	0.00000
478 QOO	1109.1254	7.50486	7.44230	34.70176	20.61337	0.57188	0.00000	2.8391	-1.69490	1.15965	0.06050	0.00000
479 XO	1114.7108	7.52488	7.50219	57.11664	11.20781	0.90979	0.00000	2.8391	-2.31822	0.52431	0.06050	0.00000
480 Q1	1115.7776	7.52777	7.51783	59.52417	10.69585	0.95357	0.00000	2.8391	0.09520	-0.03727	0.02128	0.00000
481 QF2	1116.8444	7.53067	7.53337	56.72241	11.37161	0.95485	0.00000	2.8391	2.49184	-0.60561	-0.01889	0.00000
482 FUG	1117.7444	7.53330	7.54537	52.34004	12.55906	0.93785	0.00000	2.8391	2.37745	-0.71378	-0.01889	0.00000
483 OOO	1118.8526	7.53685	7.55855	47.22675	14.28868	0.91691	0.00000	2.8391	2.23660	-0.84697	-0.01889	0.00000
484 SB	1124.9232	7.56526	7.60674	24.75551	29.00121	0.80224	0.00000	2.8391	1.46505	-1.57660	-0.01889	0.00000
485 O	1125.2982	7.56772	7.60876	23.67460	30.20056	0.79515	0.00000	2.8391	1.41738	-1.62167	-0.01889	0.00000
486 B2	1131.3688	7.62866	7.63271	11.15023	54.30130	0.74406	0.00000	2.8550	0.64588	-2.34753	0.00205	0.00000
487 O	1131.7438	7.63413	7.63379	10.68370	56.07881	0.74483	0.00000	2.8550	0.59822	-2.39250	0.00205	0.00000
488 QD2	1132.8106	7.65071	7.63673	9.99696	58.71754	0.76361	0.00000	2.8550	0.05500	-0.04433	0.03330	0.00000
489 QD2	1133.8774	7.66748	7.63966	10.44198	56.26241	0.81640	0.00000	2.8550	-0.47831	2.31160	0.06602	0.00000
490 FUG	1134.7774	7.68063	7.64230	11.39825	52.19287	0.87582	0.00000	2.8550	-0.58422	2.21012	0.06602	0.00000
491 OOO	1135.8856	7.69523	7.64585	12.83763	47.43282	0.94898	0.00000	2.8550	-0.71463	2.08518	0.06602	0.00000
492 B2	1141.9562	7.74930	7.67336	25.84946	26.25605	1.41331	0.00000	2.8795	-1.42895	1.40247	0.08697	0.00000
493 O	1142.3312	7.75156	7.67568	26.93772	25.22009	1.44593	0.00000	2.8795	-1.47307	1.36010	0.08697	0.00000
494 SB	1148.4018	7.77823	7.73038	49.15926	12.87114	1.97386	0.00000	2.8795	-2.18744	0.67412	0.08697	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
495 O	1148.7768	7.77943	7.73511	50.81639	12.38144	2.00648	0.00000	2.8795	-2.23157	0.63175	0.08697	0.00000
496 QF2	1149.8436	7.78267	7.74935	53.32902	11.68578	2.05384	0.00000	2.8795	-0.08849	0.03006	0.00150	0.00000
497 QF2	1150.9104	7.78589	7.76366	51.18285	12.24933	2.00966	0.00000	2.8795	2.07019	-0.56617	-0.08402	0.00000
498 FUG	1151.8104	7.78880	7.77487	47.54016	13.35577	1.93404	0.00000	2.8795	1.97724	-0.66320	-0.08402	0.00000
499 OOO	1152.9186	7.79268	7.78736	43.28462	14.95808	1.84093	0.00000	2.8795	1.86280	-0.78267	-0.08402	0.00000
500 B2	1158.9892	7.82254	7.83492	24.47484	28.42489	1.39446	0.00000	2.9131	1.23593	-1.43521	-0.06308	0.00000
501 O	1159.3642	7.82503	7.83698	23.56242	29.51644	1.37080	0.00000	2.9131	1.19721	-1.47558	-0.06308	0.00000
502 B2	1165.4348	7.88178	7.86189	12.83316	51.38181	1.05147	0.00000	2.9383	0.57034	-2.12548	-0.04213	0.00000
503 O	1165.8098	7.88651	7.86304	12.41993	52.99102	1.03567	0.00000	2.9383	0.53161	-2.16575	-0.04213	0.00000
504 QD2	1166.8766	7.90058	7.86615	11.93018	55.28105	1.01345	0.00000	2.9383	-0.06577	0.05095	0.00031	0.00000
505 QD2	1167.9434	7.91449	7.86927	12.70893	52.77999	1.03633	0.00000	2.9383	-0.67498	2.25874	0.04276	0.00000
506 FUG	1168.8434	7.92523	7.87209	14.01668	48.80789	1.07482	0.00000	2.9383	-0.77806	2.15469	0.04276	0.00000
507 OOO	1169.9516	7.93706	7.87589	15.88184	44.17421	1.12221	0.00000	2.9383	-0.90499	2.02657	0.04276	0.00000
508 B2	1176.0222	7.98110	7.90586	31.08893	23.81570	1.44534	0.00000	2.9649	-1.60023	1.32632	0.06371	0.00000
509 O	1176.3972	7.98298	7.90842	32.30521	22.83725	1.46923	0.00000	2.9649	-1.64318	1.28287	0.06371	0.00000
510 B2	1182.4678	8.00567	7.96946	56.47414	11.52448	1.91950	0.00000	3.0002	-2.33842	0.58025	0.08465	0.00000
511 O	1182.8428	8.00671	7.97473	58.24406	11.10560	1.95125	0.00000	3.0002	-2.38137	0.53676	0.08465	0.00000
512 QF2	1183.9096	8.00955	7.99055	60.73593	10.56421	1.99739	0.00000	3.0002	0.08047	-0.02172	0.00154	0.00000
513 QF2	1184.9764	8.01239	8.00630	57.91083	11.20109	1.95451	0.00000	3.0002	2.52812	-0.58415	-0.08164	0.00000
514 FUG	1185.8764	8.01496	8.01849	53.46361	12.34956	1.88103	0.00000	3.0002	2.41325	-0.69192	-0.08164	0.00000
515 OOO	1186.9846	8.01844	8.03191	48.27163	14.03018	1.79056	0.00000	3.0002	2.27180	-0.82462	-0.08164	0.00000
516 B2	1193.0552	8.04617	8.08105	25.39412	28.44640	1.35856	0.00000	3.0330	1.49705	-1.54962	-0.06070	0.00000
517 O	1193.4302	8.04857	8.08310	24.28929	29.62543	1.33580	0.00000	3.0330	1.44918	-1.59446	-0.06070	0.00000
518 B2	1199.5008	8.10801	8.10750	11.39864	53.37327	1.03094	0.00000	3.0575	0.67443	-2.31662	-0.03975	0.00000
519 O	1199.8758	8.11336	8.10860	10.91077	55.12752	1.01603	0.00000	3.0575	0.62656	-2.36136	-0.03975	0.00000
520 QD2	1200.9426	8.12962	8.11158	10.17259	57.74263	0.99593	0.00000	3.0575	0.07559	-0.05366	0.00192	0.00000
521 QD2	1202.0094	8.14614	8.11457	10.57860	55.34978	1.02016	0.00000	3.0575	-0.46178	2.26342	0.04368	0.00000
522 FUG	1202.9094	8.15914	8.11725	11.50271	51.36524	1.05947	0.00000	3.0575	-0.56500	2.16385	0.04368	0.00000
523 OOO	1204.0176	8.17364	8.12085	12.89583	46.70513	1.10787	0.00000	3.0575	-0.69210	2.04126	0.04368	0.00000
524 B2	1210.0882	8.22794	8.14873	25.52403	25.98349	1.43657	0.00000	3.0840	-1.38828	1.37143	0.06462	0.00000
525 O	1210.4632	8.23023	8.15107	26.58136	24.97051	1.46080	0.00000	3.0840	-1.43128	1.32986	0.06462	0.00000
526 B2	1216.5338	8.25736	8.20598	48.18349	12.90291	1.91664	0.00000	3.1191	-2.12746	0.65758	0.08557	0.00000
527 O	1216.9088	8.25858	8.21070	49.79521	12.42534	1.94872	0.00000	3.1191	-2.17047	0.61595	0.08557	0.00000
528 QF2	1217.9756	8.26188	8.22486	52.22299	11.76408	1.99590	0.00000	3.1191	-0.07124	0.01311	0.00254	0.00000
529 QF2	1219.0424	8.26518	8.23906	50.09024	12.36769	1.95410	0.00000	3.1191	2.04054	-0.58734	-0.08060	0.00000
530 FUG	1219.9424	8.26814	8.25015	46.50076	13.51300	1.88156	0.00000	3.1191	1.94776	-0.68522	-0.08060	0.00000
531 OOO	1221.0506	8.27212	8.26249	42.31035	15.16527	1.79224	0.00000	3.1191	1.83352	-0.80573	-0.08060	0.00000
532 B2	1227.1212	8.30272	8.30927	23.84943	28.94666	1.36656	0.00000	3.1520	1.20774	-1.46396	-0.05965	0.00000
533 O	1227.4962	8.30527	8.31129	22.95812	30.05990	1.34419	0.00000	3.1520	1.16908	-1.50468	-0.05965	0.00000
534 B2	1233.5668	8.36344	8.33575	12.56362	52.31286	1.04565	0.00000	3.1768	0.54331	-2.16021	-0.03871	0.00000
535 O	1233.9418	8.36827	8.33688	12.17063	53.94825	1.03113	0.00000	3.1768	0.50465	-2.20083	-0.03871	0.00000
536 QD2	1235.0086	8.38261	8.33994	11.72869	56.27016	1.01249	0.00000	3.1768	-0.08428	0.05660	0.00362	0.00000
537 QD2	1236.0754	8.39673	8.34300	12.54100	53.71382	1.03891	0.00000	3.1768	-0.68839	2.30413	0.04611	0.00000
538 FUG	1236.9754	8.40759	8.34578	13.87530	49.66152	1.08040	0.00000	3.1768	-0.79416	2.19842	0.04611	0.00000
539 OOO	1238.0836	8.41953	8.34951	15.77981	44.93319	1.13150	0.00000	3.1768	-0.92440	2.06826	0.04611	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
540 B2	1244.1542	8.46353	8.37902	31.33274	24.13638	1.47493	0.00000	3.2038	-1.63780	1.35681	0.06705	0.00000
541 O	1244.5292	8.46540	8.38154	32.57762	23.13532	1.50008	0.00000	3.2038	-1.68187	1.31268	0.06705	0.00000
542 B2	1250.5998	8.48783	8.44216	57.32642	11.52886	1.97065	0.00000	3.2400	-2.39526	0.59882	0.08799	0.00000
543 O	1250.9748	8.48886	8.44743	59.13939	11.09632	2.00365	0.00000	3.2400	-2.43933	0.55463	0.08799	0.00000
544 QF2	1252.0416	8.49164	8.46329	61.71517	10.51737	2.05216	0.00000	3.2400	0.06096	-0.00387	0.00263	0.00000
545 QF2	1253.1084	8.49444	8.47914	58.88696	11.11332	2.00921	0.00000	3.2400	2.55050	-0.56307	-0.08286	0.00000
546 FUG	1254.0084	8.49697	8.49144	54.39930	12.22283	1.93464	0.00000	3.2400	2.43580	-0.66973	-0.08286	0.00000
547 OOO	1255.1166	8.50038	8.50502	49.15712	13.85276	1.84282	0.00000	3.2400	2.29456	-0.80106	-0.08286	0.00000
548 B2	1261.1872	8.52754	8.55494	25.99653	27.93775	1.40344	0.00000	3.2737	1.52093	-1.51863	-0.06191	0.00000
549 O	1261.5622	8.52989	8.55704	24.87376	29.09337	1.38022	0.00000	3.2737	1.47313	-1.56301	-0.06191	0.00000
550 B2	1267.6328	8.58782	8.58188	11.68553	52.41442	1.06798	0.00000	3.2992	0.69950	-2.27779	-0.04097	0.00000
551 O	1268.0078	8.59305	8.58300	11.17882	54.13936	1.05262	0.00000	3.2992	0.65171	-2.32206	-0.04097	0.00000
552 QD2	1269.0746	8.60894	8.58604	10.39726	56.71492	1.03202	0.00000	3.2992	0.09172	-0.05642	0.00221	0.00000
553 QD2	1270.1414	8.62513	8.58908	10.77576	54.37305	1.05737	0.00000	3.2992	-0.45175	2.21909	0.04549	0.00000
554 FUG	1271.0414	8.63791	8.59181	11.67942	50.46693	1.09831	0.00000	3.2992	-0.55232	2.12103	0.04549	0.00000
555 OOO	1272.1496	8.65222	8.59548	13.04081	45.89969	1.14871	0.00000	3.2992	-0.67615	2.00028	0.04549	0.00000
556 B2	1278.2202	8.70637	8.62380	25.36673	25.61437	1.48839	0.00000	3.3266	-1.35443	1.34055	0.06643	0.00000
557 O	1278.5952	8.70868	8.62618	26.39826	24.62432	1.51330	0.00000	3.3266	-1.39633	1.29960	0.06643	0.00000
558 B2	1284.6658	8.73611	8.68158	47.46738	12.86251	1.98011	0.00000	3.3629	-2.07461	0.63748	0.08737	0.00000
559 O	1285.0408	8.73735	8.68631	49.03905	12.39977	2.01287	0.00000	3.3629	-2.11651	0.59648	0.08737	0.00000
560 QF2	1286.1076	8.74070	8.70048	51.38513	11.77823	2.06053	0.00000	3.3629	-0.04976	-0.00519	0.00164	0.00000
561 QF2	1287.1744	8.74405	8.71464	49.24513	12.42257	2.01634	0.00000	3.3629	2.02576	-0.60779	-0.08417	0.00000
562 FUG	1288.0744	8.74707	8.72567	45.68271	13.60589	1.94058	0.00000	3.3629	1.93248	-0.70700	-0.08417	0.00000
563 OOO	1289.1826	8.75112	8.73790	41.52684	15.30827	1.84731	0.00000	3.3629	1.81763	-0.82917	-0.08417	0.00000
564 B2	1295.2532	8.78240	8.78406	23.27900	29.42886	1.39994	0.00000	3.3967	1.18853	-1.49638	-0.06323	0.00000
565 O	1295.6282	8.78501	8.78605	22.40218	30.56662	1.37623	0.00000	3.3967	1.14966	-1.53766	-0.06323	0.00000
566 B2	1301.6988	8.84468	8.81009	12.26365	53.27438	1.05600	0.00000	3.4219	0.52056	-2.20213	-0.04228	0.00000
567 O	1302.0738	8.84963	8.81119	11.88780	54.94142	1.04014	0.00000	3.4219	0.48170	-2.24331	-0.04228	0.00000
568 QD2	1303.1406	8.86429	8.81419	11.48420	57.30954	1.01785	0.00000	3.4219	-0.09779	0.05639	0.00034	0.00000
569 QD2	1304.2074	8.87869	8.81720	12.31755	54.70785	1.04087	0.00000	3.4219	-0.69489	2.34623	0.04298	0.00000
570 FUG	1305.1074	8.88974	8.81993	13.66587	50.58095	1.07956	0.00000	3.4219	-0.80324	2.23922	0.04298	0.00000
571 OOO	1306.2156	8.90183	8.82359	15.59403	45.76397	1.12719	0.00000	3.4219	-0.93665	2.10745	0.04298	0.00000
572 B2	1312.2862	8.94606	8.85258	31.40119	24.54426	1.45166	0.00000	3.4487	-1.66742	1.38727	0.06393	0.00000
573 O	1312.6612	8.94792	8.85507	32.66868	23.52056	1.47564	0.00000	3.4487	-1.71257	1.34259	0.06393	0.00000
574 B2	1318.7318	8.97021	8.91495	57.89568	11.60424	1.92725	0.00000	3.4841	-2.44334	0.61994	0.08487	0.00000
575 O	1319.1068	8.97122	8.92020	59.74512	11.15606	1.95908	0.00000	3.4841	-2.48848	0.57520	0.08487	0.00000
576 QF2	1320.1736	8.97398	8.93600	62.39917	10.53629	2.00528	0.00000	3.4841	0.03783	0.01440	0.00143	0.00000
577 QF2	1321.2404	8.97675	8.95185	59.58846	11.09277	1.96210	0.00000	3.4841	2.55747	-0.54379	-0.08208	0.00000
578 FUG	1322.1404	8.97925	8.96419	55.08752	12.16621	1.88823	0.00000	3.4841	2.44358	-0.64892	-0.08208	0.00000
579 OOO	1323.2486	8.98261	8.97785	49.82698	13.74792	1.79728	0.00000	3.4841	2.30334	-0.77836	-0.08208	0.00000
580 B2	1329.3192	9.00931	9.02838	26.52649	27.49466	1.36263	0.00000	3.5170	1.53519	-1.48562	-0.06113	0.00000
581 O	1329.6942	9.01161	9.03051	25.39289	28.62527	1.33971	0.00000	3.5170	1.48774	-1.52936	-0.06113	0.00000
582 SB	1335.7648	9.06816	9.05578	11.99347	51.49208	0.96860	0.00000	3.5170	0.71953	-2.23745	-0.06113	0.00000
583 O	1336.1398	9.07325	9.05692	11.47162	53.18657	0.94568	0.00000	3.5170	0.67207	-2.28119	-0.06113	0.00000
584 QD2	1337.2066	9.08874	9.06002	10.65744	55.71752	0.90103	0.00000	3.5170	0.10237	-0.05610	-0.02288	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
585 QD2	1338.2734	9.10455	9.06311	11.02173	53.41894	0.89650	0.00000	3.5170	-0.44889	2.17880	0.01435	0.00000
586 FUG	1339.1734	9.11706	9.06589	11.91804	49.58423	0.90941	0.00000	3.5170	-0.54700	2.08198	0.01435	0.00000
587 000	1340.2816	9.13110	9.06962	13.26429	45.10187	0.92531	0.00000	3.5170	-0.66781	1.96275	0.01435	0.00000
588 B2	1346.3522	9.18476	9.09843	25.38847	25.22202	1.07597	0.00000	3.5378	-1.32953	1.31131	0.03529	0.00000
589 0	1346.7272	9.18707	9.10084	26.40095	24.25370	1.08920	0.00000	3.5378	-1.37041	1.27088	0.03529	0.00000
590 SB	1352.7978	9.21461	9.15683	47.05672	12.79729	1.30344	0.00000	3.5378	-2.03218	0.61632	0.03529	0.00000
591 0	1353.1728	9.21586	9.16158	48.59619	12.35021	1.31668	0.00000	3.5378	-2.07306	0.57589	0.03529	0.00000
592 QF2	1354.2396	9.21925	9.17578	50.86876	11.76992	1.32470	0.00000	3.5378	-0.02535	-0.02384	-0.02030	0.00000
593 Q1	1355.3064	9.22264	9.18993	48.70114	12.45500	1.27368	0.00000	3.5378	2.02684	-0.62790	-0.07499	0.00000
594 XO	1360.8918	9.24625	9.24350	29.33184	22.96136	0.85481	0.00000	3.5378	1.44101	-1.25314	-0.07499	0.00000
595 QOO	1361.4851	9.24955	9.24750	28.04758	24.16044	0.81608	0.00000	3.5378	0.73348	-0.75864	-0.05570	0.00000
596 0	1361.8601	9.25169	9.24994	27.50519	24.73859	0.79519	0.00000	3.5378	0.71291	-0.78310	-0.05570	0.00000
597 B2	1367.9307	9.29246	9.28226	20.87070	36.63656	0.52066	0.00000	3.5513	0.38006	-1.17641	-0.03475	0.00000
598 0	1368.3057	9.29534	9.28387	20.59337	37.52802	0.50763	0.00000	3.5513	0.35949	-1.20081	-0.03475	0.00000
599 B2	1374.3763	9.34603	9.30530	18.24951	54.48558	0.36023	0.00000	3.5602	0.02664	-1.59197	-0.01381	0.00000
600 0	1374.7513	9.34930	9.30638	18.23724	55.68868	0.35505	0.00000	3.5602	0.00607	-1.61630	-0.01381	0.00000
601 B2	1380.8219	9.40053	9.32109	20.18400	77.67425	0.33480	0.00000	3.5672	-0.32678	-2.00456	0.00714	0.00000
602 0	1381.1969	9.40347	9.32185	20.43680	79.18676	0.33747	0.00000	3.5672	-0.34735	-2.02878	0.00714	0.00000
603 QO	1383.7795	9.42121	9.32716	28.74591	69.47563	0.40153	0.00000	3.5672	-3.14406	5.45739	0.04354	0.00000
604 XI	1386.9095	9.43409	9.33666	52.13746	39.65314	0.53781	0.00000	3.5672	-4.32928	4.07056	0.04354	0.00000
605 QI	1389.0431	9.43992	9.34684	61.32111	29.80562	0.58056	0.00000	3.5672	0.28487	0.81699	-0.00407	0.00000
606 LS	1403.5431	9.47944	9.45494	56.76686	17.87534	0.52148	0.00000	3.5672	0.02922	0.00579	-0.00407	0.00000
607 LS	1418.0431	9.51953	9.56377	59.62642	29.46988	0.46240	0.00000	3.5672	-0.22643	-0.80541	-0.00407	0.00000
608 QI	1420.1767	9.52554	9.57407	50.50773	39.19814	0.41320	0.00000	3.5672	4.24224	-4.02294	-0.04135	0.00000
609 XI	1423.3067	9.53889	9.58368	27.63606	68.67661	0.28376	0.00000	3.5672	3.06501	-5.39510	-0.04135	0.00000
610 QO	1425.8893	9.55742	9.58905	19.47686	78.28058	0.20996	0.00000	3.5672	0.36341	2.00433	-0.01703	0.00000
611 0	1426.2643	9.56051	9.58982	19.21248	76.78635	0.20358	0.00000	3.5672	0.34161	1.98029	-0.01703	0.00000
612 B2	1432.3349	9.61468	9.60469	17.20688	55.07684	0.16376	0.00000	3.5708	-0.01121	1.59510	0.00391	0.00000
613 0	1432.7099	9.61815	9.60579	17.22346	53.88956	0.16523	0.00000	3.5708	-0.03300	1.57096	0.00391	0.00000
614 B2	1438.7805	9.67150	9.62744	19.76581	37.16825	0.25256	0.00000	3.5750	-0.38582	1.18291	0.02486	0.00000
615 0	1439.1555	9.67450	9.62907	20.06336	36.29015	0.26188	0.00000	3.5750	-0.40762	1.15870	0.02486	0.00000
616 B2	1445.2261	9.71637	9.66164	27.15366	24.58818	0.47634	0.00000	3.5825	-0.76044	0.76852	0.04580	0.00000
617 0	1445.6011	9.71855	9.66410	27.73217	24.02088	0.49352	0.00000	3.5825	-0.78224	0.74426	0.04580	0.00000
618 QOO	1446.1944	9.72188	9.66812	29.07162	22.84043	0.52414	0.00000	3.5825	-1.48572	1.23627	0.05756	0.00000
619 XO	1451.7798	9.74549	9.72177	49.11013	12.48370	0.84561	0.00000	3.5825	-2.10194	0.61798	0.05756	0.00000
620 Q1	1452.8466	9.74885	9.73587	51.42132	11.82026	0.88771	0.00000	3.5825	-0.03212	0.01316	0.02107	0.00000
621 QF2	1453.9134	9.75220	9.75001	49.24315	12.42586	0.89024	0.00000	3.5825	2.04336	-0.58928	-0.01635	0.00000
622 FUG	1454.8134	9.75522	9.76104	45.65023	13.57439	0.87552	0.00000	3.5825	1.94877	-0.68686	-0.01635	0.00000
623 000	1455.9216	9.75927	9.77332	41.46004	15.22990	0.85740	0.00000	3.5825	1.83230	-0.80702	-0.01635	0.00000
624 SB	1461.9922	9.79071	9.81994	23.08674	29.02367	0.75815	0.00000	3.5825	1.19430	-1.46521	-0.01635	0.00000
625 0	1462.3672	9.79334	9.82196	22.20579	30.13782	0.75202	0.00000	3.5825	1.15489	-1.50587	-0.01635	0.00000
626 B2	1468.4378	9.85383	9.84637	12.05758	52.39925	0.71634	0.00000	3.5976	0.51693	-2.16042	0.00459	0.00000
627 0	1468.8128	9.85886	9.84749	11.68466	54.03478	0.71806	0.00000	3.5976	0.47752	-2.20098	0.00459	0.00000
628 QD2	1469.8796	9.87378	9.85054	11.28278	56.35302	0.73899	0.00000	3.5976	-0.09525	0.06013	0.03477	0.00000
629 QD2	1470.9464	9.88843	9.85361	12.10324	53.78573	0.79280	0.00000	3.5976	-0.68517	2.31072	0.06650	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
630 FUG	1471.8464	9.89968	9.85638	13.43490	49.72191	0.85265	0.00000	3.5976	-0.79444	2.20464	0.06650	0.00000
631 OOO	1472.9546	9.91197	9.86011	15.34481	44.98030	0.92635	0.00000	3.5976	-0.92899	2.07402	0.06650	0.00000
632 B2	1479.0252	9.95679	9.88960	31.09665	24.12853	1.39357	0.00000	3.6217	-1.66597	1.36010	0.08744	0.00000
633 O	1479.4002	9.95867	9.89213	32.36321	23.12506	1.42637	0.00000	3.6217	-1.71150	1.31581	0.08744	0.00000
634 SB	1485.4708	9.98112	9.95283	57.61715	11.50224	1.95720	0.00000	3.6217	-2.44854	0.59880	0.08744	0.00000
635 O	1485.8458	9.98214	9.95812	59.47063	11.06975	1.98999	0.00000	3.6217	-2.49407	0.55450	0.08744	0.00000
636 QF2	1486.9126	9.98491	9.97402	62.14950	10.49019	2.03823	0.00000	3.6217	0.02051	-0.00315	0.00266	0.00000
637 QF2	1487.9794	9.98768	9.98991	59.38572	11.08361	1.99562	0.00000	3.6217	2.53146	-0.56138	-0.08225	0.00000
638 FUG	1488.8794	9.99019	10.00225	54.93013	12.19021	1.92160	0.00000	3.6217	2.41919	-0.66817	-0.08225	0.00000
639 OOO	1489.9876	9.99357	10.01585	49.72144	13.81688	1.83045	0.00000	3.6217	2.28094	-0.79967	-0.08225	0.00000
640 B2	1496.0582	10.02024	10.06589	26.62669	27.89042	1.39477	0.00000	3.6552	1.52370	-1.51813	-0.06130	0.00000
641 O	1496.4332	10.02253	10.06799	25.50146	29.04568	1.37178	0.00000	3.6552	1.47692	-1.56257	-0.06130	0.00000
642 B2	1502.5038	10.07853	10.09286	12.16784	52.36681	1.06324	0.00000	3.6805	0.71967	-2.27824	-0.04036	0.00000
643 O	1502.8788	10.08354	10.09398	11.64563	54.09212	1.04810	0.00000	3.6805	0.67289	-2.32257	-0.04036	0.00000
644 QD2	1503.9456	10.09879	10.09703	10.83541	56.67095	1.02806	0.00000	3.6805	0.09779	-0.05894	0.00264	0.00000
645 QD2	1505.0124	10.11433	10.10006	11.21590	54.33625	1.05378	0.00000	3.6805	-0.45971	2.21500	0.04576	0.00000
646 FUG	1505.9124	10.12662	10.10280	12.13086	50.43730	1.09497	0.00000	3.6805	-0.55691	2.11717	0.04576	0.00000
647 OOO	1507.0206	10.14042	10.10647	13.49783	45.87830	1.14568	0.00000	3.6805	-0.67660	1.99671	0.04576	0.00000
648 B2	1513.0912	10.19327	10.13479	25.69143	25.62677	1.48703	0.00000	3.7079	-1.33218	1.33856	0.06671	0.00000
649 O	1513.4662	10.19555	10.13717	26.70575	24.63817	1.51205	0.00000	3.7079	-1.37268	1.29771	0.06671	0.00000
650 B2	1519.5368	10.22285	10.19249	47.35004	12.88971	1.98054	0.00000	3.7442	-2.02827	0.63717	0.08765	0.00000
651 O	1519.9118	10.22409	10.19721	48.88643	12.42717	2.01341	0.00000	3.7442	-2.06877	0.59627	0.08765	0.00000
652 QF2	1520.9786	10.22746	10.21135	51.13619	11.80703	2.06135	0.00000	3.7442	-0.00857	-0.00631	0.00189	0.00000
653 QF2	1522.0454	10.23083	10.22547	48.92192	12.45491	2.01740	0.00000	3.7442	2.05314	-0.61004	-0.08396	0.00000
654 FUG	1522.9454	10.23387	10.23647	45.31263	13.64221	1.94184	0.00000	3.7442	1.95719	-0.70919	-0.08396	0.00000
655 OOO	1524.0536	10.23796	10.24867	41.10564	15.34936	1.84879	0.00000	3.7442	1.83905	-0.83128	-0.08396	0.00000
656 B2	1530.1242	10.26979	10.29472	22.70709	29.49308	1.40269	0.00000	3.7781	1.19194	-1.49808	-0.06302	0.00000
657 O	1530.4992	10.27248	10.29671	21.82813	30.63211	1.37905	0.00000	3.7781	1.15196	-1.53933	-0.06302	0.00000
658 B2	1536.5698	10.33429	10.32070	11.77108	53.35769	1.06009	0.00000	3.8034	0.50484	-2.20339	-0.04207	0.00000
659 O	1536.9448	10.33944	10.32180	11.40744	55.02567	1.04431	0.00000	3.8034	0.46487	-2.24454	-0.04207	0.00000
660 QD2	1538.0116	10.35472	10.32480	11.02263	57.39259	1.02234	0.00000	3.8034	-0.09883	0.05873	0.00073	0.00000
661 QD2	1539.0784	10.36971	10.32780	11.84176	54.78240	1.04588	0.00000	3.8034	-0.68033	2.35174	0.04357	0.00000
662 FUG	1539.9784	10.38119	10.33052	13.16642	50.64583	1.08509	0.00000	3.8034	-0.79151	2.24445	0.04357	0.00000
663 OOO	1541.0866	10.39372	10.33418	15.07242	45.81764	1.13337	0.00000	3.8034	-0.92841	2.11234	0.04357	0.00000
664 B2	1547.1572	10.43911	10.36315	30.89535	24.55005	1.46140	0.00000	3.8303	-1.67827	1.39027	0.06451	0.00000
665 O	1547.5322	10.44100	10.36563	32.17142	23.52415	1.48559	0.00000	3.8303	-1.72459	1.34547	0.06451	0.00000
666 B2	1553.6028	10.46351	10.42557	57.66031	11.58429	1.94075	0.00000	3.8660	-2.47446	0.62093	0.08546	0.00000
667 O	1553.9778	10.46452	10.43082	59.53353	11.13542	1.97279	0.00000	3.8660	-2.52078	0.57608	0.08546	0.00000
668 QF2	1555.0446	10.46729	10.44666	62.26731	10.51314	2.01931	0.00000	3.8660	-0.00349	0.01590	0.00143	0.00000
669 QF2	1556.1114	10.47006	10.46255	59.54798	11.06552	1.97582	0.00000	3.8660	2.51442	-0.54139	-0.08266	0.00000
670 FUG	1557.0114	10.47256	10.47492	55.12163	12.13467	1.90143	0.00000	3.8660	2.40375	-0.64656	-0.08266	0.00000
671 OOL	1560.9758	10.48636	10.51685	37.99536	19.09771	1.57373	0.00000	3.8660	1.91627	-1.10983	-0.08266	0.00000
672 B2	1567.0464	10.52238	10.55359	19.26212	36.86756	1.13555	0.00000	3.8941	1.16985	-1.81672	-0.06171	0.00000
673 OOL	1571.0108	10.56451	10.56786	11.91916	53.10528	0.89089	0.00000	3.8941	0.68237	-2.27916	-0.06171	0.00000
674 QD2	1572.0776	10.57941	10.57097	11.09835	55.63558	0.84439	0.00000	3.8941	0.09837	-0.05753	-0.02577	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
675 QD2	1573.1444	10.59458	10.57406	11.48685	53.34357	0.83549	0.00000	3.8941	-0.46791	2.17416	0.00902	0.00000
676 FUG	1574.0444	10.60658	10.57685	12.41505	49.51703	0.84360	0.00000	3.8941	-0.56342	2.07754	0.00902	0.00000
677 OOL	1578.0088	10.64865	10.59208	18.55006	34.73197	0.87936	0.00000	3.8941	-0.98411	1.65192	0.00902	0.00000
678 B2	1584.0794	10.68727	10.63045	34.40746	18.62132	0.99767	0.00000	3.9136	-1.62825	1.00138	0.02996	0.00000
679 OOL	1588.0438	10.70266	10.67250	48.98530	12.37192	1.11646	0.00000	3.9136	-2.04894	0.57500	0.02996	0.00000
680 QF2	1589.1106	10.70603	10.68668	51.18753	11.79424	1.12331	0.00000	3.9136	0.01549	-0.02545	-0.01718	0.00000
681 QF2	1590.1774	10.70939	10.70080	48.92117	12.48376	1.08008	0.00000	3.9136	2.07718	-0.63051	-0.06356	0.00000
682 FUG	1591.0774	10.71244	10.71176	45.27025	13.70937	1.02288	0.00000	3.9136	1.97940	-0.73127	-0.06356	0.00000
683 OOL	1595.0418	10.72924	10.74905	31.28334	21.26688	0.77092	0.00000	3.9136	1.54872	-1.17508	-0.06356	0.00000
684 B2	1601.1124	10.77230	10.78257	16.48430	39.64686	0.44870	0.00000	3.9261	0.88928	-1.85196	-0.04261	0.00000
685 OOL	1605.0768	10.81955	10.79596	11.14080	56.08669	0.27977	0.00000	3.9261	0.45859	-2.29490	-0.04261	0.00000
686 QD2	1606.1436	10.83520	10.79891	10.76012	58.51379	0.24020	0.00000	3.9261	-0.09649	0.05352	-0.03184	0.00000
687 QD2	1607.2104	10.85056	10.80185	11.56481	55.86501	0.21133	0.00000	3.9261	-0.66894	2.39259	-0.02249	0.00000
688 FUG	1608.1104	10.86231	10.80452	12.87028	51.65585	0.19109	0.00000	3.9261	-0.78158	2.28425	-0.02249	0.00000
689 OOL	1612.0748	10.90104	10.81929	21.03440	35.43624	0.10193	0.00000	3.9261	-1.27778	1.80706	-0.02249	0.00000
690 B2	1618.1454	10.93411	10.85801	41.15882	17.92154	0.02898	0.00000	3.9273	-2.03753	1.07748	-0.00154	0.00000
691 OOL	1622.1098	10.94690	10.90300	59.28109	11.27352	0.02286	0.00000	3.9273	-2.53372	0.59945	-0.00154	0.00000
692 QF2	1623.1766	10.94967	10.91866	62.05463	10.60727	0.02071	0.00000	3.9273	-0.02725	0.03437	-0.00246	0.00000
693 QF2	1624.2434	10.95245	10.93444	59.39394	11.12246	0.01764	0.00000	3.9273	2.48402	-0.52448	-0.00327	0.00000
694 FUG	1625.1434	10.95496	10.94677	55.02048	12.15938	0.01470	0.00000	3.9273	2.37537	-0.62766	-0.00327	0.00000
695 000	1626.2516	10.95832	10.96045	49.90398	13.69131	0.01108	0.00000	3.9273	2.24158	-0.75470	-0.00327	0.00000
696 SB	1632.3222	10.98470	11.01150	27.13748	27.07900	-0.00877	0.00000	3.9273	1.50871	-1.45063	-0.00327	0.00000
697 0	1632.6972	10.98694	11.01366	26.02292	28.18309	-0.00999	0.00000	3.9273	1.46343	-1.49362	-0.00327	0.00000
698 SB	1638.7678	11.04112	11.03937	12.70410	50.54220	-0.02984	0.00000	3.9273	0.73056	-2.18956	-0.00327	0.00000
699 0	1639.1428	11.04592	11.04054	12.17316	52.20048	-0.03107	0.00000	3.9273	0.68528	-2.23255	-0.00327	0.00000
700 INS1	1640.6571	11.06743	11.04487	10.37454	59.22485	-0.03602	0.00000	3.9273	0.50247	-2.40615	-0.00327	0.00000
701 QDI	1641.7239	11.08436	11.04766	9.87693	61.74846	-0.04033	0.00000	3.9273	-0.02913	0.07564	-0.00485	0.00000
702 QDI	1642.7907	11.10119	11.05045	10.50257	58.91155	-0.04644	0.00000	3.9273	-0.56598	2.54420	-0.00665	0.00000
703 FUG	1643.6907	11.11417	11.05298	11.62316	54.43474	-0.05243	0.00000	3.9273	-0.67912	2.43003	-0.00665	0.00000
704 000	1644.7989	11.12838	11.05639	13.28276	49.20460	-0.05979	0.00000	3.9273	-0.81844	2.28946	-0.00665	0.00000
705 SB	1650.8695	11.17948	11.08349	27.85249	26.08253	-0.10015	0.00000	3.9273	-1.58161	1.51940	-0.00665	0.00000
706 0	1651.2445	11.18158	11.08583	29.05638	24.96082	-0.10264	0.00000	3.9273	-1.62875	1.47183	-0.00665	0.00000
707 SB	1657.3151	11.20619	11.14346	53.46424	11.76573	-0.14300	0.00000	3.9273	-2.39192	0.70177	-0.00665	0.00000
708 0	1657.6901	11.20729	11.14865	55.27586	11.25723	-0.14549	0.00000	3.9273	-2.43906	0.65421	-0.00665	0.00000
709 INS2	1658.6297	11.20989	11.16266	59.97033	10.13984	-0.15174	0.00000	3.9273	-2.55718	0.53502	-0.00665	0.00000
710 QF2	1659.6965	11.21264	11.18006	62.76268	9.57097	-0.15540	0.00000	3.9273	-0.02116	0.00616	-0.00018	0.00000
711 QF2	1660.7633	11.21538	11.19748	60.05797	10.11276	-0.15213	0.00000	3.9273	2.51859	-0.52158	0.00629	0.00000
712 FUG	1661.6633	11.21786	11.21098	55.62356	11.15349	-0.14647	0.00000	3.9273	2.40854	-0.63478	0.00629	0.00000
713 000	1662.7715	11.22119	11.22582	50.43542	12.71490	-0.13950	0.00000	3.9273	2.27304	-0.77418	0.00629	0.00000
714 SB	1668.8421	11.24732	11.27920	27.34386	26.74986	-0.10132	0.00000	3.9273	1.53079	-1.53778	0.00629	0.00000
715 0	1669.2171	11.24955	11.28138	26.21296	27.92088	-0.09896	0.00000	3.9273	1.48494	-1.58495	0.00629	0.00000
716 SB	1675.2877	11.30356	11.30690	12.68990	51.79950	-0.06078	0.00000	3.9273	0.74269	-2.34854	0.00629	0.00000
717 0	1675.6627	11.30836	11.30803	12.15007	53.57860	-0.05842	0.00000	3.9273	0.69684	-2.39571	0.00629	0.00000
718 INS2	1676.6023	11.32134	11.31071	10.94852	58.19167	-0.05251	0.00000	3.9273	0.58196	-2.51390	0.00629	0.00000
719 QDI	1677.6691	11.33748	11.31354	10.30386	60.99609	-0.04692	0.00000	3.9273	0.03124	-0.07594	0.00423	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
720 QDI	1678.7359	11.35371	11.31636	10.81124	58.50621	-0.04342	0.00000	3.9273	-0.51385	2.37530	0.00236	0.00000
721 FUG	1679.6359	11.36639	11.31890	11.83088	54.32263	-0.04129	0.00000	3.9273	-0.61908	2.27313	0.00236	0.00000
722 OOO	1680.7441	11.38044	11.32231	13.34661	49.42389	-0.03868	0.00000	3.9273	-0.74865	2.14731	0.00236	0.00000
723 SB	1686.8147	11.43250	11.34861	26.74489	27.53665	-0.02436	0.00000	3.9273	-1.45842	1.45814	0.00236	0.00000
724 O	1687.1897	11.43469	11.35083	27.85515	26.45901	-0.02347	0.00000	3.9273	-1.50227	1.41556	0.00236	0.00000
725 SB	1693.2603	11.46059	11.40296	50.40325	13.45610	-0.00915	0.00000	3.9273	-2.21204	0.72638	0.00236	0.00000
726 O	1693.6353	11.46176	11.40748	52.07872	12.92728	-0.00827	0.00000	3.9273	-2.25589	0.68381	0.00236	0.00000
727 INS1	1695.1496	11.46610	11.42764	59.17901	11.11661	-0.00469	0.00000	3.9273	-2.43294	0.51190	0.00236	0.00000
728 QF2	1696.2164	11.46889	11.44340	61.73913	10.62752	-0.00209	0.00000	3.9273	0.06903	-0.04662	0.00250	0.00000
729 QF2	1697.2832	11.47168	11.45902	58.89317	11.32152	0.00060	0.00000	3.9273	2.55882	-0.61360	0.00253	0.00000
730 FUG	1698.1832	11.47421	11.47106	54.39109	12.52447	0.00288	0.00000	3.9273	2.44348	-0.72302	0.00253	0.00000
731 OOL	1702.1476	11.48829	11.51119	37.03140	20.16800	0.01293	0.00000	3.9273	1.93542	-1.20502	0.00253	0.00000
732 B2	1708.2182	11.52579	11.54579	18.25703	39.26695	0.09187	0.00000	3.9282	1.15748	-1.94043	0.02348	0.00000
733 OOL	1712.1826	11.57072	11.55920	11.09376	56.55947	0.18495	0.00000	3.9282	0.64942	-2.42153	0.02348	0.00000
734 QD2	1713.2494	11.58674	11.56211	10.31421	59.23895	0.21430	0.00000	3.9282	0.09209	-0.05292	0.03175	0.00000
735 QD2	1714.3162	11.60305	11.56501	10.68908	56.77868	0.25319	0.00000	3.9282	-0.44866	2.32493	0.04143	0.00000
736 FUG	1715.2162	11.61594	11.56763	11.58771	52.68518	0.29047	0.00000	3.9282	-0.54981	2.22340	0.04143	0.00000
737 OOL	1719.1806	11.66056	11.58198	17.71335	36.82927	0.45472	0.00000	3.9282	-0.99535	1.77617	0.04143	0.00000
738 B2	1725.2512	11.70038	11.61843	33.93828	19.41036	0.76977	0.00000	3.9408	-1.67755	1.09259	0.06237	0.00000
739 OOL	1729.2156	11.71587	11.65935	49.00554	12.52372	1.01705	0.00000	3.9408	-2.12309	0.64453	0.06237	0.00000
740 QF2	1730.2824	11.71923	11.67343	51.36744	11.80644	1.06043	0.00000	3.9408	-0.05780	0.03784	0.01865	0.00000
741 QF2	1731.3492	11.72258	11.68761	49.24488	12.35741	1.05654	0.00000	3.9408	2.01769	-0.56199	-0.02591	0.00000
742 FUG	1732.2492	11.72560	11.69873	45.69646	13.45524	1.03322	0.00000	3.9408	1.92501	-0.65782	-0.02591	0.00000
743 OOL	1736.2136	11.74212	11.73724	32.05189	20.34447	0.93050	0.00000	3.9408	1.51677	-1.07995	-0.02591	0.00000
744 B2	1742.2842	11.78345	11.77257	17.43220	37.36867	0.83679	0.00000	3.9590	0.89169	-1.72380	-0.00497	0.00000
745 OOL	1746.2486	11.82768	11.78681	11.98062	52.70665	0.81711	0.00000	3.9590	0.48345	-2.14513	-0.00497	0.00000
746 QD2	1747.3154	11.84223	11.78994	11.57660	54.96516	0.82996	0.00000	3.9590	-0.09913	0.05944	0.02915	0.00000
747 QD2	1748.3822	11.85651	11.79308	12.41627	52.46045	0.87976	0.00000	3.9590	-0.69956	2.25362	0.06456	0.00000
748 FUG	1749.2822	11.86747	11.79592	13.77265	48.49780	0.93786	0.00000	3.9590	-0.80752	2.14933	0.06456	0.00000
749 OOL	1753.2466	11.90399	11.81165	22.06061	33.27733	1.19380	0.00000	3.9590	-1.28307	1.68996	0.06456	0.00000
750 B2	1759.3172	11.93592	11.85270	42.05746	17.01929	1.64925	0.00000	3.9886	-2.01122	0.98761	0.08550	0.00000
751 OOL	1763.2816	11.94851	11.89946	59.88926	11.01287	1.98823	0.00000	3.9886	-2.48677	0.52748	0.08550	0.00000
752 QF2	1764.3484	11.95126	11.91540	62.53293	10.48776	2.03445	0.00000	3.9886	0.04571	-0.02793	0.00083	0.00000
753 QF2	1765.4152	11.95402	11.93126	59.69998	11.13564	1.98999	0.00000	3.9886	2.57013	-0.58841	-0.08387	0.00000
754 FUG	1766.3152	11.95651	11.94351	55.17694	12.29270	1.91451	0.00000	3.9886	2.45547	-0.69721	-0.08387	0.00000
755 OOO	1767.4234	11.95988	11.95698	49.89110	13.98648	1.82156	0.00000	3.9886	2.31429	-0.83119	-0.08387	0.00000
756 B2	1773.4940	11.98658	12.00613	26.48905	28.52496	1.37602	0.00000	4.0219	1.54097	-1.56319	-0.06293	0.00000
757 O	1773.8690	11.98888	12.00818	25.35124	29.71432	1.35242	0.00000	4.0219	1.49320	-1.60846	-0.06293	0.00000
758 B2	1779.9396	12.04566	12.03246	11.91745	53.67440	1.03401	0.00000	4.0466	0.71989	-2.33758	-0.04198	0.00000
759 O	1780.3146	12.05078	12.03356	11.39545	55.44452	1.01827	0.00000	4.0466	0.67211	-2.38275	-0.04198	0.00000
760 QD2	1781.3814	12.06638	12.03653	10.57874	58.09137	0.99582	0.00000	4.0466	0.10474	-0.06158	-0.00027	0.00000
761 QD2	1782.4482	12.08231	12.03949	10.93515	55.69958	1.01769	0.00000	4.0466	-0.44376	2.27036	0.04144	0.00000
762 FUG	1783.3482	12.09492	12.04216	11.82259	51.70243	1.05499	0.00000	4.0466	-0.54228	2.17091	0.04144	0.00000
763 OOO	1784.4564	12.10908	12.04574	13.15891	47.02652	1.10091	0.00000	4.0466	-0.66358	2.04846	0.04144	0.00000
764 B2	1790.5270	12.16312	12.07339	25.24807	26.21254	1.41600	0.00000	4.0728	-1.32800	1.37944	0.06238	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
765 O	1790.9020	12.16544	12.07572	26.25946	25.19353	1.43939	0.00000	4.0728	-1.36904	1.33791	0.06238	0.00000
766 B2	1796.9726	12.19310	12.13011	46.91320	13.02333	1.88162	0.00000	4.1073	-2.03346	0.66643	0.08333	0.00000
767 O	1797.3476	12.19435	12.13478	48.45368	12.53910	1.91287	0.00000	4.1073	-2.07451	0.62485	0.08333	0.00000
768 QF2	1798.4144	12.19775	12.14882	50.73604	11.86332	1.95847	0.00000	4.1073	-0.03293	0.01804	0.00184	0.00000
769 QF2	1799.4812	12.20115	12.16291	48.59003	12.45981	1.91677	0.00000	4.1073	2.01446	-0.58549	-0.07972	0.00000
770 FUG	1800.3812	12.20421	12.17392	45.04832	13.60099	1.84502	0.00000	4.1073	1.92077	-0.68249	-0.07972	0.00000
771 OOO	1801.4894	12.20832	12.18618	40.91896	15.24600	1.75667	0.00000	4.1073	1.80541	-0.80192	-0.07972	0.00000
772 B2	1807.5600	12.24013	12.23284	22.83628	28.94499	1.33630	0.00000	4.1395	1.17353	-1.46420	-0.05878	0.00000
773 O	1807.9350	12.24280	12.23487	21.97077	30.05077	1.31426	0.00000	4.1395	1.13450	-1.49455	-0.05878	0.00000
774 B2	1814.0056	12.30369	12.25937	12.03326	52.14484	1.02103	0.00000	4.1637	0.50261	-2.14417	-0.03783	0.00000
775 O	1814.3806	12.30872	12.26050	11.67093	53.76806	1.00684	0.00000	4.1637	0.46358	-2.18442	-0.03783	0.00000
776 QD2	1815.4474	12.32364	12.26357	11.29792	56.06276	0.98859	0.00000	4.1637	-0.10876	0.06531	0.00349	0.00000
777 QD2	1816.5142	12.33826	12.26664	12.14889	53.49754	1.01435	0.00000	4.1637	-0.70069	2.30363	0.04498	0.00000
778 FUG	1817.4142	12.34945	12.26943	13.50953	49.44649	1.05483	0.00000	4.1637	-0.81114	2.19753	0.04498	0.00000
779 OOO	1818.5224	12.36167	12.27318	15.45806	44.72067	1.10467	0.00000	4.1637	-0.94714	2.06689	0.04498	0.00000
780 B2	1824.5930	12.40604	12.30287	31.47863	23.95650	1.44127	0.00000	4.1902	-1.69209	1.35281	0.06592	0.00000
781 O	1824.9680	12.40790	12.30541	32.76496	22.95851	1.46599	0.00000	4.1902	-1.73812	1.30851	0.06592	0.00000
782 B2	1831.0386	12.43006	12.36658	58.38822	11.41856	1.92972	0.00000	4.2255	-2.48307	0.59203	0.08687	0.00000
783 O	1831.4136	12.43106	12.37191	60.26778	10.99117	1.96229	0.00000	4.2255	-2.52909	0.54768	0.08687	0.00000
784 QF2	1832.4804	12.43380	12.38792	62.98550	10.42323	2.01054	0.00000	4.2255	0.01965	-0.00738	0.00325	0.00000
785 QF2	1833.5472	12.43653	12.40390	60.18639	11.02362	1.96917	0.00000	4.2255	2.56493	-0.56378	-0.08052	0.00000
786 FUG	1834.4472	12.43901	12.41630	55.67151	12.13525	1.89670	0.00000	4.2255	2.45160	-0.67137	-0.08052	0.00000
787 OOO	1835.5554	12.44234	12.42996	50.39243	13.77010	1.80747	0.00000	4.2255	2.31205	-0.80386	-0.08052	0.00000
788 B2	1841.6260	12.46867	12.48005	26.96327	27.92729	1.38229	0.00000	4.2587	1.54768	-1.52772	-0.05957	0.00000
789 O	1842.0010	12.47093	12.48215	25.82022	29.08987	1.35995	0.00000	4.2587	1.50046	-1.57249	-0.05957	0.00000
790 SB	1848.0716	12.52639	12.50695	12.24343	52.58118	0.99831	0.00000	4.2587	0.73603	-2.29719	-0.05957	0.00000
791 O	1848.4466	12.53137	12.50807	11.70912	54.32086	0.97597	0.00000	4.2587	0.68880	-2.34196	-0.05957	0.00000
792 QD2	1849.5134	12.54656	12.51110	10.86815	56.93116	0.93367	0.00000	4.2587	0.11113	-0.06861	-0.02002	0.00000
793 QD2	1850.5802	12.56207	12.51412	11.22077	54.60505	0.93294	0.00000	4.2587	-0.44654	2.21673	0.01864	0.00000
794 FUG	1851.4802	12.57437	12.51684	12.11113	50.70265	0.94971	0.00000	4.2587	-0.54275	2.11926	0.01864	0.00000
795 OOO	1852.5884	12.58821	12.52049	13.44534	46.13853	0.97037	0.00000	4.2587	-0.66120	1.99924	0.01864	0.00000
796 B2	1858.6590	12.64146	12.54862	25.41114	25.84167	1.14708	0.00000	4.2806	-1.31005	1.34350	0.03958	0.00000
797 O	1859.0340	12.64377	12.55097	26.40870	24.84931	1.16193	0.00000	4.2806	-1.35013	1.30279	0.03958	0.00000
798 SB	1865.1046	12.67141	12.60574	46.74010	13.03197	1.40223	0.00000	4.2806	-1.99903	0.64386	0.03958	0.00000
799 O	1865.4796	12.67266	12.61040	48.25440	12.56434	1.41707	0.00000	4.2806	-2.03911	0.60315	0.03958	0.00000
800 QF2	1866.5464	12.67608	12.62439	50.46936	11.93467	1.42741	0.00000	4.2806	-0.00610	-0.00414	-0.02029	0.00000
801 Q1	1867.6132	12.67949	12.63837	48.27966	12.58253	1.37411	0.00000	4.2806	2.02798	-0.61218	-0.07925	0.00000
802 XO	1873.1986	12.70337	12.69181	28.92915	22.82964	0.93146	0.00000	4.2806	1.43650	-1.22244	-0.07925	0.00000
803 QOO	1873.7919	12.70671	12.69584	27.64510	23.99348	0.89073	0.00000	4.2806	0.73763	-0.73022	-0.05821	0.00000
804 O	1874.1669	12.70889	12.69830	27.09973	24.55014	0.86890	0.00000	4.2806	0.71669	-0.75418	-0.05821	0.00000
805 B2	1880.2375	12.75039	12.73101	20.45697	36.04896	0.57913	0.00000	4.2956	0.37764	-1.13958	-0.03726	0.00000
806 O	1880.6125	12.75333	12.73264	20.18159	36.91261	0.56515	0.00000	4.2956	0.35670	-1.16350	-0.03726	0.00000
807 B2	1886.6831	12.80505	12.75448	17.90923	53.36942	0.40252	0.00000	4.3055	0.01765	-1.54681	-0.01632	0.00000
808 O	1887.0581	12.80839	12.75558	17.90384	54.53847	0.39640	0.00000	4.3055	-0.00329	-1.57065	-0.01632	0.00000
809 B2	1893.1287	12.86036	12.77062	20.00189	75.92262	0.36090	0.00000	4.3132	-0.34234	-1.95115	0.00462	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
810 O	1893.5037	12.86332	12.77140	20.26650	77.39489	0.36264	0.00000	4.3132	-0.36328	-1.97489	0.00462	0.00000
811 QO	1896.0863	12.88117	12.77683	28.63213	67.87010	0.42326	0.00000	4.3132	-3.15187	5.33771	0.04334	0.00000
812 XI	1899.2163	12.89408	12.78655	52.10416	38.71299	0.55892	0.00000	4.3132	-4.34718	3.97765	0.04334	0.00000
813 QI	1901.3499	12.89991	12.79698	61.37483	29.09109	0.59939	0.00000	4.3132	0.26445	0.79792	-0.00598	0.00000
814 LS	1915.8499	12.93920	12.90701	57.37114	17.78022	0.51275	0.00000	4.3132	0.01167	-0.01786	-0.00598	0.00000
815 LS	1930.3499	12.97871	13.01477	60.69791	30.12677	0.42611	0.00000	4.3132	-0.24110	-0.83363	-0.00598	0.00000
816 QI	1932.4835	12.98461	13.02484	51.45319	40.11659	0.37617	0.00000	4.3132	4.31241	-4.12454	-0.04013	0.00000
817 XI	1935.6135	12.99771	13.03422	28.18882	70.33493	0.25056	0.00000	4.3132	3.12029	-5.52988	-0.04013	0.00000
818 QO	1938.1961	13.01587	13.03946	19.88306	80.19030	0.17564	0.00000	4.3132	0.36970	2.05034	-0.01914	0.00000
819 O	1938.5711	13.01889	13.04021	19.61383	78.66167	0.16846	0.00000	4.3132	0.34826	2.02601	-0.01914	0.00000
820 B2	1944.6417	13.07203	13.05474	17.49228	56.42592	0.11586	0.00000	4.3160	0.00124	1.63605	0.00181	0.00000
821 O	1945.0167	13.07544	13.05580	17.49939	55.20804	0.11654	0.00000	4.3160	-0.02020	1.61161	0.00181	0.00000
822 B2	1951.0873	13.12824	13.07695	19.85103	38.02244	0.19108	0.00000	4.3190	-0.36722	1.21872	0.02275	0.00000
823 O	1951.4623	13.13122	13.07854	20.13448	37.11759	0.19961	0.00000	4.3190	-0.38865	1.19421	0.02275	0.00000
824 B2	1957.5329	13.17318	13.11046	26.95932	25.01414	0.40129	0.00000	4.3250	-0.73567	0.79913	0.04370	0.00000
825 O	1957.9079	13.17537	13.11288	27.51911	24.42400	0.41768	0.00000	4.3250	-0.75711	0.77457	0.04370	0.00000
826 QOO	1958.5012	13.17873	13.11684	28.82521	23.20269	0.44653	0.00000	4.3250	-1.45436	1.27450	0.05368	0.00000
827 XO	1964.0866	13.20261	13.17003	48.44303	12.49402	0.74634	0.00000	4.3250	-2.05798	0.64276	0.05368	0.00000
828 Q1	1965.1534	13.20601	13.18415	50.69007	11.77938	0.78654	0.00000	4.3250	-0.01685	0.03709	0.02141	0.00000
829 QF2	1966.2202	13.20941	13.19836	48.51282	12.33097	0.79169	0.00000	4.3250	2.02725	-0.56184	-0.01181	0.00000
830 FUG	1967.1202	13.21247	13.20950	44.94909	13.42871	0.78106	0.00000	4.3250	1.93245	-0.65787	-0.01181	0.00000
831 OOO	1968.2284	13.21659	13.22194	40.79536	15.01783	0.76798	0.00000	4.3250	1.81573	-0.77611	-0.01181	0.00000
832 SB	1974.2990	13.24860	13.26944	22.63179	28.37266	0.69631	0.00000	4.3250	1.17633	-1.42381	-0.01181	0.00000
833 O	1974.6740	13.25129	13.27151	21.76435	29.45553	0.69189	0.00000	4.3250	1.13683	-1.46382	-0.01181	0.00000
834 B2	1980.7446	13.31300	13.29650	11.84386	51.14326	0.68379	0.00000	4.3392	0.49748	-2.10798	0.00914	0.00000
835 O	1981.1196	13.31812	13.29765	11.48557	52.73922	0.68722	0.00000	4.3392	0.45798	-2.14789	0.00914	0.00000
836 QD2	1982.1864	13.33328	13.30078	11.11793	55.00220	0.71234	0.00000	4.3392	-0.10828	0.05807	0.03813	0.00000
837 QD2	1983.2532	13.34813	13.30392	11.96141	52.49870	0.76917	0.00000	4.3392	-0.69404	2.25387	0.06881	0.00000
838 FUG	1984.1532	13.35949	13.30676	13.31101	48.53553	0.83110	0.00000	4.3392	-0.80552	2.14964	0.06881	0.00000
839 OOO	1985.2614	13.37189	13.31058	15.24850	43.91329	0.90735	0.00000	4.3392	-0.94280	2.02130	0.06881	0.00000
840 B2	1991.3320	13.41673	13.34075	31.25866	23.62629	1.38861	0.00000	4.3630	-1.69472	1.31981	0.08976	0.00000
841 O	1991.7070	13.41860	13.34333	32.54712	22.65275	1.42227	0.00000	4.3630	-1.74117	1.27629	0.08976	0.00000
842 SB	1997.7776	13.44086	13.40489	58.25204	11.43386	1.96714	0.00000	4.3630	-2.49315	0.57178	0.08976	0.00000
843 O	1998.1526	13.44187	13.41021	60.13933	11.02134	2.00080	0.00000	4.3630	-2.53961	0.52826	0.08976	0.00000
844 QF2	1999.2194	13.44461	13.42614	62.88577	10.49488	2.05125	0.00000	4.3630	0.00365	-0.02743	0.00447	0.00000
845 QF2	2000.2862	13.44735	13.44198	60.12422	11.14190	2.01026	0.00000	4.3630	2.54626	-0.58809	-0.08102	0.00000
846 FUG	2001.1862	13.44983	13.45423	55.64177	12.29831	1.93735	0.00000	4.3630	2.43424	-0.69681	-0.08102	0.00000
847 OOO	2002.2944	13.45316	13.46770	50.39938	13.99106	1.84756	0.00000	4.3630	2.29631	-0.83067	-0.08102	0.00000
848 B2	2008.3650	13.47941	13.51684	27.10768	28.51950	1.41934	0.00000	4.3970	1.54078	-1.56205	-0.06007	0.00000
849 O	2008.7400	13.48166	13.51889	25.96961	29.70800	1.39681	0.00000	4.3970	1.49410	-1.60728	-0.06007	0.00000
850 B2	2014.8106	13.53654	13.54319	12.41693	53.65012	1.09572	0.00000	4.4229	0.73857	-2.33580	-0.03913	0.00000
851 O	2015.1856	13.54146	13.54428	11.88050	55.41889	1.08105	0.00000	4.4229	0.69190	-2.38092	-0.03913	0.00000
852 QD2	2016.2524	13.55642	13.54725	11.03877	58.06298	1.06306	0.00000	4.4229	0.10876	-0.06084	0.00528	0.00000
853 QD2	2017.3192	13.57169	13.55022	11.40255	55.67091	1.09239	0.00000	4.4229	-0.45479	2.26988	0.04992	0.00000
854 FUG	2018.2192	13.58379	13.55289	12.30691	51.67465	1.13732	0.00000	4.4229	-0.55005	2.17041	0.04992	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
855 000	2019.3274	13.59741	13.55647	13.65603	46.99987	1.19265	0.00000	4.4229	-0.66734	2.04794	0.04992	0.00000
856 B2	2025.3980	13.64997	13.58414	25.65759	26.19284	1.55925	0.00000	4.4515	-1.30980	1.37881	0.07087	0.00000
857 0	2025.7730	13.65226	13.58647	26.65482	25.17430	1.58582	0.00000	4.4515	-1.34949	1.33728	0.07087	0.00000
858 B2	2031.8436	13.67970	13.64090	46.93791	13.01243	2.07956	0.00000	4.4897	-1.99195	0.66569	0.09181	0.00000
859 0	2032.2186	13.68096	13.64558	48.44676	12.52876	2.11399	0.00000	4.4897	-2.03164	0.62410	0.09181	0.00000
860 QF2	2033.2854	13.68436	13.65963	50.63660	11.85416	2.16410	0.00000	4.4897	0.00963	0.01765	0.00177	0.00000
861 QF2	2034.3522	13.68776	13.67373	48.40690	12.45116	2.11773	0.00000	4.4897	2.04920	-0.58559	-0.08836	0.00000
862 FUG	2035.2522	13.69084	13.68475	44.80535	13.59257	2.03821	0.00000	4.4897	1.95253	-0.68266	-0.08836	0.00000
863 000	2036.3604	13.69497	13.69702	40.60967	15.23807	1.94029	0.00000	4.4897	1.83350	-0.80218	-0.08836	0.00000
864 B2	2042.4310	13.72729	13.74369	22.30795	28.94334	1.46752	0.00000	4.5251	1.18153	-1.45497	-0.06741	0.00000
865 0	2042.8060	13.73002	13.74571	21.43691	30.04971	1.44224	0.00000	4.5251	1.14125	-1.49536	-0.06741	0.00000
866 B2	2048.8766	13.79309	13.77022	11.53933	52.15662	1.09660	0.00000	4.5515	0.48928	-2.14548	-0.04647	0.00000
867 0	2049.2516	13.79834	13.77134	11.18747	53.78084	1.07918	0.00000	4.5515	0.44900	-2.18577	-0.04647	0.00000
868 QD2	2050.3184	13.81390	13.77441	10.82854	56.07785	1.05326	0.00000	4.5515	-0.10759	0.06451	-0.00230	0.00000
869 QD2	2051.3852	13.82915	13.77749	11.66025	53.51361	1.07423	0.00000	4.5515	-0.68354	2.30352	0.04176	0.00000
870 FUG	2052.2852	13.84080	13.78027	12.99256	49.46273	1.11181	0.00000	4.5515	-0.79679	2.19746	0.04176	0.00000
871 000	2053.3934	13.85348	13.78402	14.91311	44.73700	1.15810	0.00000	4.5515	-0.93624	2.06687	0.04176	0.00000
872 B2	2059.4640	13.89910	13.81370	30.91587	23.97142	1.47517	0.00000	4.5788	-1.70006	1.35306	0.06271	0.00000
873 0	2059.8390	13.90099	13.81624	32.20861	22.97323	1.49868	0.00000	4.5788	-1.74725	1.30878	0.06271	0.00000
874 B2	2065.9096	13.92340	13.87736	58.05724	11.42834	1.94289	0.00000	4.6147	-2.51107	0.59257	0.08365	0.00000
875 0	2066.2846	13.92442	13.88268	59.95824	11.00054	1.97426	0.00000	4.6147	-2.55825	0.54824	0.08365	0.00000
876 QF2	2067.3514	13.92716	13.89868	62.75347	10.43174	2.01884	0.00000	4.6147	-0.02275	-0.00713	-0.00040	0.00000
877 QF2	2068.4182	13.92991	13.91465	60.05247	11.03186	1.97342	0.00000	4.6147	2.51676	-0.56378	-0.08442	0.00000
878 FUG	2069.3182	13.93239	13.92704	55.62123	12.14342	1.89744	0.00000	4.6147	2.40684	-0.67129	-0.08442	0.00000
879 000	2070.4264	13.93572	13.94069	50.43669	13.77799	1.80388	0.00000	4.6147	2.27150	-0.80368	-0.08442	0.00000
880 B2	2076.4970	13.96184	13.99076	27.35998	27.92974	1.35499	0.00000	4.6475	1.53017	-1.52700	-0.06348	0.00000
881 0	2076.8720	13.96407	13.99286	26.22953	29.09177	1.33118	0.00000	4.6475	1.48437	-1.57174	-0.06348	0.00000
882 B2	2082.9426	14.01801	14.01767	12.70885	52.55372	1.00942	0.00000	4.6718	0.74303	-2.29226	-0.04253	0.00000
883 0	2083.3176	14.02281	14.01879	12.16874	54.28965	0.99347	0.00000	4.6718	0.69724	-2.33689	-0.04253	0.00000
884 QD2	2084.3844	14.03740	14.02182	11.32555	56.89041	0.96987	0.00000	4.6718	0.10481	-0.06486	-0.00187	0.00000
885 QD2	2085.4512	14.05228	14.02484	11.70816	54.55832	0.98945	0.00000	4.6718	-0.46875	2.21651	0.03871	0.00000
886 FUG	2086.3512	14.06406	14.02757	12.63630	50.65292	1.02429	0.00000	4.6718	-0.56251	2.12082	0.03871	0.00000
887 000	2087.4594	14.07733	14.03122	14.01098	46.08564	1.06719	0.00000	4.6718	-0.67796	2.00054	0.03871	0.00000
888 B2	2093.5300	14.12876	14.05940	26.08021	25.78179	1.36573	0.00000	4.6971	-1.31033	1.34335	0.05966	0.00000
889 0	2093.9050	14.13101	14.06176	27.07761	24.78957	1.38811	0.00000	4.6971	-1.34940	1.30256	0.05966	0.00000
890 B2	2099.9756	14.15814	14.11671	47.29832	12.97641	1.81379	0.00000	4.7304	-1.98177	0.64298	0.08060	0.00000
891 0	2100.3506	14.15938	14.12140	48.79930	12.50949	1.84402	0.00000	4.7304	-2.02084	0.60213	0.08060	0.00000
892 QF2	2101.4174	14.16276	14.13545	50.94937	11.88001	1.88826	0.00000	4.7304	0.03555	-0.00330	0.00204	0.00000
893 QF2	2102.4842	14.16614	14.14949	48.65210	12.52398	1.84834	0.00000	4.7304	2.08566	-0.60933	-0.07660	0.00000
894 FUG	2103.3842	14.16921	14.16043	44.98698	13.70946	1.77940	0.00000	4.7304	1.98669	-0.70787	-0.07660	0.00000
895 000	2104.4924	14.17333	14.17257	40.71872	15.41285	1.69450	0.00000	4.7304	1.86483	-0.82921	-0.07660	0.00000
896 B2	2110.5630	14.20573	14.21851	22.13090	29.50652	1.29307	0.00000	4.7614	1.19733	-1.49191	-0.05566	0.00000
897 0	2110.9380	14.20849	14.22050	21.24837	30.64082	1.27220	0.00000	4.7614	1.15610	-1.53290	-0.05566	0.00000
898 B2	2117.0086	14.27265	14.24451	11.26482	53.26344	0.99790	0.00000	4.7850	0.48860	-2.19287	-0.03472	0.00000
899 0	2117.3836	14.27804	14.24561	10.91384	54.92342	0.98488	0.00000	4.7850	0.44736	-2.23376	-0.03472	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
900 QD2	2118.4504	14.29401	14.24862	10.54915	57.27173	0.96949	0.00000	4.7850	-0.10047	0.06514	0.00576	0.00000
901 QD2	2119.5172	14.30966	14.25163	11.35536	54.65360	0.99727	0.00000	4.7850	-0.66639	2.35266	0.04650	0.00000
902 FUG	2120.4172	14.32162	14.25435	12.65787	50.51567	1.03911	0.00000	4.7850	-0.78084	2.24504	0.04650	0.00000
903 000	2121.5254	14.33463	14.25803	14.54471	45.68660	1.09064	0.00000	4.7850	-0.92178	2.11253	0.04650	0.00000
904 B2	2127.5960	14.38122	14.28711	30.42122	24.42994	1.43646	0.00000	4.8112	-1.69373	1.38827	0.06744	0.00000
905 0	2127.9710	14.38314	14.28960	31.70940	23.40559	1.46175	0.00000	4.8112	-1.74142	1.34334	0.06744	0.00000
906 B2	2134.0416	14.40584	14.34991	57.53659	11.50495	1.93471	0.00000	4.8466	-2.51337	0.61660	0.08839	0.00000
907 0	2134.4166	14.40686	14.35521	59.43950	11.05937	1.96785	0.00000	4.8466	-2.56105	0.57162	0.08839	0.00000
908 QF2	2135.4834	14.40963	14.37115	62.26489	10.44387	2.01759	0.00000	4.8466	-0.04781	0.01393	0.00450	0.00000
909 QF2	2136.5502	14.41239	14.38714	59.63747	10.99816	1.97739	0.00000	4.8466	2.47387	-0.54124	-0.07958	0.00000
910 FUG	2137.4502	14.41489	14.39958	55.28121	12.06760	1.90576	0.00000	4.8466	2.36642	-0.64704	-0.07958	0.00000
911 000	2138.5584	14.41824	14.41334	50.18290	13.64607	1.81757	0.00000	4.8466	2.23411	-0.77732	-0.07958	0.00000
912 B2	2144.6290	14.44438	14.46416	27.45915	27.40791	1.39805	0.00000	4.8800	1.50941	-1.48915	-0.05864	0.00000
913 0	2145.0040	14.44660	14.46630	26.34389	28.54128	1.37606	0.00000	4.8800	1.46464	-1.53317	-0.05864	0.00000
914 B2	2151.0746	14.49987	14.49161	12.96184	51.46551	1.08367	0.00000	4.9056	0.73993	-2.24227	-0.03769	0.00000
915 0	2151.4496	14.50457	14.49275	12.42368	53.16368	1.06954	0.00000	4.9056	0.69516	-2.28619	-0.03769	0.00000
916 QD2	2152.5164	14.51885	14.49585	11.59337	55.70653	1.05283	0.00000	4.9056	0.09464	-0.06208	0.00626	0.00000
917 QD2	2153.5832	14.53336	14.49894	12.00781	53.42083	1.08300	0.00000	4.9056	-0.48885	2.17288	0.05050	0.00000
918 FUG	2154.4832	14.54485	14.50172	12.97131	49.59639	1.12845	0.00000	4.9056	-0.58171	2.07649	0.05050	0.00000
919 000	2155.5914	14.55778	14.50545	14.38732	45.12558	1.18441	0.00000	4.9056	-0.69605	1.95780	0.05050	0.00000
920 B2	2161.6620	14.60795	14.53421	26.63951	25.28781	1.55453	0.00000	4.9340	-1.32238	1.30932	0.07144	0.00000
921 0	2162.0370	14.61015	14.53661	27.64580	24.32092	1.58132	0.00000	4.9340	-1.36107	1.26907	0.07144	0.00000
922 B2	2168.1076	14.63680	14.59238	47.97147	12.86121	2.07857	0.00000	4.9721	-1.98739	0.61826	0.09239	0.00000
923 0	2168.4826	14.63803	14.59710	49.47652	12.41263	2.11321	0.00000	4.9721	-2.02608	0.57795	0.09239	0.00000
924 QF2	2169.5494	14.64136	14.61124	51.60648	11.83022	2.16394	0.00000	4.9721	0.05936	-0.02390	0.00236	0.00000
925 QF2	2170.6162	14.64471	14.62531	49.23072	12.51767	2.11822	0.00000	4.9721	2.13433	-0.63009	-0.08777	0.00000
926 FUG	2171.5162	14.64773	14.63624	45.48032	13.74223	2.03923	0.00000	4.9721	2.03277	-0.73053	-0.08777	0.00000
927 000	2172.6244	14.65181	14.64834	41.11347	15.49844	1.94196	0.00000	4.9721	1.90772	-0.85421	-0.08777	0.00000
928 B2	2178.6950	14.68408	14.69378	22.11109	29.97332	1.47277	0.00000	5.0077	1.22274	-1.52969	-0.06682	0.00000
929 0	2179.0700	14.68683	14.69573	21.20990	31.13626	1.44772	0.00000	5.0077	1.18042	-1.57148	-0.06682	0.00000
930 B2	2185.1406	14.75176	14.71932	11.03711	54.30450	1.10566	0.00000	5.0342	0.49545	-2.24415	-0.04588	0.00000
931 0	2185.5156	14.75726	14.72040	10.68139	56.00324	1.08846	0.00000	5.0342	0.45313	-2.28584	-0.04588	0.00000
932 QD2	2186.5824	14.77360	14.72334	10.29689	58.41456	1.06338	0.00000	5.0342	-0.08739	0.05902	-0.00131	0.00000
933 QD2	2187.6492	14.78965	14.72630	11.06543	55.75876	1.08565	0.00000	5.0342	-0.64365	2.39356	0.04320	0.00000
934 FUG	2188.5492	14.80192	14.72897	12.32753	51.54810	1.12453	0.00000	5.0342	-0.75868	2.28495	0.04320	0.00000
935 000	2189.6574	14.81529	14.73257	14.16603	46.63195	1.17240	0.00000	5.0342	-0.90032	2.15121	0.04320	0.00000
936 B2	2195.7280	14.86302	14.76105	29.80560	24.94641	1.49821	0.00000	5.0619	-1.67615	1.42023	0.06415	0.00000
937 0	2196.1030	14.86498	14.76349	31.08069	23.89825	1.52226	0.00000	5.0619	-1.72408	1.37488	0.06415	0.00000
938 B2	2202.1736	14.88807	14.82274	56.72098	11.65572	1.97521	0.00000	5.0984	-2.49991	0.64137	0.08509	0.00000
939 0	2202.5486	14.88910	14.82797	58.61388	11.19172	2.00711	0.00000	5.0984	-2.54784	0.59596	0.08509	0.00000
940 QF2	2203.6154	14.89191	14.84375	61.44903	10.53001	2.05248	0.00000	5.0984	-0.07002	0.03353	-0.00036	0.00000
941 QF2	2204.6822	14.89471	14.85964	58.90385	11.04431	2.00636	0.00000	5.0984	2.42014	-0.52280	-0.08579	0.00000
942 FUG	2205.5822	14.89724	14.87205	54.64189	12.07875	1.92915	0.00000	5.0984	2.31537	-0.62657	-0.08579	0.00000
943 000	2206.6904	14.90062	14.88583	49.65306	13.60906	1.83408	0.00000	5.0984	2.18636	-0.75433	-0.08579	0.00000
944 B2	2212.7610	14.92693	14.93710	27.39931	27.00838	1.37692	0.00000	5.1318	1.47973	-1.45243	-0.06484	0.00000

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
945	O	2213.1360	14.92916	14.93927	26.30588	28.11389	1.35260	0.00000	5.1318	1.43607	-1.49560	-0.06484	0.00000
946	B2	2219.2066	14.98205	14.96502	13.16089	50.49889	1.02257	0.00000	5.1564	0.72944	-2.19103	-0.04390	0.00000
947	O	2219.5816	14.98668	14.96619	12.63018	52.15832	1.00611	0.00000	5.1564	0.68578	-2.23411	-0.04390	0.00000
948	QD2	2220.6484	15.00069	14.96934	11.82633	54.63470	0.98133	0.00000	5.1564	0.07885	-0.05279	-0.00273	0.00000
949	QD2	2221.7152	15.01490	14.97249	12.28369	52.37697	1.00024	0.00000	5.1564	-0.51389	2.13776	0.03831	0.00000
950	FUG	2222.6152	15.02612	14.97533	13.29206	48.61513	1.03471	0.00000	5.1564	-0.60651	2.04205	0.03831	0.00000
951	OOO	2223.7234	15.03872	14.97914	14.76271	44.21973	1.07717	0.00000	5.1564	-0.72055	1.92420	0.03831	0.00000
952	B2	2229.7940	15.08761	15.00850	27.30229	24.76239	1.37327	0.00000	5.1818	-1.34522	1.28027	0.05925	0.00000
953	O	2230.1690	15.08976	15.01096	28.32567	23.81718	1.39549	0.00000	5.1818	-1.38381	1.24030	0.05925	0.00000
954	B2	2236.2396	15.11583	15.06776	48.91739	12.67883	1.81873	0.00000	5.2153	-2.00848	0.59409	0.08020	0.00000
955	O	2236.6146	15.11703	15.07255	50.43822	12.24827	1.84881	0.00000	5.2153	-2.04707	0.55408	0.08020	0.00000
956	QF2	2237.6814	15.12030	15.08685	52.56894	11.70999	1.89252	0.00000	5.2153	0.07964	-0.04200	0.00145	0.00000
957	QF2	2238.7482	15.12359	15.10104	50.10841	12.43288	1.85188	0.00000	5.2153	2.19232	-0.64571	-0.07736	0.00000
958	FUG	2239.6482	15.12656	15.11203	46.25610	13.68747	1.78225	0.00000	5.2153	2.08803	-0.74828	-0.07736	0.00000
959	OOO	2240.7564	15.13057	15.12416	41.77050	15.48591	1.69652	0.00000	5.2153	1.95962	-0.87457	-0.07736	0.00000
960	B2	2246.8270	15.16248	15.16937	22.24970	30.29510	1.29049	0.00000	5.2463	1.25625	-1.56438	-0.05642	0.00000
961	O	2247.2020	15.16522	15.17130	21.32381	31.48439	1.26933	0.00000	5.2463	1.21279	-1.60706	-0.05642	0.00000
962	B2	2253.2726	15.23049	15.19457	10.86969	55.17132	0.99044	0.00000	5.2698	0.50942	-2.29400	-0.03547	0.00000
963	O	2253.6476	15.23608	15.19563	10.50392	56.90778	0.97714	0.00000	5.2698	0.46597	-2.33656	-0.03547	0.00000
964	QD2	2254.7144	15.25272	15.19853	10.08671	59.38727	0.96077	0.00000	5.2698	-0.06913	0.04680	0.00466	0.00000
965	QD2	2255.7812	15.26913	15.20144	10.80769	56.71394	0.98717	0.00000	5.2698	-0.61667	2.42198	0.04501	0.00000
966	FUG	2256.6812	15.28171	15.20406	12.02114	52.45244	1.02767	0.00000	5.2698	-0.73161	2.31302	0.04501	0.00000
967	OOO	2257.7894	15.29542	15.20760	13.79953	47.47454	1.07755	0.00000	5.2698	-0.87314	2.17886	0.04501	0.00000
968	B2	2263.8600	15.34440	15.23553	29.10553	25.46700	1.41434	0.00000	5.2957	-1.64838	1.44561	0.06595	0.00000
969	O	2264.2350	15.34641	15.23792	30.35978	24.39986	1.43907	0.00000	5.2957	-1.69627	1.40011	0.06595	0.00000
970	B2	2270.3056	15.37000	15.29599	55.65882	11.86492	1.90300	0.00000	5.3304	-2.47151	0.66429	0.08690	0.00000
971	O	2270.6806	15.37105	15.30112	57.53041	11.38378	1.93558	0.00000	5.3304	-2.51940	0.61874	0.08690	0.00000
972	QF2	2271.7474	15.37391	15.31666	60.35431	10.68119	1.98446	0.00000	5.3304	-0.08808	0.04966	0.00439	0.00000
973	QF2	2272.8142	15.37676	15.33235	57.89516	11.16552	1.94488	0.00000	5.3304	2.35876	-0.51041	-0.07831	0.00000
974	FUG	2273.7142	15.37933	15.34464	53.74121	12.17570	1.87440	0.00000	5.3304	2.25673	-0.61201	-0.07831	0.00000
975	OOO	2274.8224	15.38277	15.35833	48.87864	13.67081	1.78761	0.00000	5.3304	2.13109	-0.73712	-0.07831	0.00000
976	B2	2280.8930	15.40940	15.40972	27.18400	26.77278	1.37580	0.00000	5.3633	1.44289	-1.42067	-0.05737	0.00000
977	O	2281.2680	15.41164	15.41191	26.11778	27.85413	1.35429	0.00000	5.3633	1.40038	-1.46295	-0.05737	0.00000
978	B2	2287.3386	15.46445	15.43798	13.29418	49.75459	1.06961	0.00000	5.3885	0.71218	-2.14389	-0.03642	0.00000
979	O	2287.7136	15.46903	15.43916	12.77599	51.37832	1.05595	0.00000	5.3885	0.66967	-2.18607	-0.03642	0.00000
980	QD2	2288.7804	15.48285	15.44236	12.01059	53.78661	1.04031	0.00000	5.3885	0.05838	-0.03795	0.00699	0.00000
981	QD2	2289.8472	15.49682	15.44557	12.51945	51.53551	1.07098	0.00000	5.3885	-0.54241	2.11680	0.05072	0.00000
982	FUG	2290.7472	15.50782	15.44845	13.57952	47.81141	1.11663	0.00000	5.3885	-0.63544	2.02109	0.05072	0.00000
983	OOO	2291.8554	15.52014	15.45232	15.11487	43.46249	1.17284	0.00000	5.3885	-0.75000	1.90323	0.05072	0.00000
984	B2	2297.9260	15.56778	15.48225	28.02921	24.26028	1.54429	0.00000	5.4167	-1.37751	1.25923	0.07167	0.00000
985	O	2298.3010	15.56988	15.48476	29.07688	23.33085	1.57116	0.00000	5.4167	-1.41628	1.21926	0.07167	0.00000
986	B2	2304.3716	15.59530	15.54273	50.07996	12.44829	2.06975	0.00000	5.4546	-2.04378	0.57301	0.09261	0.00000
987	O	2304.7466	15.59647	15.54760	51.62733	12.03353	2.10448	0.00000	5.4546	-2.08255	0.53300	0.09261	0.00000
988	QF2	2305.8134	15.59967	15.56214	53.77962	11.53183	2.15564	0.00000	5.4546	0.09521	-0.05572	0.00294	0.00000
989	QF2	2306.8802	15.60288	15.57654	51.23308	12.27844	2.11071	0.00000	5.4546	2.25617	-0.65455	-0.08686	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
990 FUG	2307.7802	15.60579	15.58765	47.26826	13.55087	2.03255	0.00000	5.4546	2.14918	-0.75926	-0.08686	0.00000
991 000	2308.8884	15.60972	15.59988	42.65080	15.37657	1.93629	0.00000	5.4546	2.01745	-0.88818	-0.08686	0.00000
992 B2	2314.9590	15.64108	15.64515	22.53850	30.43834	1.47264	0.00000	5.4901	1.29586	-1.59237	-0.06591	0.00000
993 O	2315.3340	15.64379	15.64707	21.58332	31.64895	1.44792	0.00000	5.4901	1.25128	-1.63593	-0.06591	0.00000
994 B2	2321.4046	15.70895	15.67015	10.77251	55.77359	1.11140	0.00000	5.5167	0.52970	-2.33721	-0.04497	0.00000
995 O	2321.7796	15.71460	15.67120	10.39195	57.54279	1.09454	0.00000	5.5167	0.48512	-2.38066	-0.04497	0.00000
996 QD2	2322.8464	15.73147	15.67407	9.93110	60.08850	1.07058	0.00000	5.5167	-0.04676	0.02974	-0.00012	0.00000
997 QD2	2323.9132	15.74817	15.67694	10.59743	57.41960	1.09428	0.00000	5.5167	-0.58705	2.43494	0.04472	0.00000
998 FUG	2324.8132	15.76102	15.67953	11.75689	53.13446	1.13452	0.00000	5.5167	-0.70125	2.32633	0.04472	0.00000
999 000	2325.9214	15.77505	15.68302	13.46696	48.12658	1.18408	0.00000	5.5167	-0.84186	2.19260	0.04472	0.00000
1000 B2	2331.9920	15.82531	15.71050	28.36258	25.93748	1.51908	0.00000	5.5448	-1.61205	1.46177	0.06566	0.00000
1001 O	2332.3670	15.82737	15.71285	29.58946	24.85816	1.54370	0.00000	5.5448	-1.65963	1.41642	0.06566	0.00000
1002 B2	2338.4376	15.85154	15.76974	54.41317	12.11076	2.00584	0.00000	5.5817	-2.42983	0.68298	0.08661	0.00000
1003 O	2338.8126	15.85262	15.77478	56.25338	11.61556	2.03832	0.00000	5.5817	-2.47741	0.63757	0.08661	0.00000
1004 QF2	2339.8794	15.85555	15.79001	59.04571	10.88165	2.08459	0.00000	5.5817	-0.10091	0.06061	-0.00017	0.00000
1005 QF2	2340.9462	15.85846	15.80543	56.67126	11.34914	2.03795	0.00000	5.5817	2.29338	-0.50534	-0.08694	0.00000
1006 FUG	2341.8462	15.86108	15.81754	52.63265	12.34835	1.95970	0.00000	5.5817	2.19397	-0.60489	-0.08694	0.00000
1007 000	2342.9544	15.86460	15.83106	47.90558	13.82488	1.86335	0.00000	5.5817	2.07157	-0.72748	-0.08694	0.00000
1008 B2	2349.0250	15.89168	15.88220	26.82601	26.72566	1.39915	0.00000	5.6157	1.40109	-1.39718	-0.06600	0.00000
1009 O	2349.4000	15.89395	15.88439	25.79073	27.78908	1.37440	0.00000	5.6157	1.35967	-1.43861	-0.06600	0.00000
1010 B2	2355.4706	15.94698	15.91061	13.35381	49.31016	1.03733	0.00000	5.6407	0.68919	-2.10575	-0.04506	0.00000
1011 O	2355.8456	15.95154	15.91180	12.85245	50.90497	1.02044	0.00000	5.6407	0.64777	-2.14707	-0.04506	0.00000
1012 QD2	2356.9124	15.96525	15.91503	12.13523	53.25064	0.99473	0.00000	5.6407	0.03444	-0.01911	-0.00332	0.00000
1013 QD2	2357.9792	15.97904	15.91827	12.70109	50.98414	1.01331	0.00000	5.6407	-0.57269	2.11219	0.03827	0.00000
1014 FUG	2358.8792	15.98986	15.92119	13.81662	47.26897	1.04775	0.00000	5.6407	-0.66679	2.01578	0.03827	0.00000
1015 000	2359.9874	16.00196	15.92510	15.42289	42.93275	1.09017	0.00000	5.6407	-0.78266	1.89707	0.03827	0.00000
1016 B2	2366.0580	16.04848	15.95549	28.77713	23.83378	1.38605	0.00000	5.6664	-1.41733	1.24838	0.05922	0.00000
1017 O	2366.4330	16.05051	15.95804	29.85483	22.91259	1.40826	0.00000	5.6664	-1.45653	1.20812	0.05922	0.00000
1018 B2	2372.5036	16.07528	16.01720	51.39015	12.19359	1.83128	0.00000	5.7001	-2.09120	0.55721	0.08016	0.00000
1019 O	2372.8786	16.07642	16.02218	52.97326	11.79080	1.86134	0.00000	5.7001	-2.13041	0.51691	0.08016	0.00000
1020 QF2	2373.9454	16.07954	16.03701	55.16665	11.31432	1.90474	0.00000	5.7001	0.10512	-0.06362	0.00089	0.00000
1021 QF2	2375.0122	16.08267	16.05167	52.53797	12.07046	1.86324	0.00000	5.7001	2.32211	-0.65571	-0.07842	0.00000
1022 FUG	2375.9122	16.08551	16.06296	48.45672	13.34669	1.79266	0.00000	5.7001	2.21261	-0.76233	-0.07842	0.00000
1023 000	2377.0204	16.08934	16.07537	43.70212	15.18181	1.70576	0.00000	5.7001	2.07778	-0.89361	-0.07842	0.00000
1024 B2	2383.0910	16.12003	16.12097	22.96035	30.38810	1.29334	0.00000	5.7313	1.33923	-1.61074	-0.05747	0.00000
1025 O	2383.4660	16.12269	16.12289	21.97303	31.61279	1.27179	0.00000	5.7313	1.29361	-1.65510	-0.05747	0.00000
1026 B2	2389.5366	16.18730	16.14593	10.75133	56.04853	0.98650	0.00000	5.7548	0.55506	-2.36928	-0.03653	0.00000
1027 O	2389.9116	16.19296	16.14698	10.35214	57.84208	0.97280	0.00000	5.7548	0.50944	-2.41352	-0.03653	0.00000
1028 QD2	2390.9784	16.20994	16.14983	9.83929	60.44516	0.95520	0.00000	5.7548	-0.02161	0.00962	0.00341	0.00000
1029 QD2	2392.0452	16.22684	16.15268	10.44712	57.80222	0.98013	0.00000	5.7548	-0.55656	2.43109	0.04349	0.00000
1030 FUG	2392.9452	16.23990	16.15525	11.55047	53.52310	1.01927	0.00000	5.7548	-0.66939	2.32350	0.04349	0.00000
1031 000	2394.0534	16.25421	16.15871	13.18807	48.52012	1.06747	0.00000	5.7548	-0.80832	2.19101	0.04349	0.00000
1032 B2	2400.1240	16.30572	16.18589	27.62084	26.30881	1.39503	0.00000	5.7803	-1.56934	1.46702	0.06444	0.00000
1033 O	2400.4990	16.30784	16.18821	28.81547	25.22539	1.41919	0.00000	5.7803	-1.61635	1.42209	0.06444	0.00000
1034 B2	2406.5696	16.33264	16.24404	53.05794	12.36763	1.87389	0.00000	5.8146	-2.37736	0.69548	0.08538	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1035 O	2406.9446	16.33375	16.24897	54.85860	11.86288	1.90591	0.00000	5.8146	-2.42438	0.65050	0.08538	0.00000
1036 QF2	2408.0114	16.33675	16.26389	57.60090	11.11051	1.95384	0.00000	5.8146	-0.10775	0.06526	0.00414	0.00000
1037 QF2	2409.0782	16.33973	16.27900	55.30481	11.57604	1.91468	0.00000	5.8146	2.22787	-0.50813	-0.07728	0.00000
1038 FUG	2409.9782	16.34242	16.29088	51.38198	12.57871	1.84512	0.00000	5.8146	2.13083	-0.60595	-0.07728	0.00000
1039 OOO	2411.0864	16.34602	16.30416	46.79165	14.05522	1.75948	0.00000	5.8146	2.01133	-0.72640	-0.07728	0.00000
1040 B2	2417.1570	16.37367	16.35472	26.34659	26.87194	1.35392	0.00000	5.8470	1.35680	-1.38441	-0.05634	0.00000
1041 O	2417.5320	16.37598	16.35690	25.34415	27.92551	1.33279	0.00000	5.8470	1.31636	-1.42512	-0.05634	0.00000
1042 B2	2423.6026	16.42954	16.38308	13.33622	49.21191	1.05437	0.00000	5.8717	0.66183	-2.08059	-0.03539	0.00000
1043 O	2423.9776	16.43410	16.38427	12.85502	50.78758	1.04109	0.00000	5.8717	0.62139	-2.12120	-0.03539	0.00000
1044 QD2	2425.0444	16.44777	16.38752	12.19284	53.08263	1.02623	0.00000	5.8717	0.00846	0.00175	0.00742	0.00000
1045 QD2	2426.1112	16.46147	16.39077	12.81782	50.78031	1.05705	0.00000	5.8717	-0.60294	2.12440	0.05057	0.00000
1046 FUG	2427.0112	16.47218	16.39370	13.98929	47.04434	1.10256	0.00000	5.8717	-0.69868	2.02669	0.05057	0.00000
1047 OOO	2428.1194	16.48410	16.39763	15.66850	42.68572	1.15861	0.00000	5.8717	-0.81657	1.90637	0.05057	0.00000
1048 B2	2434.1900	16.52966	16.42831	29.50165	23.52735	1.52915	0.00000	5.8997	-1.46231	1.24886	0.07152	0.00000
1049 O	2434.5650	16.53164	16.43090	30.61334	22.60601	1.55597	0.00000	5.8997	-1.50220	1.20806	0.07152	0.00000
1050 B2	2440.6356	16.55577	16.49113	52.77021	11.94129	2.05365	0.00000	5.9372	-2.14793	0.54833	0.09246	0.00000
1051 O	2441.0106	16.55689	16.49622	54.39612	11.54536	2.08832	0.00000	5.9372	-2.18782	0.50749	0.09246	0.00000
1052 QF2	2442.0774	16.55992	16.51136	56.64772	11.08012	2.13968	0.00000	5.9372	0.10879	-0.06489	0.00347	0.00000
1053 QF2	2443.1442	16.56297	16.52633	53.94563	11.83059	2.09567	0.00000	5.9372	2.38622	-0.64905	-0.08568	0.00000
1054 FUG	2444.0442	16.56574	16.53784	49.75096	13.09619	2.01856	0.00000	5.9372	2.27454	-0.75717	-0.08568	0.00000
1055 OOO	2445.1524	16.56947	16.55047	44.86206	14.92192	1.92362	0.00000	5.9372	2.13702	-0.89031	-0.08568	0.00000
1056 B2	2451.2230	16.59941	16.59667	23.49021	30.14962	1.46712	0.00000	5.9725	1.38379	-1.61758	-0.06473	0.00000
1057 O	2451.5980	16.60200	16.59861	22.46982	31.37967	1.44284	0.00000	5.9725	1.33725	-1.66256	-0.06473	0.00000
1058 B2	2457.6686	16.66568	16.62175	10.80741	55.96751	1.11348	0.00000	5.9991	0.58402	-2.38687	-0.04379	0.00000
1059 O	2458.0436	16.67132	16.62280	10.38685	57.77449	1.09706	0.00000	5.9991	0.53748	-2.43174	-0.04379	0.00000
1060 QD2	2459.1104	16.68829	16.62565	9.81673	60.42011	1.07443	0.00000	5.9991	0.00481	-0.01145	0.00119	0.00000
1061 QD2	2460.1772	16.70528	18.62850	10.36570	57.82192	1.09962	0.00000	5.9991	-0.52699	2.41084	0.04622	0.00000
1062 FUG	2461.0772	16.71846	16.63107	11.41412	53.57784	1.14121	0.00000	5.9991	-0.63793	2.30481	0.04622	0.00000
1063 OOO	2462.1854	16.73297	16.63453	12.97941	48.61416	1.19243	0.00000	5.9991	-0.77453	2.17425	0.04622	0.00000
1064 B2	2468.2560	16.78561	16.66156	26.92433	26.54230	1.53654	0.00000	6.0274	-1.52276	1.46082	0.06716	0.00000
1065 O	2468.6310	16.78778	16.66385	28.08373	25.46329	1.56173	0.00000	6.0274	-1.56899	1.41654	0.06716	0.00000
1066 B2	2474.7016	16.81325	16.71886	51.67360	12.60875	2.03298	0.00000	6.0649	-2.31722	0.70051	0.08811	0.00000
1067 O	2475.0766	16.81438	16.72369	53.42885	12.10000	2.06602	0.00000	6.0649	-2.36344	0.65617	0.08811	0.00000
1068 QF2	2476.1434	16.81746	16.73832	56.10563	11.34391	2.11327	0.00000	6.0649	-0.10820	0.06311	0.00014	0.00000
1069 QF2	2477.2102	16.82053	16.75311	53.87690	11.82258	2.06632	0.00000	6.0649	2.16612	-0.51848	-0.08783	0.00000
1070 FUG	2478.1102	16.82328	16.76474	50.06346	12.84278	1.98727	0.00000	6.0649	2.07104	-0.61507	-0.08783	0.00000
1071 OOO	2479.2184	16.82698	16.77775	45.60296	14.33783	1.88993	0.00000	6.0649	1.95396	-0.73401	-0.08783	0.00000
1072 B2	2485.2890	16.85530	16.82749	25.77418	27.19637	1.42036	0.00000	6.0993	1.31265	-1.38369	-0.06689	0.00000
1073 O	2485.6640	16.85766	16.82964	24.80456	28.24921	1.39527	0.00000	6.0993	1.27303	-1.42388	-0.06689	0.00000
1074 B2	2491.7346	16.91202	16.85560	13.24248	49.47008	1.05283	0.00000	6.1247	0.63172	-2.07103	-0.04594	0.00000
1075 O	2492.1096	16.91661	16.85679	12.78355	51.03839	1.03560	0.00000	6.1247	0.59210	-2.11112	-0.04594	0.00000
1076 QD2	2493.1764	16.93033	16.86002	12.18001	53.30009	1.00928	0.00000	6.1247	-0.01802	0.02248	-0.00359	0.00000
1077 QD2	2494.2432	16.94402	16.86326	12.86273	50.94526	1.02789	0.00000	6.1247	-0.63138	2.15216	0.03860	0.00000
1078 FUG	2495.1432	16.95466	16.86618	14.08728	47.16092	1.06263	0.00000	6.1247	-0.72924	2.05267	0.03860	0.00000
1079 OOO	2496.2514	16.96648	16.87011	15.83710	42.74714	1.10542	0.00000	6.1247	-0.84974	1.93016	0.03860	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1080 B2	2502.3220	17.01128	16.90086	30.15977	23.37292	1.40332	0.00000	6.1508	-1.50978	1.26062	0.05955	0.00000
1081 O	2502.6970	17.01322	16.90347	31.30740	22.44303	1.42565	0.00000	6.1508	-1.55056	1.21908	0.05955	0.00000
1082 B2	2508.7676	17.03677	16.96454	54.13823	11.71767	1.85070	0.00000	6.1849	-2.21060	0.54730	0.08049	0.00000
1083 O	2509.1426	17.03786	16.96972	55.81147	11.32279	1.88088	0.00000	6.1849	-2.25138	0.50571	0.08049	0.00000
1084 QF2	2510.2094	17.04082	16.98517	58.13491	10.85363	1.92420	0.00000	6.1849	0.10600	-0.05939	0.00041	0.00000
1085 QF2	2511.2762	17.04379	17.00045	55.37252	11.58384	1.88174	0.00000	6.1849	2.44469	-0.63527	-0.07970	0.00000
1086 FUG	2512.1762	17.04648	17.01221	51.07413	12.82547	1.81001	0.00000	6.1849	2.33129	-0.74432	-0.07970	0.00000
1087 OOO	2513.2844	17.05012	17.02511	46.06179	14.62400	1.72168	0.00000	6.1849	2.19167	-0.87860	-0.07970	0.00000
1088 B2	2519.3550	17.07928	17.07211	24.09663	29.74775	1.30145	0.00000	6.2163	1.42688	-1.61216	-0.05876	0.00000
1089 O	2519.7300	17.08181	17.07408	23.04419	30.97389	1.27941	0.00000	6.2163	1.37963	-1.65753	-0.05876	0.00000
1090 B2	2525.8006	17.14425	17.09745	10.93743	55.53896	0.98631	0.00000	6.2398	0.61484	-2.38814	-0.03781	0.00000
1091 O	2526.1756	17.14983	17.09851	10.49402	57.34704	0.97213	0.00000	6.2398	0.56759	-2.43340	-0.03781	0.00000
1092 QD2	2527.2424	17.16667	17.10138	9.86476	60.01595	0.95314	0.00000	6.2398	0.03095	-0.03129	0.00206	0.00000
1093 QD2	2528.3092	17.18362	17.10425	10.35799	57.47665	0.97657	0.00000	6.2398	-0.50011	2.37629	0.04203	0.00000
1094 FUG	2529.2092	17.19684	17.10684	11.35595	53.29300	1.01440	0.00000	6.2398	-0.60873	2.27221	0.04203	0.00000
1095 OOO	2530.3174	17.21146	17.11032	12.85336	48.39889	1.06097	0.00000	6.2398	-0.74248	2.14406	0.04203	0.00000
1096 B2	2536.3880	17.26500	17.13737	26.31439	26.61363	1.37967	0.00000	6.2651	-1.47509	1.44381	0.06298	0.00000
1097 O	2536.7630	17.26722	17.13965	27.43768	25.54707	1.40329	0.00000	6.2651	-1.52035	1.40034	0.06298	0.00000
1098 B2	2542.8336	17.29333	17.19412	50.34229	12.80900	1.84913	0.00000	6.2990	-2.25296	0.69752	0.08392	0.00000
1099 O	2543.2086	17.29450	17.19888	52.04899	12.30219	1.88060	0.00000	6.2990	-2.29822	0.65400	0.08392	0.00000
1100 QF2	2544.2754	17.29766	17.21324	54.64867	11.55754	1.92754	0.00000	6.2990	-0.10222	0.05440	0.00377	0.00000
1101 QF2	2545.3422	17.30080	17.22775	52.47229	12.06307	1.88857	0.00000	6.2990	2.11180	-0.53532	-0.07656	0.00000
1102 FUG	2546.2422	17.30364	17.23915	48.75533	13.11304	1.81967	0.00000	6.2990	2.01816	-0.63131	-0.07656	0.00000
1103 OOO	2547.3504	17.30743	17.25189	44.41008	14.64326	1.73483	0.00000	6.2990	1.90285	-0.74950	-0.07656	0.00000
1104 B2	2553.4210	17.33650	17.30065	25.14278	27.66514	1.33370	0.00000	6.3309	1.27125	-1.39510	-0.05561	0.00000
1105 O	2553.7960	17.33892	17.30277	24.20397	28.72644	1.31284	0.00000	6.3309	1.23224	-1.43503	-0.05561	0.00000
1106 B2	2559.8666	17.39433	17.32836	13.07813	50.05777	1.03885	0.00000	6.3553	0.60064	-2.07807	-0.03467	0.00000
1107 O	2560.2416	17.39897	17.32953	12.64228	51.63126	1.02585	0.00000	6.3553	0.56162	-2.11791	-0.03467	0.00000
1108 QD2	2561.3084	17.41282	17.33273	12.09750	53.88035	1.01143	0.00000	6.3553	-0.04343	0.04091	0.00753	0.00000
1109 QD2	2562.3752	17.42657	17.33593	12.83313	51.46180	1.04203	0.00000	6.3553	-0.65630	2.19258	0.05006	0.00000
1110 FUG	2563.2752	17.43722	17.33882	14.10478	47.60656	1.08709	0.00000	6.3553	-0.75664	2.09102	0.05006	0.00000
1111 OOO	2564.3834	17.44900	17.34272	15.91871	43.11061	1.14256	0.00000	6.3553	-0.88019	1.96596	0.05006	0.00000
1112 B2	2570.4540	17.49326	17.37333	30.71243	23.38657	1.51001	0.00000	6.3829	-1.55693	1.28244	0.07100	0.00000
1113 O	2570.8290	17.49517	17.37594	31.89581	22.44065	1.53663	0.00000	6.3829	-1.59874	1.24003	0.07100	0.00000
1114 B2	2576.8996	17.51823	17.43748	55.41299	11.54604	2.03121	0.00000	6.4200	-2.27549	0.55423	0.09195	0.00000
1115 O	2577.2746	17.51929	17.44274	57.13529	11.14629	2.06569	0.00000	6.4200	-2.31730	0.51177	0.09195	0.00000
1116 QF2	2578.3414	17.52218	17.45846	59.53995	10.65846	2.11702	0.00000	6.4200	0.09692	-0.04769	0.00391	0.00000
1117 QF2	2579.4082	17.52508	17.47404	56.73393	11.35591	2.07398	0.00000	6.4200	2.49405	-0.61581	-0.08430	0.00000
1118 FUG	2580.3082	17.52771	17.48604	52.34772	12.56275	1.99811	0.00000	6.4200	2.37951	-0.72512	-0.08430	0.00000
1119 OOO	2581.4164	17.53126	17.49921	47.23007	14.31907	1.90469	0.00000	6.4200	2.23848	-0.85972	-0.08430	0.00000
1120 B2	2587.4870	17.55967	17.54716	24.74362	29.22437	1.45654	0.00000	6.4550	1.46595	-1.59507	-0.06336	0.00000
1121 O	2587.8620	17.56214	17.54916	23.66205	30.43772	1.43278	0.00000	6.4550	1.41823	-1.64055	-0.06336	0.00000
1122 B2	2593.9326	17.62314	17.57290	11.13366	54.80754	1.11178	0.00000	6.4814	0.64570	-2.37297	-0.04241	0.00000
1123 O	2594.3076	17.62862	17.57397	10.66728	56.60429	1.09587	0.00000	6.4814	0.59798	-2.41834	-0.04241	0.00000
1124 QD2	2595.3744	17.64522	17.57688	9.98053	59.27480	1.07469	0.00000	6.4814	0.05526	-0.04783	0.00255	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1125 QD2	2596.4412	17.66202	17.57979	10.42445	56.80239	1.10134	0.00000	6.4814	-0.47751	2.33105	0.04761	0.00000
1126 FUG	2597.3412	17.67519	17.58241	11.37939	52.69824	1.14420	0.00000	6.4814	-0.58354	2.22911	0.04761	0.00000
1127 000	2598.4494	17.68982	17.58592	12.81742	47.89675	1.19696	0.00000	6.4814	-0.71408	2.10359	0.04761	0.00000
1128 B2	2604.5200	17.74395	17.61316	25.82724	26.51535	1.54956	0.00000	6.5099	-1.42916	1.41776	0.06856	0.00000
1129 0	2604.8950	17.74622	17.61546	26.91567	25.46800	1.57527	0.00000	6.5099	-1.47334	1.37519	0.06856	0.00000
1130 B2	2610.9656	17.77290	17.66971	49.14305	12.94752	2.05501	0.00000	6.5477	-2.18841	0.68684	0.08950	0.00000
1131 0	2611.3406	17.77410	17.67441	50.80092	12.44838	2.08857	0.00000	6.5477	-2.23259	0.64421	0.08950	0.00000
1132 QF2	2612.4074	17.77734	17.68859	53.31648	11.72914	2.13680	0.00000	6.5477	-0.09018	0.04002	0.00057	0.00000
1133 QF2	2613.4742	17.78056	17.70286	51.17436	12.27246	2.08978	0.00000	6.5477	2.06813	-0.55689	-0.08839	0.00000
1134 FUG	2614.3742	17.78347	17.71406	47.53525	13.36134	2.01022	0.00000	6.5477	1.97532	-0.65297	-0.08839	0.00000
1135 000	2615.4824	17.78736	17.72655	43.28379	14.93969	1.91227	0.00000	6.5477	1.86104	-0.77128	-0.08839	0.00000
1136 B2	2621.5530	17.81720	17.77431	24.48984	28.22941	1.43928	0.00000	6.5826	1.23508	-1.41744	-0.06745	0.00000
1137 0	2621.9280	17.81969	17.77639	23.57803	29.30748	1.41399	0.00000	6.5826	1.19641	-1.45741	-0.06745	0.00000
1138 B2	2627.9986	17.87638	17.80151	12.85293	50.91374	1.06814	0.00000	6.6084	0.57045	-2.10097	-0.04650	0.00000
1139 0	2628.3736	17.88110	17.80266	12.43960	52.50442	1.05070	0.00000	6.6084	0.53178	-2.14085	-0.04650	0.00000
1140 QD2	2629.4404	17.89514	17.80580	11.95020	54.76296	1.02412	0.00000	6.6084	-0.06626	0.05512	-0.00353	0.00000
1141 QD2	2630.5072	17.90903	17.80895	12.73079	52.27610	1.04312	0.00000	6.6084	-0.67624	2.24145	0.03929	0.00000
1142 FUG	2631.4072	17.91975	17.81180	14.04074	48.33483	1.07848	0.00000	6.6084	-0.77926	2.13774	0.03929	0.00000
1143 000	2632.5154	17.93156	17.81564	15.90847	43.73826	1.12201	0.00000	6.6084	-0.90611	2.01004	0.03929	0.00000
1144 B2	2638.5860	17.97553	17.84592	31.12683	23.56689	1.42406	0.00000	6.6348	-1.60096	1.31203	0.06023	0.00000
1145 0	2638.9610	17.97742	17.84850	32.34365	22.59911	1.44664	0.00000	6.6348	-1.64389	1.26873	0.06023	0.00000
1146 B2	2645.0316	18.00009	17.91011	56.51885	11.44427	1.87583	0.00000	6.6694	-2.33874	0.56839	0.08118	0.00000
1147 0	2645.4066	18.00113	17.91542	58.28901	11.03423	1.90627	0.00000	6.6694	-2.38167	0.52503	0.08118	0.00000
1148 QF2	2646.4734	18.00396	17.93132	60.77945	10.51494	1.94974	0.00000	6.6694	0.08209	-0.03101	0.00001	0.00000
1149 QF2	2647.5402	18.00680	17.94713	57.94906	11.17056	1.90630	0.00000	6.6694	2.53138	-0.59270	-0.08115	0.00000
1150 FUG	2648.4402	18.00937	17.95935	53.49613	12.33540	1.83327	0.00000	6.6694	2.41633	-0.70157	-0.08115	0.00000
1151 000	2649.5484	18.01284	17.97277	48.29758	14.03892	1.74334	0.00000	6.6694	2.27466	-0.83563	-0.08115	0.00000
1152 B2	2655.6190	18.04057	18.02172	25.39277	28.63401	1.31433	0.00000	6.7012	1.49869	-1.56807	-0.06020	0.00000
1153 0	2655.9940	18.04297	18.02377	24.28673	29.82705	1.29176	0.00000	6.7012	1.45075	-1.61337	-0.06020	0.00000
1154 SB	2662.0646	18.10245	18.04796	11.38386	53.86685	0.92629	0.00000	6.7012	0.67472	-2.34667	-0.06020	0.00000
1155 0	2662.4396	18.10781	18.04905	10.89580	55.64384	0.90372	0.00000	6.7012	0.62678	-2.39197	-0.06020	0.00000
1156 QD2	2663.5064	18.12410	18.05201	10.15671	58.30148	0.85913	0.00000	6.7012	0.07624	-0.06232	-0.02369	0.00000
1157 QD2	2664.5732	18.14065	18.05496	10.56075	55.90197	0.85280	0.00000	6.7012	-0.46057	2.27822	0.01177	0.00000
1158 FUG	2665.4732	18.15367	18.05762	11.48273	51.89086	0.86339	0.00000	6.7012	-0.56386	2.17856	0.01177	0.00000
1159 000	2666.5814	18.16820	18.06119	12.87344	47.19829	0.87643	0.00000	6.7012	-0.69106	2.05585	0.01177	0.00000
1160 B2	2672.6520	18.22258	18.08875	25.49224	26.30346	1.01142	0.00000	6.7207	-1.38777	1.38537	0.03271	0.00000
1161 0	2673.0270	18.22487	18.09106	26.54920	25.28003	1.02369	0.00000	6.7207	-1.43081	1.34375	0.03271	0.00000
1162 SB	2679.0976	18.25203	18.14529	48.15068	13.05526	1.22227	0.00000	6.7207	-2.12757	0.67002	0.03271	0.00000
1163 0	2679.4726	18.25324	18.14995	49.76250	12.56835	1.23453	0.00000	6.7207	-2.17061	0.62840	0.03271	0.00000
1164 QF2	2680.5394	18.25655	18.16396	52.19210	11.88621	1.24166	0.00000	6.7207	-0.07279	0.02054	-0.01941	0.00000
1165 Q1	2681.6062	18.25985	18.17802	50.06394	12.47805	1.19343	0.00000	6.7207	2.03786	-0.58358	-0.07066	0.00000
1166 X0	2687.1916	18.28267	18.23230	30.51040	22.34868	0.79876	0.00000	6.7207	1.46298	-1.18364	-0.07066	0.00000
1167 Q00	2687.7849	18.28584	18.23642	29.21539	23.47282	0.76223	0.00000	6.7207	0.72972	-0.70242	-0.05263	0.00000
1168 0	2688.1599	18.28790	18.23893	28.67547	24.00859	0.74249	0.00000	6.7207	0.71005	-0.72628	-0.05263	0.00000
1169 B2	2694.2305	18.32676	18.27243	21.98804	35.15867	0.48656	0.00000	6.7334	0.39164	-1.11005	-0.03169	0.00000

POS		S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1170	O	2694.6055	18.32950	18.27411	21.70168	36.00014	0.47468	0.00000	6.7334	0.37197	-1.13386	-0.03169	0.00000
1171	B2	2700.6761	18.37766	18.29650	19.11865	52.08748	0.34588	0.00000	6.7418	0.05356	-1.51560	-0.01075	0.00000
1172	O	2701.0511	18.38078	18.29763	19.08586	53.23308	0.34185	0.00000	6.7418	0.03389	-1.53934	-0.01075	0.00000
1173	B2	2707.1217	18.43029	18.31302	20.60723	74.22771	0.34020	0.00000	6.7487	-0.28452	-1.91832	0.01020	0.00000
1174	O	2707.4967	18.43317	18.31382	20.82799	75.67532	0.34402	0.00000	6.7487	-0.30419	-1.94196	0.01020	0.00000
1175	QO	2710.0793	18.45067	18.31937	28.96703	66.41635	0.41721	0.00000	6.7487	-3.11575	5.21093	0.04770	0.00000
1176	XI	2713.2093	18.46351	18.32930	52.09311	37.94882	0.56651	0.00000	6.7487	-4.27278	3.88413	0.04770	0.00000
1177	QI	2715.3429	18.46936	18.33993	61.03226	28.57892	0.61534	0.00000	6.7487	0.33604	0.76637	-0.00262	0.00000
1178	LS	2729.8429	18.50957	18.45020	55.12095	18.03192	0.57738	0.00000	6.7487	0.07163	-0.03899	-0.00262	0.00000
1179	LSI	2729.8687	18.50965	18.45043	55.11727	18.03397	0.57731	0.00000	6.7487	0.07116	-0.04042	-0.00262	0.00000
1180	LS	2744.3687	18.55134	18.55573	56.88743	30.88372	0.53936	0.00000	6.7487	-0.19324	-0.84577	-0.00262	0.00000
1181	QI	2746.5023	18.55764	18.56556	48.10763	41.07203	0.48639	0.00000	6.7487	4.05980	-4.21092	-0.04629	0.00000
1182	XI	2749.6323	18.57167	18.57473	26.25340	71.90045	0.34150	0.00000	6.7487	2.92238	-5.63842	-0.04629	0.00000
1183	QO	2752.2149	18.59120	18.57986	18.48126	81.89465	0.26206	0.00000	6.7487	0.34339	2.10987	-0.01656	0.00000
1184	O	2752.5899	18.59445	18.58060	18.23222	80.32161	0.25586	0.00000	6.7487	0.32071	2.08491	-0.01656	0.00000
1185	B2	2758.6605	18.65124	18.59484	16.56754	57.43185	0.21893	0.00000	6.7534	-0.04647	1.68486	0.00439	0.00000
1186	O	2759.0355	18.65483	18.59589	16.61089	56.17760	0.22057	0.00000	6.7534	-0.06915	1.65980	0.00439	0.00000
1187	B2	2765.1061	18.70933	18.61673	19.67927	38.46867	0.31078	0.00000	6.7588	-0.43633	1.25673	0.02533	0.00000
1188	O	2765.4811	18.71233	18.61830	20.01502	37.53556	0.32028	0.00000	6.7588	-0.45902	1.23158	0.02533	0.00000
1189	B2	2771.5517	18.75374	18.65003	27.81646	25.04046	0.53763	0.00000	6.7675	-0.82620	0.82626	0.04628	0.00000
1190	O	2771.9267	18.75586	18.65244	28.44461	24.43021	0.55499	0.00000	6.7675	-0.84888	0.80106	0.04628	0.00000
1191	QOO	2772.5200	18.75911	18.65640	29.87453	23.17826	0.58632	0.00000	6.7675	-1.57224	1.29942	0.05946	0.00000
1192	XO	2778.1054	18.78195	18.71010	51.06334	12.28128	0.91842	0.00000	6.7675	-2.22136	0.65156	0.05946	0.00000
1193	Q1	2779.1722	18.78517	18.72449	53.54231	11.54097	0.96091	0.00000	6.7675	-0.06762	0.05271	0.01990	0.00000
1194	QF2	2780.2390	18.78839	18.73901	51.34337	12.04960	0.96056	0.00000	6.7675	2.09804	-0.53657	-0.02054	0.00000
1195	FUG	2781.1390	18.79128	18.75042	47.65212	13.10200	0.94208	0.00000	6.7675	2.00335	-0.63277	-0.02054	0.00000
1196	OOO	2782.2472	18.79516	18.76318	43.34110	14.63573	0.91931	0.00000	6.7675	1.88676	-0.75121	-0.02054	0.00000
1197	SB	2788.3178	18.82511	18.81192	24.31076	27.69528	0.79462	0.00000	6.7675	1.24808	-1.40006	-0.02054	0.00000
1198	O	2788.6928	18.82761	18.81404	23.38949	28.76036	0.78692	0.00000	6.7675	1.20863	-1.44015	-0.02054	0.00000
1199	B2	2794.7634	18.88515	18.83958	12.59300	50.16791	0.72580	0.00000	6.7832	0.56999	-2.08551	0.00040	0.00000
1200	O	2795.1384	18.88997	18.84075	12.18030	51.74704	0.72595	0.00000	6.7832	0.53054	-2.12550	0.00040	0.00000
1201	QD2	2796.2052	18.90432	18.84394	11.68436	54.00722	0.74255	0.00000	6.7832	-0.05880	0.03826	0.03082	0.00000
1202	QD2	2797.2720	18.91853	18.84714	12.43871	51.58855	0.79219	0.00000	6.7832	-0.65873	2.19533	0.06261	0.00000
1203	FUG	2798.1720	18.92950	18.85002	13.71781	47.72832	0.84854	0.00000	6.7832	-0.76249	2.09381	0.06261	0.00000
1204	OOO	2799.2802	18.94159	18.85391	15.54935	43.22614	0.91792	0.00000	6.7832	-0.89024	1.96880	0.06261	0.00000
1205	B2	2805.3508	18.98647	18.88443	30.60482	23.46600	1.36152	0.00000	6.8068	-1.59000	1.28554	0.08355	0.00000
1206	O	2805.7258	18.98838	18.88703	31.81353	22.51774	1.39285	0.00000	6.8068	-1.63323	1.24315	0.08355	0.00000
1207	SB	2811.7964	19.01138	18.94834	55.89126	11.59018	1.90006	0.00000	6.8068	-2.33305	0.55693	0.08355	0.00000
1208	O	2812.1714	19.01243	18.95358	57.65726	11.18838	1.93139	0.00000	6.8068	-2.37628	0.51454	0.08355	0.00000
1209	QF2	2813.2382	19.01529	18.96924	60.16530	10.69619	1.97681	0.00000	6.8068	0.06045	-0.04630	0.00129	0.00000
1210	QF2	2814.3050	19.01816	18.98476	57.40692	11.39191	1.93412	0.00000	6.8068	2.48653	-0.61555	-0.08103	0.00000
1211	FUG	2815.2050	19.02075	18.99673	53.03251	12.59795	1.86120	0.00000	6.8068	2.37392	-0.72449	-0.08103	0.00000
1212	OOO	2816.3132	19.02425	19.00986	47.92462	14.35237	1.77141	0.00000	6.8068	2.23526	-0.85863	-0.08103	0.00000
1213	B2	2822.3838	19.05208	19.05775	25.39817	29.22929	1.34313	0.00000	6.8392	1.47575	-1.59148	-0.06008	0.00000
1214	O	2822.7588	19.05449	19.05975	24.30895	30.43990	1.32060	0.00000	6.8392	1.42883	-1.63681	-0.06008	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1215 B2	2828.8294	19.11342	19.08351	11.57277	54.74914	1.01947	0.00000	6.8635	0.66933	-2.36674	-0.03914	0.00000
1216 O	2829.2044	19.11869	19.08458	11.08837	56.54115	1.00479	0.00000	6.8635	0.62241	-2.41195	-0.03914	0.00000
1217 QD2	2830.2712	19.13467	19.08749	10.36442	59.20072	0.98510	0.00000	6.8635	0.06621	-0.04412	0.00208	0.00000
1218 QD2	2831.3380	19.15087	19.09040	10.79740	56.72389	1.00926	0.00000	6.8635	-0.47806	2.33143	0.04338	0.00000
1219 FUG	2832.2380	19.16360	19.09302	11.75008	52.61921	1.04831	0.00000	6.8635	-0.58047	2.22932	0.04338	0.00000
1220 OOO	2833.3462	19.17780	19.09654	13.17636	47.81748	1.09638	0.00000	6.8635	-0.70656	2.10359	0.04338	0.00000
1221 B2	2839.4168	19.23103	19.12384	25.94669	26.44303	1.42330	0.00000	6.8897	-1.39723	1.41662	0.06433	0.00000
1222 O	2839.7918	19.23329	19.12615	27.01061	25.39655	1.44742	0.00000	6.8897	-1.43990	1.37397	0.06433	0.00000
1223 B2	2845.8624	19.26005	19.18059	48.68390	12.89778	1.90148	0.00000	6.9245	-2.13057	0.68448	0.08527	0.00000
1224 O	2846.2374	19.26126	19.18531	50.29782	12.40043	1.93346	0.00000	6.9245	-2.17324	0.64178	0.08527	0.00000
1225 QF2	2847.3042	19.26453	19.19954	52.70816	11.68457	1.98066	0.00000	6.9245	-0.05237	0.03924	0.00289	0.00000
1226 QF2	2848.3710	19.26780	19.21387	50.51470	12.22796	1.93958	0.00000	6.9245	2.07772	-0.55618	-0.07962	0.00000
1227 FUG	2849.2710	19.27074	19.22510	46.86006	13.31581	1.86792	0.00000	6.9245	1.98299	-0.65255	-0.07962	0.00000
1228 OOO	2850.3792	19.27469	19.23764	42.59421	14.89361	1.77968	0.00000	6.9245	1.86635	-0.77121	-0.07962	0.00000
1229 B2	2856.4498	19.30521	19.28551	23.81445	28.19444	1.35992	0.00000	6.9572	1.22743	-1.41933	-0.05868	0.00000
1230 O	2856.8248	19.30777	19.28758	22.90867	29.27397	1.33791	0.00000	6.9572	1.18796	-1.45943	-0.05868	0.00000
1231 B2	2862.8954	19.36649	19.31271	12.36474	50.91664	1.04529	0.00000	6.9819	0.54905	-2.10495	-0.03773	0.00000
1232 O	2863.2704	19.37140	19.31387	11.96775	52.51036	1.03114	0.00000	6.9819	0.50958	-2.14495	-0.03773	0.00000
1233 QD2	2864.3372	19.38600	19.31701	11.50836	54.77750	1.01354	0.00000	6.9819	-0.07260	0.05128	0.00461	0.00000
1234 QD2	2865.4040	19.40040	19.32016	12.28681	52.29793	1.04106	0.00000	6.9819	-0.66786	2.23855	0.04717	0.00000
1235 FUG	2866.3040	19.41150	19.32301	13.58428	48.36164	1.08351	0.00000	6.9819	-0.77378	2.13511	0.04717	0.00000
1236 OOO	2867.4122	19.42368	19.32684	15.44382	43.77054	1.13578	0.00000	6.9819	-0.90420	2.00773	0.04717	0.00000
1237 B2	2873.4828	19.46861	19.35707	30.75760	23.61622	1.48567	0.00000	7.0091	-1.61860	1.31153	0.06811	0.00000
1238 O	2873.8578	19.47051	19.35965	31.98810	22.64877	1.51122	0.00000	7.0091	-1.66273	1.26834	0.06811	0.00000
1239 B2	2879.9284	19.49331	19.42106	56.51067	11.48770	1.98825	0.00000	7.0456	-2.37713	0.56980	0.08906	0.00000
1240 O	2880.3034	19.49435	19.42636	58.31007	11.07656	2.02164	0.00000	7.0456	-2.42126	0.52656	0.08906	0.00000
1241 QF2	2881.3702	19.49718	19.44220	60.88517	10.55549	2.07089	0.00000	7.0456	0.04351	-0.03085	0.00292	0.00000
1242 QF2	2882.4370	19.50001	19.45795	58.12988	11.21217	2.02782	0.00000	7.0456	2.50061	-0.59387	-0.08335	0.00000
1243 FUG	2883.3370	19.50257	19.47012	53.72984	12.37885	1.95281	0.00000	7.0456	2.38832	-0.70245	-0.08335	0.00000
1244 OOO	2884.4452	19.50603	19.48350	48.58961	14.08392	1.86044	0.00000	7.0456	2.25004	-0.83614	-0.08335	0.00000
1245 B2	2890.5158	19.53341	19.53234	25.87088	28.67329	1.41806	0.00000	7.0797	1.49265	-1.56661	-0.06241	0.00000
1246 O	2890.8908	19.53577	19.53438	24.76894	29.86519	1.39465	0.00000	7.0797	1.44586	-1.61179	-0.06241	0.00000
1247 B2	2896.9614	19.59350	19.55856	11.81327	53.85644	1.07941	0.00000	7.1054	0.68846	-2.33938	-0.04146	0.00000
1248 O	2897.3364	19.59867	19.55965	11.31446	55.62787	1.06386	0.00000	7.1054	0.64167	-2.38445	-0.04146	0.00000
1249 QD2	2898.4032	19.61434	19.56261	10.55796	58.26996	1.04298	0.00000	7.1054	0.07791	-0.05547	0.00217	0.00000
1250 QD2	2899.4700	19.63026	19.56556	10.97207	55.85765	1.06853	0.00000	7.1054	-0.47182	2.28320	0.04591	0.00000
1251 FUG	2900.3700	19.64280	19.56823	11.91160	51.83798	1.10985	0.00000	7.1054	-0.57210	2.18310	0.04591	0.00000
1252 OOO	2901.4782	19.65682	19.57180	13.31646	47.13597	1.16073	0.00000	7.1054	-0.69559	2.05983	0.04591	0.00000
1253 B2	2907.5488	19.70985	19.59942	25.86696	26.21099	1.50296	0.00000	7.1330	-1.37198	1.38635	0.06685	0.00000
1254 O	2907.9238	19.71212	19.60174	26.91162	25.18690	1.52803	0.00000	7.1330	-1.41377	1.34454	0.06685	0.00000
1255 B2	2913.9944	19.73907	19.65627	48.18106	12.96328	1.99741	0.00000	7.1697	-2.09016	0.66859	0.08780	0.00000
1256 O	2914.3694	19.74029	19.66097	49.76435	12.47754	2.03033	0.00000	7.1697	-2.13195	0.62673	0.08780	0.00000
1257 QF2	2915.4362	19.74360	19.67509	52.11008	11.79566	2.07805	0.00000	7.1697	-0.03400	0.02195	0.00132	0.00000
1258 QF2	2916.5030	19.74691	19.68926	49.90516	12.38107	2.03314	0.00000	7.1697	2.06994	-0.57885	-0.08521	0.00000
1259 FUG	2917.4030	19.74989	19.70034	46.26505	13.51034	1.95645	0.00000	7.1697	1.97463	-0.67590	-0.08521	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1260 000	2918.5112	19.75389	19.71269	42.01852	15.14083	1.86202	0.00000	7.1697	1.85728	-0.79540	-0.08521	0.00000
1261 B2	2924.5818	19.78491	19.75966	23.37237	28.76299	1.40837	0.00000	7.2038	1.21449	-1.44807	-0.06426	0.00000
1262 0	2924.9568	19.78752	19.76170	22.47639	29.86418	1.38427	0.00000	7.2038	1.17478	-1.48844	-0.06426	0.00000
1263 B2	2931.0274	19.84747	19.78634	12.11603	51.88643	1.05775	0.00000	7.2291	0.53199	-2.13846	-0.04332	0.00000
1264 0	2931.4024	19.85248	19.78748	11.73193	53.50538	1.04151	0.00000	7.2291	0.49228	-2.17873	-0.04332	0.00000
1265 QD2	2932.4692	19.86735	19.79056	11.30067	55.79983	1.01813	0.00000	7.2291	-0.08206	0.05984	-0.00066	0.00000
1266 QD2	2933.5360	19.88200	19.79365	12.09256	53.25751	1.04009	0.00000	7.2291	-0.67118	2.28795	0.04197	0.00000
1267 FUG	2934.4360	19.89327	19.79645	13.39785	49.23403	1.07786	0.00000	7.2291	-0.77914	2.18259	0.04197	0.00000
1268 000	2935.5442	19.90561	19.80022	15.27203	44.54031	1.12437	0.00000	7.2291	-0.91206	2.05286	0.04197	0.00000
1269 B2	2941.6148	19.95078	19.82999	30.76448	23.91630	1.44270	0.00000	7.2558	-1.64017	1.34376	0.06291	0.00000
1270 0	2941.9898	19.95269	19.83254	32.01148	22.92498	1.46629	0.00000	7.2558	-1.68515	1.29977	0.06291	0.00000
1271 B2	2948.0604	19.97540	19.89364	56.88945	11.46089	1.91176	0.00000	7.2909	-2.41326	0.58828	0.08386	0.00000
1272 0	2948.4354	19.97644	19.89895	58.71626	11.03620	1.94321	0.00000	7.2909	-2.45824	0.54424	0.08386	0.00000
1273 QF2	2949.5022	19.97924	19.91488	61.35255	10.47691	1.98870	0.00000	7.2909	0.02399	-0.01218	0.00110	0.00000
1274 QF2	2950.5690	19.98205	19.93078	58.61692	11.08972	1.94554	0.00000	7.2909	2.50199	-0.57080	-0.08171	0.00000
1275 FUG	2951.4690	19.98459	19.94310	54.21367	12.21399	1.87200	0.00000	7.2909	2.39052	-0.67840	-0.08171	0.00000
1276 000	2952.5772	19.98801	19.95667	49.06743	13.86441	1.78145	0.00000	7.2909	2.25326	-0.81089	-0.08171	0.00000
1277 B2	2958.6478	20.01505	20.00641	26.27575	28.10709	1.34905	0.00000	7.3235	1.50145	-1.53477	-0.06076	0.00000
1278 0	2959.0228	20.01737	20.00850	25.16708	29.27496	1.32626	0.00000	7.3235	1.45500	-1.57954	-0.06076	0.00000
1279 B2	2965.0934	20.07400	20.03316	12.06648	52.83499	1.02099	0.00000	7.3478	0.70319	-2.30061	-0.03982	0.00000
1280 0	2965.4684	20.07905	20.03427	11.55650	54.57720	1.00606	0.00000	7.3478	0.65675	-2.34528	-0.03982	0.00000
1281 QD2	2966.5352	20.09440	20.03729	10.77671	57.18286	0.98566	0.00000	7.3478	0.08499	-0.06100	0.00143	0.00000
1282 QD2	2967.6020	20.11001	20.04030	11.18301	54.82989	1.00914	0.00000	7.3478	-0.47146	2.23393	0.04275	0.00000
1283 FUG	2968.5020	20.12232	20.04301	12.12017	50.89731	1.04762	0.00000	7.3478	-0.56983	2.13560	0.04275	0.00000
1284 000	2969.6102	20.13612	20.04664	13.51737	46.29814	1.09499	0.00000	7.3478	-0.69095	2.01452	0.04275	0.00000
1285 B2	2975.6808	20.18867	20.07472	25.93303	25.85074	1.41806	0.00000	7.3739	-1.35441	1.35300	0.06369	0.00000
1286 0	2976.0558	20.19093	20.07707	26.96420	24.85138	1.44194	0.00000	7.3739	-1.39539	1.31194	0.06369	0.00000
1287 B2	2982.1264	20.21793	20.13201	47.93199	12.95070	1.89215	0.00000	7.4086	-2.05885	0.64801	0.08464	0.00000
1288 0	2982.5014	20.21915	20.13671	49.49149	12.48011	1.92389	0.00000	7.4086	-2.09983	0.60689	0.08464	0.00000
1289 QF2	2983.5682	20.22248	20.15080	51.78036	11.83966	1.97063	0.00000	7.4086	-0.01362	0.00238	0.00267	0.00000
1290 QF2	2984.6350	20.22581	20.16489	49.54788	12.46966	1.92953	0.00000	7.4086	2.07500	-0.60171	-0.07942	0.00000
1291 FUG	2985.5350	20.22882	20.17589	45.89961	13.64121	1.85805	0.00000	7.4086	1.97863	-0.70002	-0.07942	0.00000
1292 000	2986.6432	20.23285	20.18810	41.64568	15.32687	1.77004	0.00000	7.4086	1.85996	-0.82106	-0.07942	0.00000
1293 B2	2992.7138	20.26426	20.23433	23.01075	29.31200	1.35149	0.00000	7.4411	1.20996	-1.48218	-0.05848	0.00000
1294 0	2993.0888	20.26691	20.23632	22.11833	30.43897	1.32957	0.00000	7.4411	1.16981	-1.52308	-0.05848	0.00000
1295 B2	2999.1594	20.32804	20.26049	11.86208	52.93276	1.03816	0.00000	7.4657	0.51981	-2.18147	-0.03753	0.00000
1296 0	2999.5344	20.33316	20.26160	11.48728	54.58416	1.02409	0.00000	7.4657	0.47966	-2.22227	-0.03753	0.00000
1297 QD2	3000.6012	20.34835	20.26462	11.07411	56.92321	1.00654	0.00000	7.4657	-0.08665	0.06220	0.00452	0.00000
1298 QD2	3001.6680	20.36329	20.26765	11.86808	54.32651	1.03381	0.00000	7.4657	-0.66856	2.33581	0.04678	0.00000
1299 FUG	3002.5680	20.37475	20.27039	13.17025	50.21831	1.07592	0.00000	7.4657	-0.77829	2.22885	0.04678	0.00000
1300 000	3003.6762	20.38730	20.27409	15.04499	45.42423	1.12776	0.00000	7.4657	-0.91341	2.09716	0.04678	0.00000
1301 B2	3009.7468	20.43293	20.30332	30.62646	24.32728	1.47531	0.00000	7.4927	-1.65349	1.37735	0.06773	0.00000
1302 0	3010.1218	20.43484	20.30582	31.88372	23.31101	1.50071	0.00000	7.4927	-1.69921	1.33269	0.06773	0.00000
1303 B2	3016.1924	20.45757	20.36624	57.00510	11.51254	1.97540	0.00000	7.5289	-2.43930	0.61043	0.08867	0.00000
1304 0	3016.5674	20.45860	20.37153	58.85172	11.07149	2.00865	0.00000	7.5289	-2.48502	0.56572	0.08867	0.00000

POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1305 QF2	3017.6342	20.46140	20.38744	61.53970	10.46865	2.05778	0.00000	7.5289	0.00304	0.00778	0.00308	0.00000
1306 QF2	3018.7010	20.46421	20.40338	58.83913	11.03731	2.01518	0.00000	7.5289	2.49056	-0.54875	-0.08264	0.00000
1307 FUG	3019.6010	20.46674	20.41578	54.45528	12.12055	1.94080	0.00000	7.5289	2.38039	-0.65485	-0.08264	0.00000
1308 000	3020.7092	20.47014	20.42948	49.32973	13.71673	1.84921	0.00000	7.5289	2.24472	-0.78549	-0.08264	0.00000
1309 B2	3026.7798	20.49694	20.47998	26.58874	27.58968	1.41111	0.00000	7.5628	1.50164	-1.49928	-0.06170	0.00000
1310 O	3027.1548	20.49923	20.48210	25.47973	28.73069	1.38798	0.00000	7.5628	1.45573	-1.54343	-0.06170	0.00000
1311 B2	3033.2254	20.55490	20.50726	12.31739	51.79123	1.07702	0.00000	7.5884	0.71264	-2.25447	-0.04076	0.00000
1312 O	3033.6004	20.55985	20.50839	11.80013	53.49860	1.06173	0.00000	7.5884	0.66673	-2.29851	-0.04076	0.00000
1313 QD2	3034.6672	20.57488	20.51147	11.00770	56.05267	1.04157	0.00000	7.5884	0.08702	-0.06014	0.00281	0.00000
1314 QD2	3035.7340	20.59016	20.51454	11.41770	53.74769	1.06777	0.00000	7.5884	-0.47702	2.18875	0.04650	0.00000
1315 FUG	3036.6340	20.60223	20.51730	12.36341	49.89522	1.10961	0.00000	7.5884	-0.57378	2.09178	0.04650	0.00000
1316 000	3037.7422	20.61576	20.52101	13.76717	45.39130	1.16114	0.00000	7.5884	-0.69292	1.97239	0.04650	0.00000
1317 B2	3043.8128	20.66760	20.54962	26.14096	25.39981	1.50694	0.00000	7.6161	-1.34554	1.32005	0.06744	0.00000
1318 O	3044.1878	20.66984	20.55201	27.16523	24.42496	1.53223	0.00000	7.6161	-1.38586	1.27956	0.06744	0.00000
1319 B2	3050.2584	20.69673	20.60765	47.95147	12.86133	2.00518	0.00000	7.6529	-2.03847	0.62488	0.08838	0.00000
1320 O	3050.6334	20.69796	20.61238	49.49544	12.40788	2.03832	0.00000	7.6529	-2.07879	0.58433	0.08838	0.00000
1321 QF2	3051.7002	20.70129	20.62653	51.73856	11.81197	2.08648	0.00000	7.6529	0.00758	-0.01743	0.00157	0.00000
1322 QF2	3052.7670	20.70462	20.64063	49.46405	12.48451	2.04164	0.00000	7.6529	2.09262	-0.62237	-0.08532	0.00000
1323 FUG	3053.6670	20.70763	20.65159	45.78543	13.69478	1.96485	0.00000	7.6529	1.99474	-0.72238	-0.08532	0.00000
1324 000	3054.7752	20.71168	20.66374	41.49783	15.43233	1.87029	0.00000	7.6529	1.87423	-0.84553	-0.08532	0.00000
1325 B2	3060.8458	20.74333	20.70943	22.75104	29.78424	1.41594	0.00000	7.6871	1.21412	-1.51812	-0.06438	0.00000
1326 O	3061.2208	20.74600	20.71140	21.85574	30.93844	1.39180	0.00000	7.6871	1.17334	-1.55973	-0.06438	0.00000
1327 SB	3067.2914	20.80821	20.73513	11.61749	53.96430	1.00099	0.00000	7.6871	0.51319	-2.23329	-0.06438	0.00000
1328 O	3067.6664	20.81343	20.73622	11.24790	55.65487	0.97685	0.00000	7.6871	0.47241	-2.27489	-0.06438	0.00000
1329 QD2	3068.7332	20.82895	20.73918	10.84181	58.05853	0.92941	0.00000	7.6871	-0.08613	0.05516	-0.02490	0.00000
1330 QD2	3069.8000	20.84420	20.74215	11.62641	55.42640	0.92334	0.00000	7.6871	-0.66018	2.37557	0.01348	0.00000
1331 FUG	3070.7000	20.85590	20.74484	12.91477	51.24747	0.93547	0.00000	7.6871	-0.77133	2.26769	0.01348	0.00000
1332 000	3071.8082	20.86868	20.74846	14.77602	46.36855	0.95040	0.00000	7.6871	-0.90819	2.13487	0.01348	0.00000
1333 B2	3077.8788	20.91495	20.77708	30.35228	24.85108	1.09578	0.00000	7.7083	-1.65785	1.40889	0.03442	0.00000
1334 O	3078.2538	20.91688	20.77953	31.61303	23.81131	1.10869	0.00000	7.7083	-1.70416	1.36385	0.03442	0.00000
1335 SB	3084.3244	20.93975	20.83883	56.85473	11.67903	1.31766	0.00000	7.7083	-2.45387	0.63468	0.03442	0.00000
1336 O	3084.6994	20.94078	20.84404	58.71250	11.21991	1.33057	0.00000	7.7083	-2.50018	0.58964	0.03442	0.00000
1337 QF2	3085.7662	20.94359	20.85978	61.43978	10.57226	1.33736	0.00000	7.7083	-0.01808	0.02649	-0.02173	0.00000
1338 Q1	3086.8330	20.94639	20.87559	58.78738	11.10349	1.28454	0.00000	7.7083	2.46720	-0.53186	-0.07692	0.00000
1339 XO	3092.4184	20.96604	20.93572	34.98768	20.64915	0.85493	0.00000	7.7083	1.79386	-1.17718	-0.07692	0.00000
1340 QOO	3093.0117	20.96881	20.94016	33.36438	21.79176	0.81506	0.00000	7.7083	0.95469	-0.73984	-0.05763	0.00000
1341 O	3093.3867	20.97062	20.94286	32.65642	22.35662	0.79345	0.00000	7.7083	0.93321	-0.76647	-0.05763	0.00000
1342 B2	3099.4573	21.00583	20.97806	23.43794	34.26743	0.50718	0.00000	7.7217	0.58545	-1.19515	-0.03669	0.00000
1343 O	3099.8323	21.00840	20.97977	23.00691	35.17375	0.49342	0.00000	7.7217	0.56397	-1.22172	-0.03669	0.00000
1344 B2	3105.9029	21.05623	21.00231	18.27112	52.59976	0.33429	0.00000	7.7302	0.21621	-1.64821	-0.01574	0.00000
1345 O	3106.2779	21.05951	21.00343	18.11702	53.84585	0.32838	0.00000	7.7302	0.19473	-1.67470	-0.01574	0.00000
1346 B2	3112.3485	21.11429	21.01848	17.86394	76.75460	0.29639	0.00000	7.7365	-0.15303	-2.09819	0.00520	0.00000
1347 O	3112.7235	21.11762	21.01925	17.98677	78.33814	0.29834	0.00000	7.7365	-0.17452	-2.12458	0.00520	0.00000
1348 QO	3115.3061	21.13809	21.02460	24.56407	69.27787	0.35198	0.00000	7.7365	-2.58920	5.32340	0.03724	0.00000
1349 XI	3118.4361	21.15329	21.03405	43.84502	40.10230	0.46854	0.00000	7.7365	-3.57085	3.99787	0.03724	0.00000

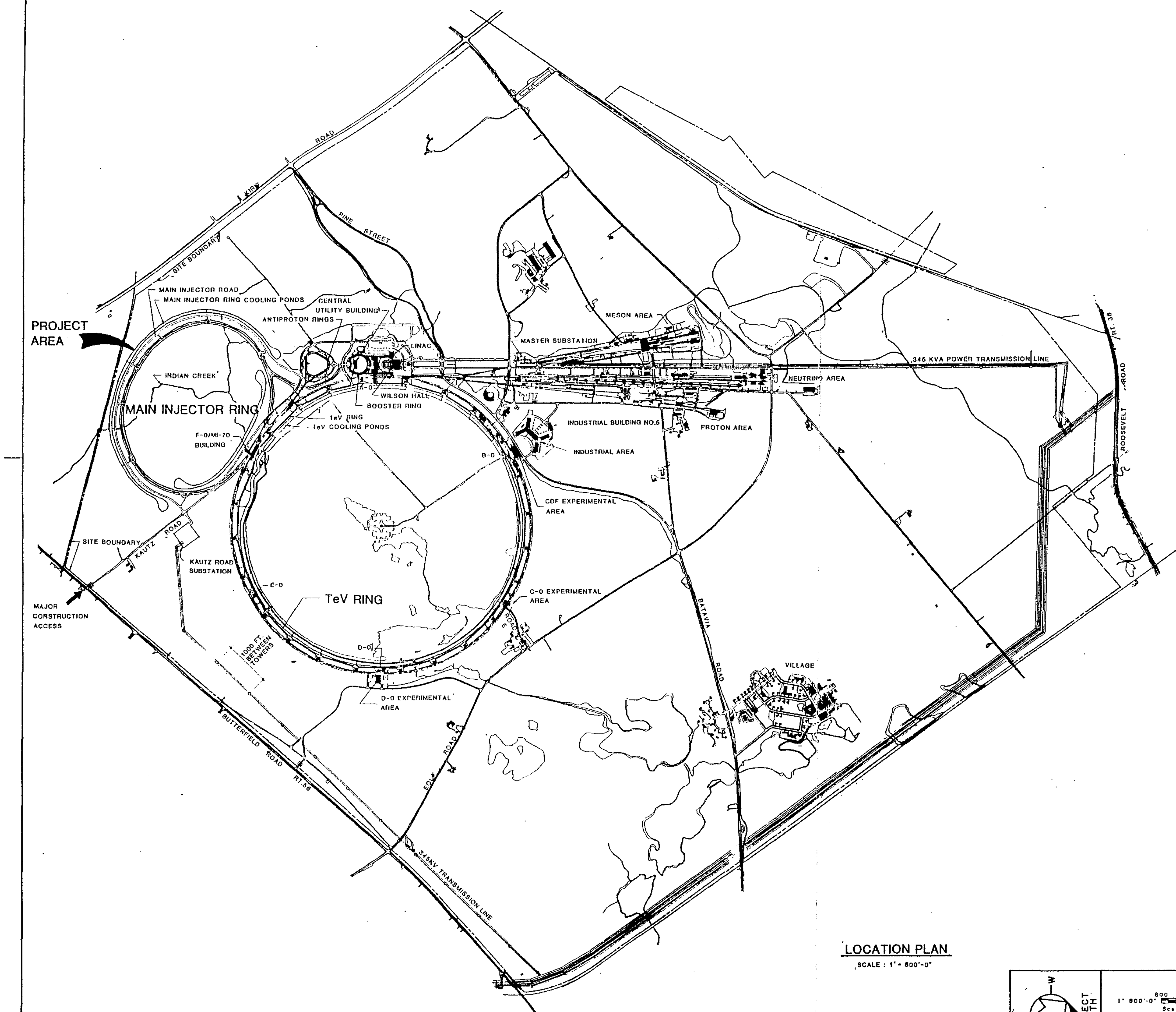
POS	S(M)	NUX	NUY	BETAX(M)	BETAY(M)	XEQ(M)	YEQ(M)	ZEQ (M)	ALPHAX	ALPHAY	DXEQ	DYEQ
1395 FUG	3254.4720	21.95572	21.92744	54.48405	12.25789	1.09403	0.00000	7.8413	2.40035	-0.67670	-0.06851	0.00000
1396 OOL	3258.4364	21.96972	21.96872	37.40264	19.49261	0.82242	0.00000	7.8413	1.90835	-1.14822	-0.06851	0.00000
1397 B2	3264.5070	22.00647	22.00462	18.80747	37.80489	0.47010	0.00000	7.8547	1.15502	-1.86767	-0.04757	0.00000
1398 OOL	3268.4714	22.04971	22.01854	11.60000	54.47913	0.28151	0.00000	7.8547	0.66303	-2.33832	-0.04757	0.00000
1399 QD2	3269.5382	22.06501	22.02156	10.80865	57.07424	0.23666	0.00000	7.8547	0.08970	-0.05822	-0.03684	0.00000
1400 QD2	3270.6050	22.08058	22.02458	11.20582	54.72028	0.20234	0.00000	7.8547	-0.46748	2.23206	-0.02774	0.00000
1401 FUG	3271.5050	22.09288	22.02729	12.13536	50.79112	0.17737	0.00000	7.8547	-0.56535	2.13367	-0.02774	0.00000
1402 OOL	3275.4694	22.13570	22.04216	18.32691	35.59181	0.06737	0.00000	7.8547	-0.99644	1.70028	-0.02774	0.00000
1403 B2	3281.5400	22.17454	22.07969	34.43078	18.96605	-0.03747	0.00000	7.8547	-1.65652	1.03786	-0.00680	0.00000
1404 OOL	3285.5044	22.18989	22.12121	49.27402	12.45834	-0.06443	0.00000	7.8547	-2.08761	0.60368	-0.00680	0.00000
1405 QF2	3286.5712	22.19323	22.13532	51.54654	11.82383	-0.07019	0.00000	7.8547	-0.01075	-0.00006	-0.00397	0.00000
1406 QF2	3287.6380	22.19657	22.14943	49.31853	12.45860	-0.07283	0.00000	7.8547	2.06801	-0.60380	-0.00096	0.00000
1407 RFO	3287.9288	22.19752	22.15309	48.12482	12.81903	-0.07311	0.00000	7.8547	2.03690	-0.63566	-0.00096	0.00000
1408 OOO	3289.0370	22.20137	22.16611	43.74163	14.36241	-0.07416	0.00000	7.8547	1.91833	-0.75704	-0.00096	0.00000
1409 SB	3295.1076	22.23112	22.21543	24.39367	27.59013	-0.07997	0.00000	7.8547	1.26883	-1.42194	-0.00096	0.00000
1410 O	3295.4826	22.23361	22.21755	23.45709	28.67199	-0.08033	0.00000	7.8547	1.22871	-1.46302	-0.00096	0.00000
1411 SB	3301.5532	22.29133	22.24306	12.48202	50.47117	-0.08613	0.00000	7.8547	0.57920	-2.12793	-0.00096	0.00000
1412 O	3301.9282	22.29620	22.24422	12.06267	52.08252	-0.08649	0.00000	7.8547	0.53908	-2.16900	-0.00096	0.00000
1413 QD2	3302.9950	22.31071	22.24739	11.54473	54.42138	-0.08944	0.00000	7.8547	-0.04642	0.00910	-0.00460	0.00000
1414 QD2	3304.0618	22.32511	22.25055	12.26665	52.04483	-0.09638	0.00000	7.8547	-0.64027	2.18561	-0.00845	0.00000
1415 RFO	3304.3526	22.32882	22.25145	12.64875	50.78306	-0.09883	0.00000	7.8547	-0.67370	2.15333	-0.00845	0.00000
1416 OOO	3305.4608	22.34196	22.25510	14.28309	46.14674	-0.10820	0.00000	7.8547	-0.80108	2.03032	-0.00845	0.00000
1417 SB	3311.5314	22.39083	22.28336	28.24496	25.58673	-0.15949	0.00000	7.8547	-1.49884	1.35650	-0.00845	0.00000
1418 O	3311.9064	22.39290	22.28574	29.38525	24.58497	-0.16265	0.00000	7.8547	-1.54194	1.31487	-0.00845	0.00000
1419 SB	3317.9770	22.41763	22.34153	52.34214	12.71138	-0.21394	0.00000	7.8547	-2.23971	0.64105	-0.00845	0.00000
1420 O	3318.3520	22.41875	22.34632	54.03808	12.24620	-0.21711	0.00000	7.8547	-2.28281	0.59942	-0.00845	0.00000
1421 QF2	3319.4188	22.42180	22.36068	56.51174	11.61313	-0.22122	0.00000	7.8547	-0.00126	0.00284	0.00078	0.00000

```
CIRCUMFERENCE =    3319.4188 M          THETX =   6.28318454 RAD      NUX =    22.42180      DNUX/(DP/P)  =  -27.52306
       RADIUS =    528.3019 M          THETY =   0.00000000 RAD      NUY =    22.36068      DNUY/(DP/P)  =  -28.31926
(DS/S)/(DP/P)=  0.0023663               TGAM=(  20.55725,     0.00000)

MAXIMA    --- BETX(  784) =     62.98550    BETY( 1183) =     81.89465     XEQ(  860) =     2.16410     YEQ( 1421) =       0.00000
MINIMA    --- BETX( 1060) =      9.81673    BETY(  710) =      9.57097     XEQ(  729) =     0.00060     YEQ( 1421) =       0.00000
--------------------------------------------------------------------------------------------------------------------------------

***           FIN    0    0  // CORE USE SUMMARY                       MAXIMUM                   USED          UNUSED
                                  STORE  (ELEMENT STORAGE)              24000  (LMAX)            6583             17417
                                  INFF   (ELEMENT DEFINITIONS)           1000  (MAX)               96               904

================================================================================================================================
END OF SYNCH RUN  MI_b
```

APPENDIX E

Civil Construction Drawings

FERMILAB UPGRADE: MAIN INJECTOR



LIST OF DRAWINGS

CDR-1	LOCATION PLAN AND LIST OF DRAWINGS
CDR-2	AERIAL PHOTOGRAPH
CDR-3	AERIAL PERSPECTIVE
CDR-4	EXISTING CONDITIONS
CDR-5	DRAINAGE AND WETLANDS
CDR-6	SITE PLAN
CDR-7	CRITERIA SITE PLAN
CDR-8	ENLARGED SITE PLAN M.I.
CDR-9	EXCAVATION SECTIONS
CDR-10	BEAMLINE PLANS
CDR-11	F-0, MI-70 AND INJECTION BEAMLINES
CDR-12	ENCLOSURE SECTIONS
CDR-13	8 GeV BEAMLINE SHT.1
CDR-14	8 GeV BEAMLINE SHT.2
CDR-15	8 GeV BEAMLINE SHT.3
CDR-16	8 GeV BEAMLINE SHT.4
CDR-17	8 GeV BEAMLINE SHT.5
CDR-18	8 GeV BEAMLINE SHT.6
CDR-19	TYPICAL SERVICE BUILDING PLAN
CDR-20	TYPICAL SERVICE BUILDING SECTIONS
CDR-21	RF/FO & RF/MI-70 SERVICE BUILDING PLAN
CDR-22	RF/FO & RF/MI-70 SERVICE BUILDING SECTION
CDR-23	NORTH HATCH BUILDING
CDR-24	MECHANICAL CRITERIA HVAC AND FIRE PROTECTION
CDR-25	HVAC PLANS
CDR-26	MECHANICAL CRITERIA PROCESS SYSTEMS
CDR-27	PROCESS SYSTEMS FLOW DIAGRAMS
CDR-28	345-13.8KV SINGLE LINE DIAGRAM
CDR-29	SINGLE LINE POWER DISTRIBUTION DIAGRAM
CDR-30	POWER AND COMMUNICATION DUCT PLAN
CDR-31	SITE PLAN-ELECTRICAL CRITERIA
CDR-32	ENCLOSURE PLAN-ELECTRICAL CRITERIA
CDR-33	INDUSTRIAL BUILDING NO.5

LOCATION PLAN

SCALE : 1" = 800'-0"

PROJECT NORTH

1" 800'-0" 800 0 800 1600 Scale Feet

REV.	DATE	DESCRIPTIONS
		REVISIONS
DESIGNED	C. FEDEROWICZ	
DRAWN	C. FEDEROWICZ	
CHECKED		
APPROVED		
SUBMITTED		

FERMI NATIONAL ACCELERATOR LABORATORY

UNITED STATES DEPARTMENT OF ENERGY

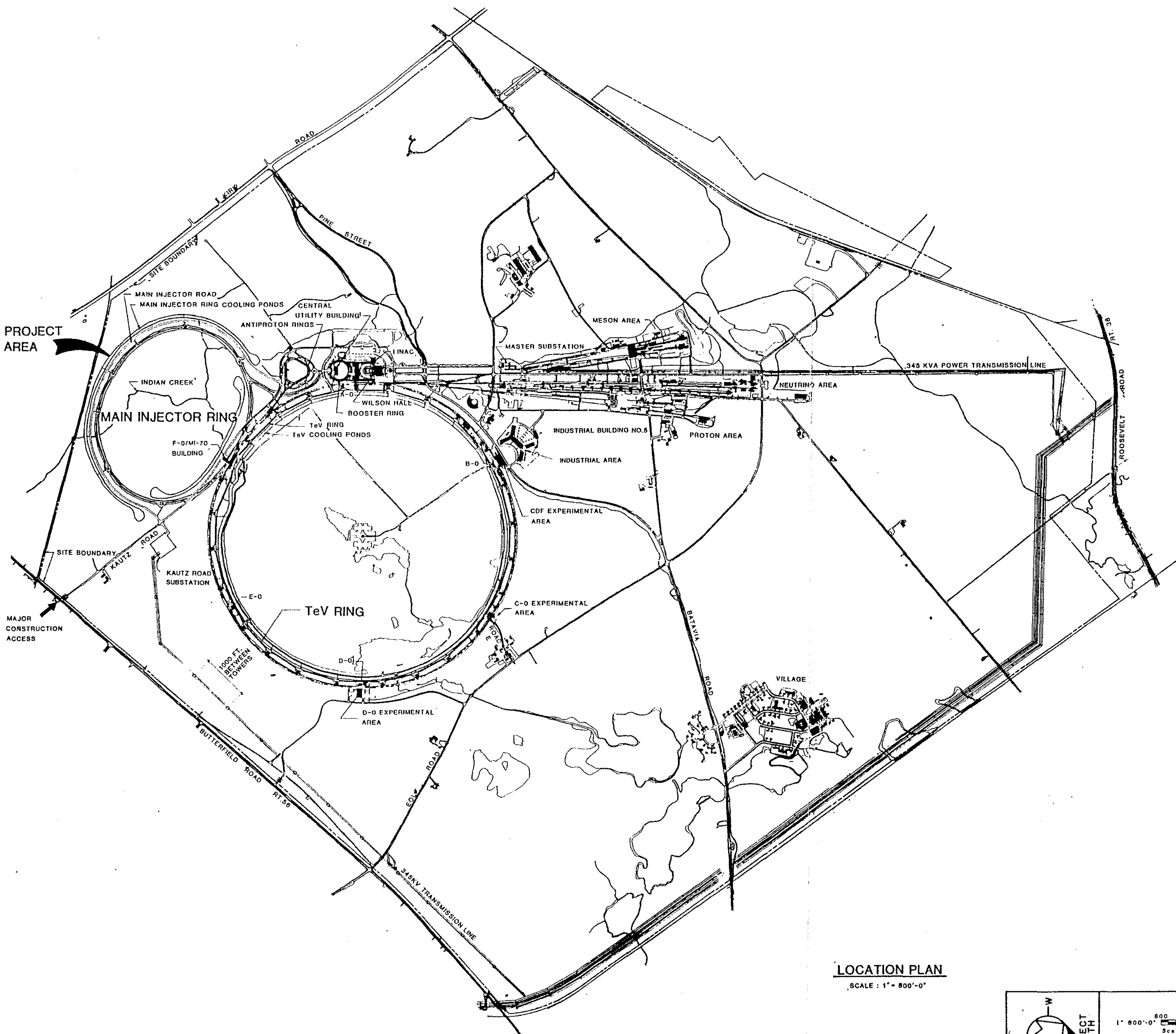
FERMILAB UPGRADE : MAIN INJECTOR

LOCATION PLAN AND LIST OF DRAWINGS

DRAWING NO. 6-6-1 CDR-1 REV.

JAN. 1990

FERMILAB UPGRADE: MAIN INJECTOR



LOCATION PLAN

SCALE : 1" = 800'-0"

LIST OF DRAWINGS

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CDR-18	8 GeV BEAMLINE SHT.6
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CDR-22	RF/F0 & RF/MI-70 SERVICE BUILDING SECTION
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REV.	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED	C. FEDEROWICZ
DRAWN	C. FEDEROWICZ
CHECKED	
APPROVED	
SUBMITTED	

PROJECT NORTH

1" 800'-0" Scale 800 0 800 1600 Feet

FERMI NATIONAL ACCELERATOR LABORATORY

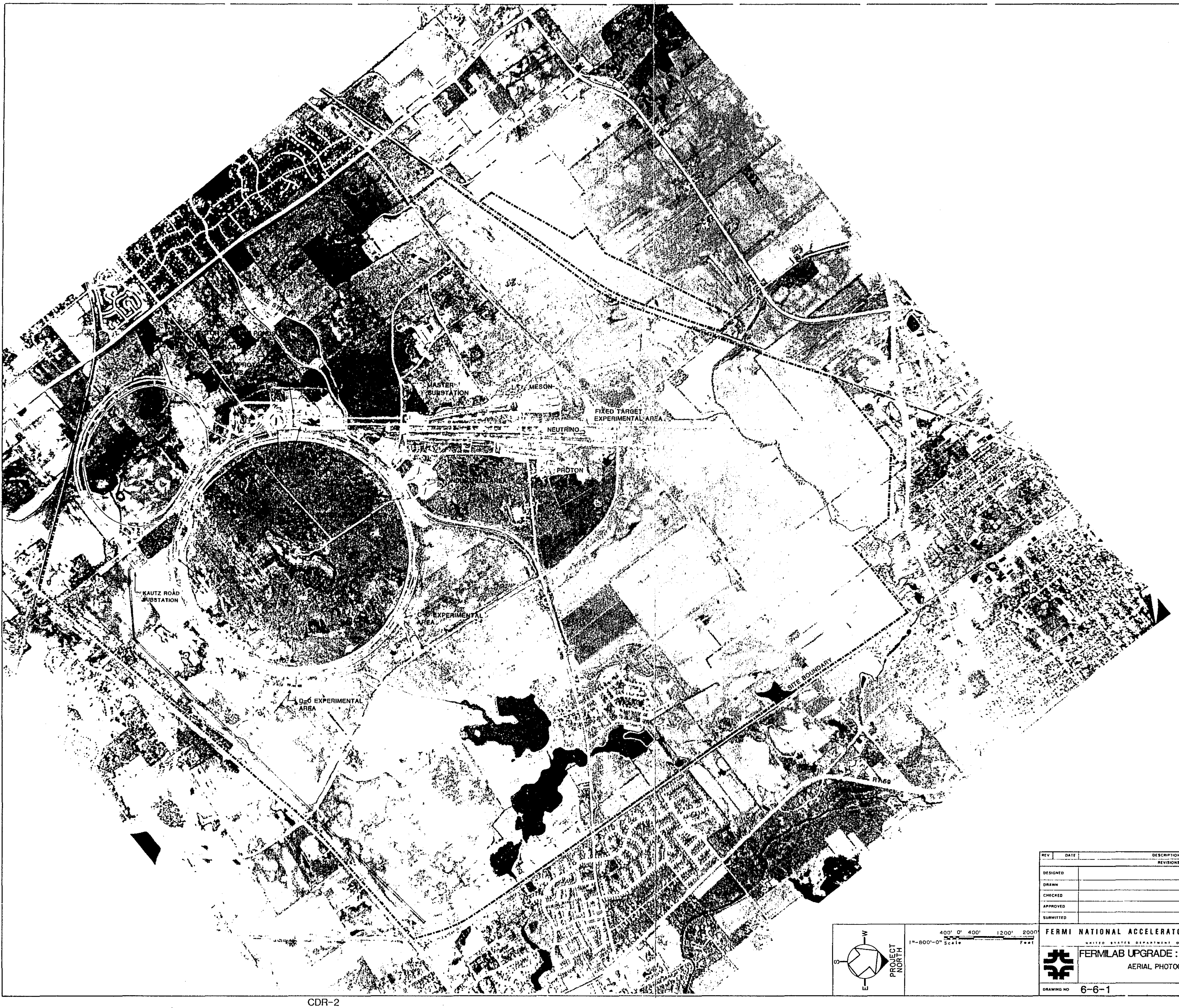
UNITED STATES DEPARTMENT OF ENERGY

FERMILAB UPGRADE : MAIN INJECTOR

LOCATION PLAN AND LIST OF DRAWINGS

DRAWING NO. 6-6-1 CDR-1 REV.

JAN. 1990



REV	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED		
DRAWN		
CHECKED		
APPROVED		
SUBMITTED		

FERMI NATIONAL ACCELERATOR LABORATORY

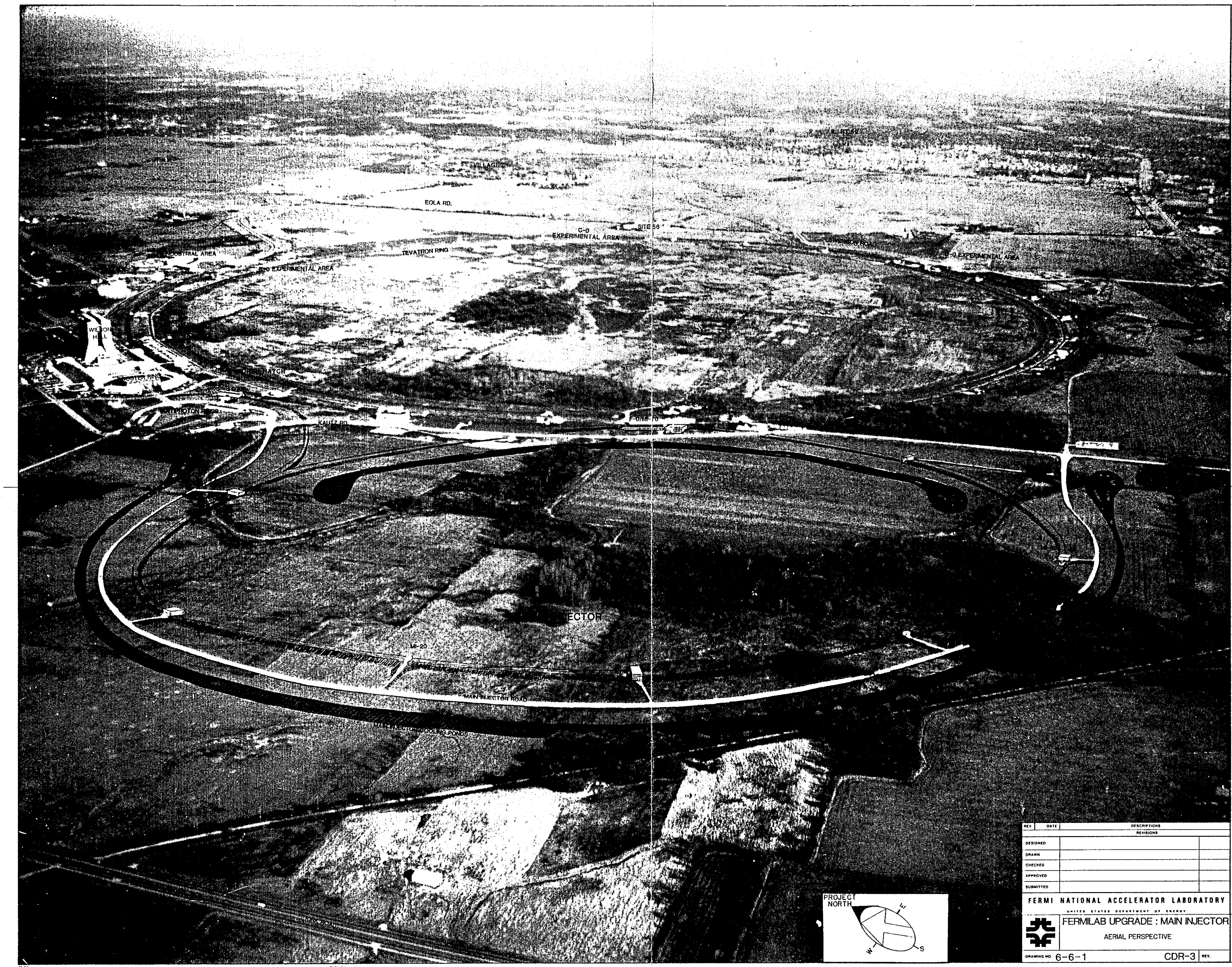
UNITED STATES DEPARTMENT OF ENERGY

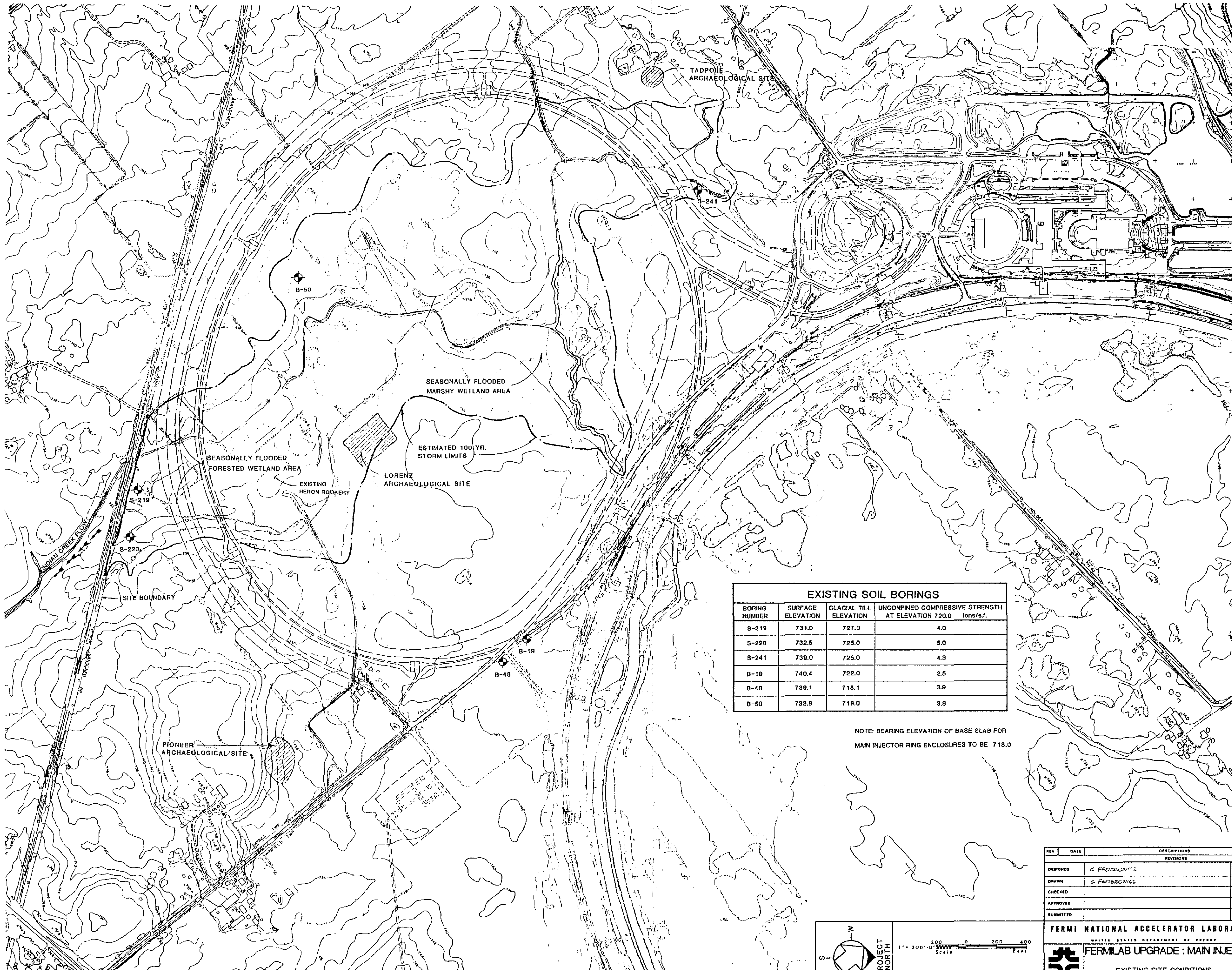
FERMILAB UPGRADE : MAIN INJECTOR

AERIAL PHOTOGRAPH

JAN. 1990

DRAWING NO 6-6-1 CDR-2 REV


EOLA RD.
C-0
EXPERIMENTAL AREA
TEVATRON RING
WILSON HALL
KAUTZ RD.
M-20
MAIN INJECTOR ROAD
PROJECT NORTH
E
W
S
REV
DATE
DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
AERIAL PERSPECTIVE
DRAWING NO 6-6-1
CDR-3
REV.
JAN. 1990



EXISTING SOIL BORINGS

BORING NUMBER	SURFACE ELEVATION	GLACIAL TILL ELEVATION	UNCONFINED COMPRESSIVE STRENGTH AT ELEVATION 720.0 tons/s.f.
S-219	731.0	727.0	4.0
S-220	732.5	725.0	5.0
S-241	739.0	725.0	4.3
B-19	740.4	722.0	2.5
B-48	739.1	718.1	3.9
B-50	733.8	719.0	3.8

NOTE: BEARING ELEVATION OF BASE SLAB FOR MAIN INJECTOR RING ENCLOSURES TO BE 718.0

REV	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED	C FEDEROWICZ	
DRAWN	C FEDEROWICZ	
CHECKED		
APPROVED		
SUBMITTED		

FERMI NATIONAL ACCELERATOR LABORATORY

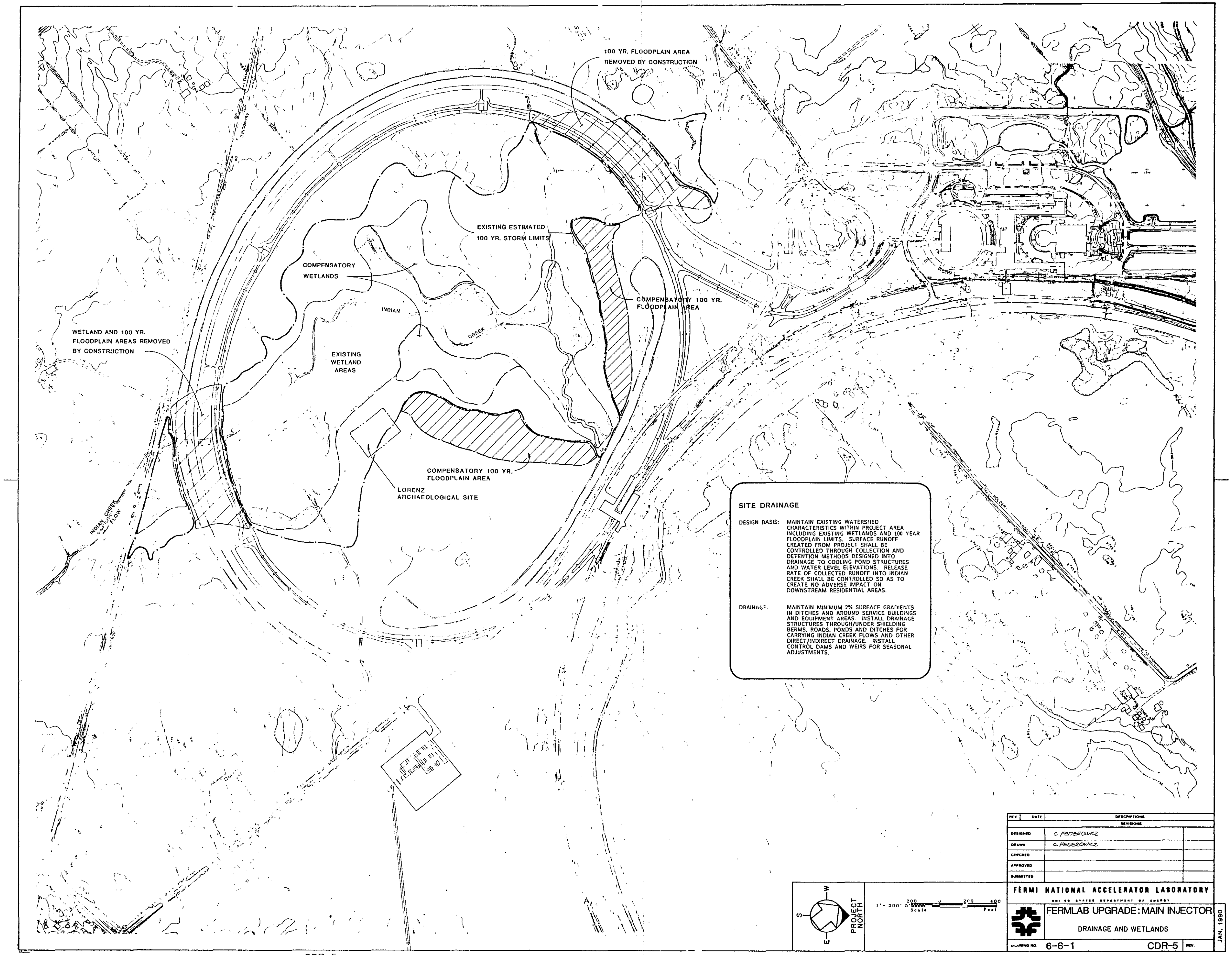
UNITED STATES DEPARTMENT OF ENERGY

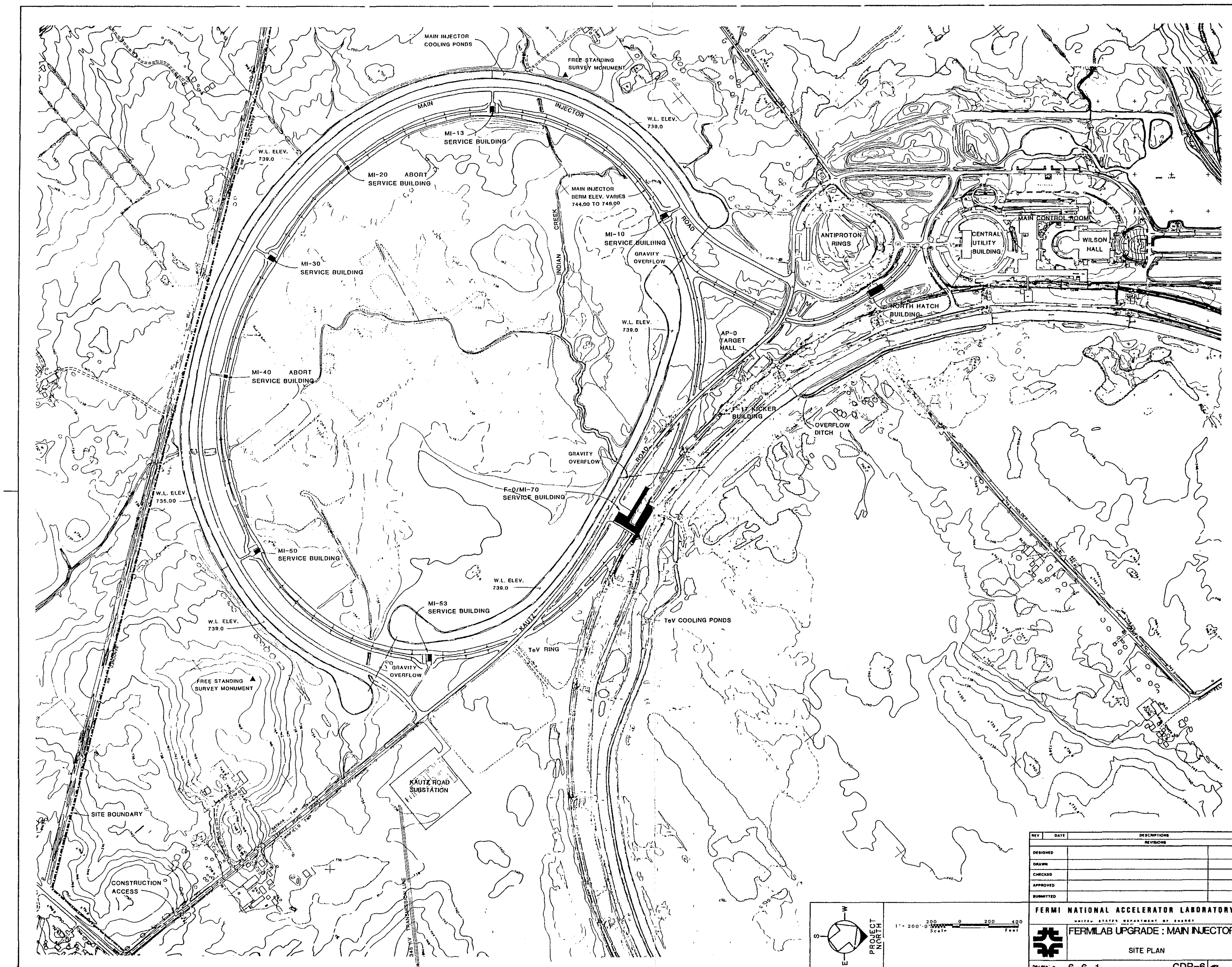
FERMILAB UPGRADE : MAIN INJECTOR

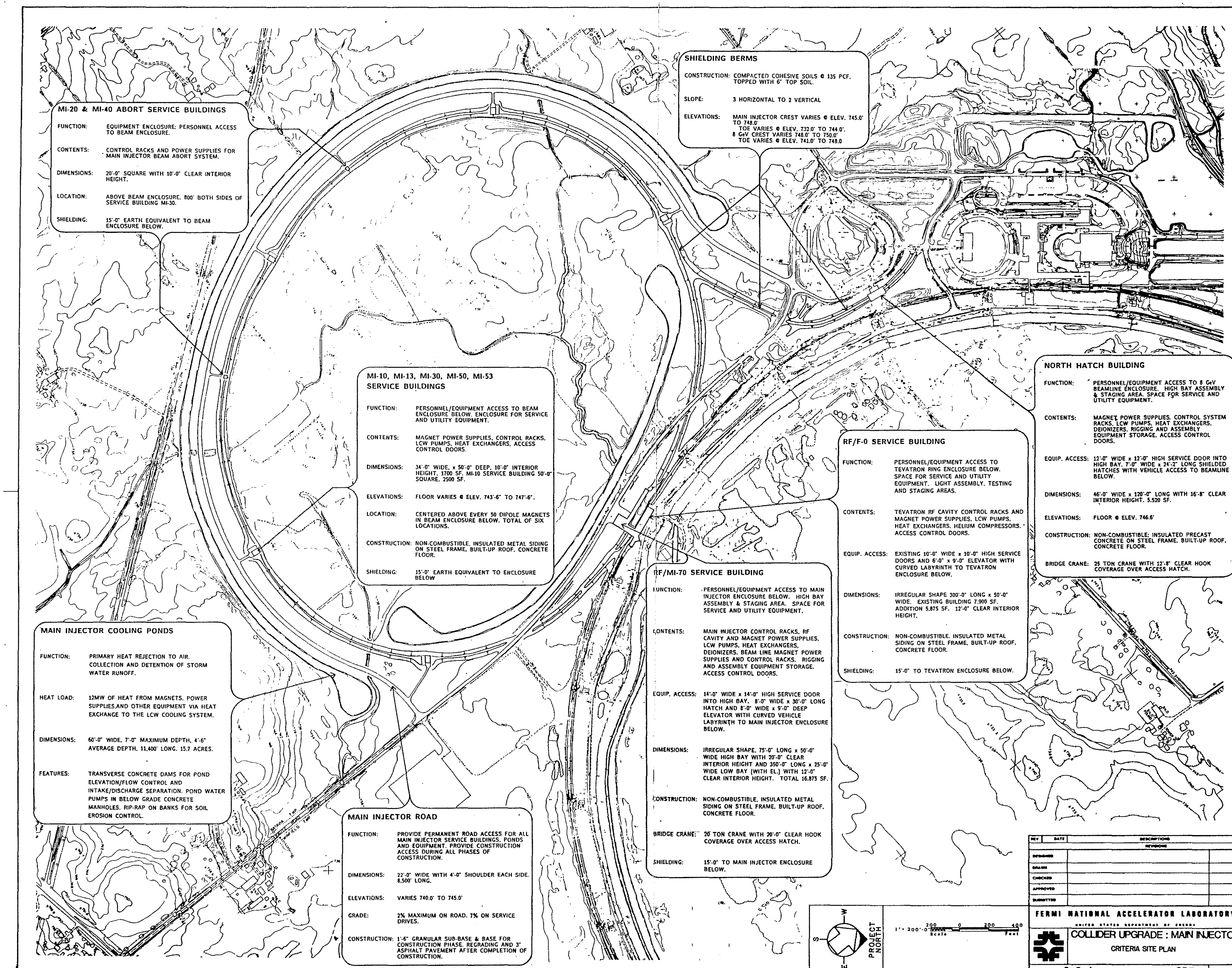
EXISTING SITE CONDITIONS

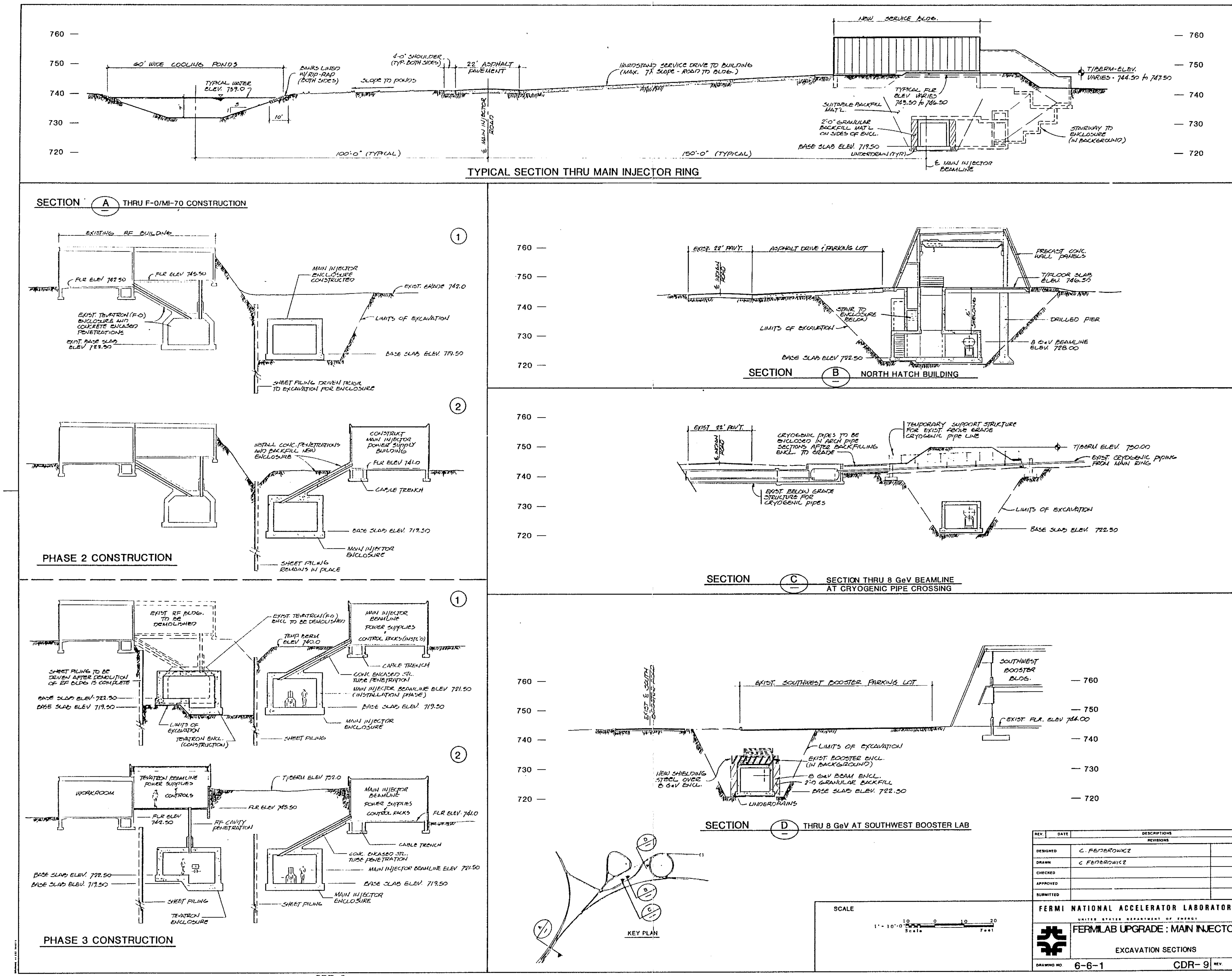
JAN. 1990

DRAWING NO. 6-6-1 CDR-4 REV.

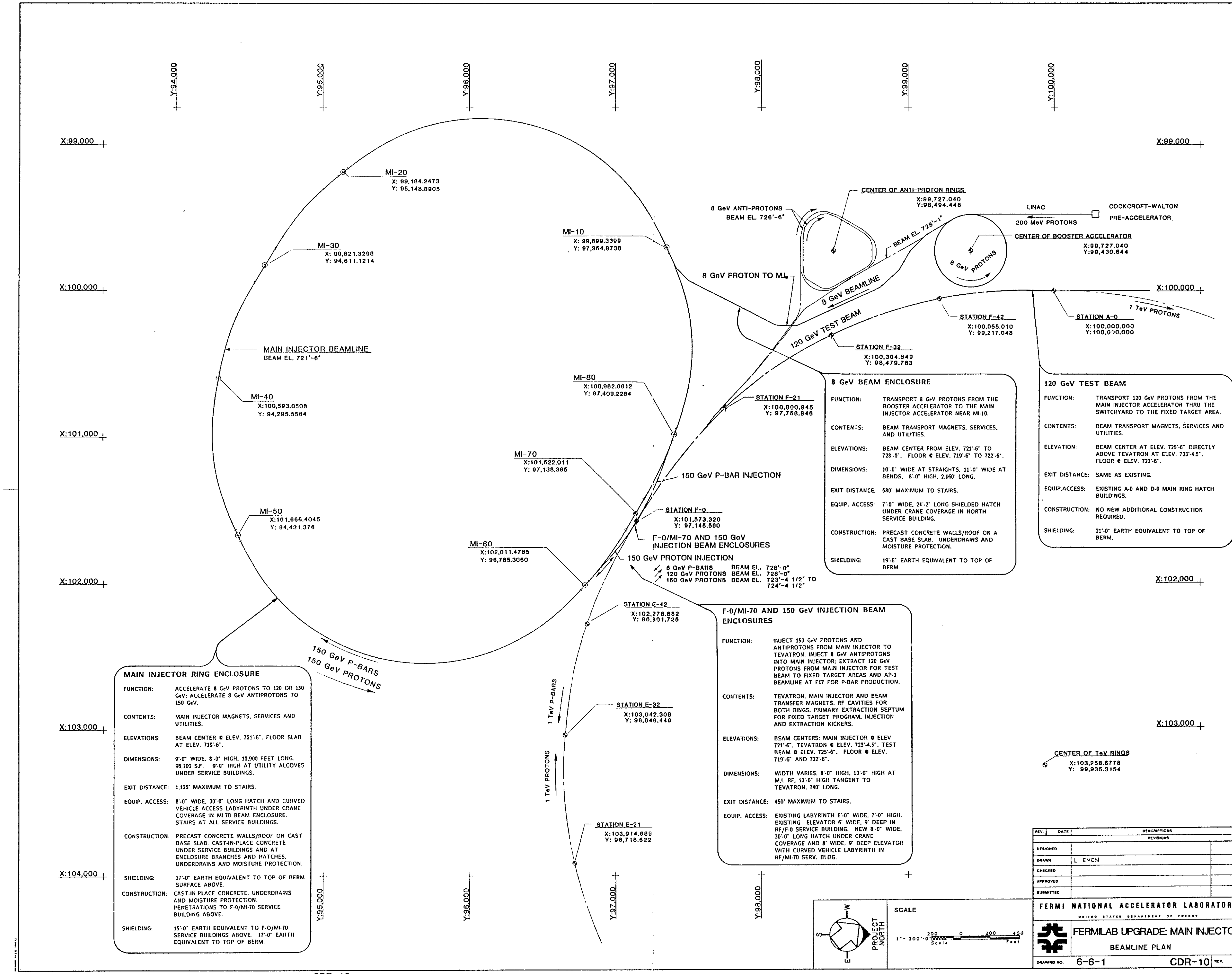

100 YR. FLOODPLAIN AREA
REMOVED BY CONSTRUCTION
EXISTING ESTIMATED
100 YR. STORM LIMITS
COMPENSATORY
WETLANDS
COMPENSATORY 100 YR.
FLOODPLAIN AREA
INDIAN
CREEK
WETLAND AND 100 YR.
FLOODPLAIN AREAS REMOVED
BY CONSTRUCTION
EXISTING
WETLAND
AREAS
COMPENSATORY 100 YR.
FLOODPLAIN AREA
LORENZ
ARCHAEOLOGICAL SITE
INDIAN CREEK
FLOW
SITE DRAINAGE
DESIGN BASIS: MAINTAIN EXISTING WATERSHED CHARACTERISTICS WITHIN PROJECT AREA INCLUDING EXISTING WETLANDS AND 100 YEAR FLOODPLAIN LIMITS. SURFACE RUNOFF CREATED FROM PROJECT SHALL BE CONTROLLED THROUGH COLLECTION AND DETENTION METHODS DESIGNED INTO DRAINAGE TO COOLING POND STRUCTURES AND WATER LEVEL ELEVATIONS. RELEASE RATE OF COLLECTED RUNOFF INTO INDIAN CREEK SHALL BE CONTROLLED SO AS TO CREATE NO ADVERSE IMPACT ON DOWNSTREAM RESIDENTIAL AREAS.
DRAINAGE: MAINTAIN MINIMUM 2% SURFACE GRADIENTS IN DITCHES AND AROUND SERVICE BUILDINGS AND EQUIPMENT AREAS. INSTALL DRAINAGE STRUCTURES THROUGH/UNDER SHIELDING BERMS, ROADS, PONDS AND DITCHES FOR CARRYING INDIAN CREEK FLOWS AND OTHER DIRECT/INDIRECT DRAINAGE. INSTALL CONTROL DAMS AND WEIRS FOR SEASONAL ADJUSTMENTS.
W
S
E
PROJECT NORTH
1" = 200'-0"
200 0 200 400
Scale Feet
REV DATE DESCRIPTIONS
REVISIONS
DESIGNED C FEDEROWICZ
DRAWN C. FEDEROWICZ
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
FERMLAB UPGRADE: MAIN INJECTOR
DRAINAGE AND WETLANDS
DRAWING NO. 6-6-1
CDR-5
REV.
JAN. 1990


MAIN INJECTOR COOLING PONDS
FREE STANDING SURVEY MONUMENT
MAIN
INJECTOR
W.L. ELEV. 739.0
MI-13 SERVICE BUILDING
MI-20 ABORT SERVICE BUILDING
MAIN INJECTOR BERM ELEV. VARIES 744.00 TO 746.00
INDIAN CREEK
ROAD
MI-10 SERVICE BUILDING
GRAVITY OVERFLOW
MI-30 SERVICE BUILDING
ANTIPROTON RINGS
CENTRAL UTILITY BUILDING
MAIN CONTROL ROOM
WILSON HALL
NORTH HATCH BUILDING
AP-0 TARGET HALL
MI-40 ABORT SERVICE BUILDING
F-17 KICKER BUILDING
OVERFLOW DITCH
W.L. ELEV. 735.00
F-0/MI-70 SERVICE BUILDING
MI-50 SERVICE BUILDING
MI-53 SERVICE BUILDING
KAUTZ
TeV COOLING PONDS
TeV RING
FREE STANDING SURVEY MONUMENT
KAUTZ ROAD SUBSTATION
SITE BOUNDARY
CONSTRUCTION ACCESS
345 KV TRANSMISSION LINE
PROJECT NORTH
1" = 200'-0"
Scale
Feet
REV
DATE
DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
SITE PLAN
6-6-1
CDR-6
JAN. 1990


SHIELDING BERMS
CONSTRUCTION: COMPACTED COHESIVE SOILS @ 135 PCF, TOPPED WITH 6" TOP SOIL.
SLOPE: 3 HORIZONTAL TO 2 VERTICAL
ELEVATIONS: MAIN INJECTOR CREST VARIES @ ELEV. 745.0' TO 748.0' TOE VARIES @ ELEV. 732.0' TO 744.0', 8 GeV CREST VARIES 748.0' TO 750.0' TOE VARIES @ ELEV. 741.0' TO 748.0
MI-20 & MI-40 ABORT SERVICE BUILDINGS
FUNCTION: EQUIPMENT ENCLOSURE; PERSONNEL ACCESS TO BEAM ENCLOSURE.
CONTENTS: CONTROL RACKS AND POWER SUPPLIES FOR MAIN INJECTOR BEAM ABORT SYSTEM.
DIMENSIONS: 20'-0" SQUARE WITH 10'-0" CLEAR INTERIOR HEIGHT.
LOCATION: ABOVE BEAM ENCLOSURE, 800' BOTH SIDES OF SERVICE BUILDING MI-30.
SHIELDING: 15'-0" EARTH EQUIVALENT TO BEAM ENCLOSURE BELOW.
MI-10, MI-13, MI-30, MI-50, MI-53 SERVICE BUILDINGS
FUNCTION: PERSONNEL/EQUIPMENT ACCESS TO BEAM ENCLOSURE BELOW. ENCLOSURE FOR SERVICE AND UTILITY EQUIPMENT.
CONTENTS: MAGNET POWER SUPPLIES, CONTROL RACKS, LCW PUMPS, HEAT EXCHANGERS, ACCESS CONTROL DOORS.
DIMENSIONS: 34'-0" WIDE, x 50'-0" DEEP, 10'-0" INTERIOR HEIGHT. 1700 SF. MI-10 SERVICE BUILDING 50'-0" SQUARE. 2500 SF.
ELEVATIONS: FLOOR VARIES @ ELEV. 743'-6" TO 747'-6".
LOCATION: CENTERED ABOVE EVERY 50 DIPOLE MAGNETS IN BEAM ENCLOSURE BELOW. TOTAL OF SIX LOCATIONS.
CONSTRUCTION: NON-COMBUSTIBLE, INSULATED METAL SIDING ON STEEL FRAME, BUILT-UP ROOF, CONCRETE FLOOR.
SHIELDING: 15'-0" EARTH EQUIVALENT TO ENCLOSURE BELOW
NORTH HATCH BUILDING
FUNCTION: PERSONNEL/EQUIPMENT ACCESS TO 8 GeV BEAMLINE ENCLOSURE. HIGH BAY ASSEMBLY & STAGING AREA. SPACE FOR SERVICE AND UTILITY EQUIPMENT.
CONTENTS: MAGNET POWER SUPPLIES, CONTROL SYSTEM RACKS, LCW PUMPS, HEAT EXCHANGERS, DEIONIZERS, RIGGING AND ASSEMBLY EQUIPMENT STORAGE, ACCESS CONTROL DOORS.
EQUIP. ACCESS: 12'-0" WIDE x 12'-0" HIGH SERVICE DOOR INTO HIGH BAY. 7'-0" WIDE x 24'-2" LONG SHIELDED HATCHES WITH VEHICLE ACCESS TO BEAMLINE BELOW.
DIMENSIONS: 46'-0" WIDE x 120'-0" LONG WITH 16'-8" CLEAR INTERIOR HEIGHT. 5,520 SF.
ELEVATIONS: FLOOR @ ELEV. 746.6'
CONSTRUCTION: NON-COMBUSTIBLE; INSULATED PRECAST CONCRETE ON STEEL FRAME, BUILT-UP ROOF, CONCRETE FLOOR.
BRIDGE CRANE: 25 TON CRANE WITH 12'-8" CLEAR HOOK COVERAGE OVER ACCESS HATCH.
RF/F-0 SERVICE BUILDING
FUNCTION: PERSONNEL/EQUIPMENT ACCESS TO TEVATRON RING ENCLOSURE BELOW. SPACE FOR SERVICE AND UTILITY EQUIPMENT. LIGHT ASSEMBLY, TESTING AND STAGING AREAS.
CONTENTS: TEVATRON RF CAVITY CONTROL RACKS AND MAGNET POWER SUPPLIES. LCW PUMPS, HEAT EXCHANGERS. HELIUM COMPRESSORS. ACCESS CONTROL DOORS.
EQUIP. ACCESS: EXISTING 10'-0" WIDE x 10'-0" HIGH SERVICE DOORS AND 6'-0" x 9'-0" ELEVATOR WITH CURVED LABYRINTH TO TEVATRON ENCLOSURE BELOW.
DIMENSIONS: IRREGULAR SHAPE 300'-0" LONG x 50'-0" WIDE. EXISTING BUILDING 7,900 SF. ADDITION 5,875 SF. 12'-0" CLEAR INTERIOR HEIGHT.
CONSTRUCTION: NON-COMBUSTIBLE, INSULATED METAL SIDING ON STEEL FRAME, BUILT-UP ROOF, CONCRETE FLOOR.
SHIELDING: 15'-0" TO TEVATRON ENCLOSURE BELOW.
RF/MI-70 SERVICE BUILDING
FUNCTION: PERSONNEL/EQUIPMENT ACCESS TO MAIN INJECTOR ENCLOSURE BELOW. HIGH BAY ASSEMBLY & STAGING AREA. SPACE FOR SERVICE AND UTILITY EQUIPMENT.
CONTENTS: MAIN INJECTOR CONTROL RACKS, RF CAVITY AND MAGNET POWER SUPPLIES. LCW PUMPS, HEAT EXCHANGERS, DEIONIZERS, BEAM LINE MAGNET POWER SUPPLIES AND CONTROL RACKS. RIGGING AND ASSEMBLY EQUIPMENT STORAGE. ACCESS CONTROL DOORS.
EQUIP. ACCESS: 14'-0" WIDE x 14'-0" HIGH SERVICE DOOR INTO HIGH BAY. 8'-0" WIDE x 30'-0" LONG HATCH AND 8'-0" WIDE x 9'-0" DEEP ELEVATOR WITH CURVED VEHICLE LABYRINTH TO MAIN INJECTOR ENCLOSURE BELOW.
DIMENSIONS: IRREGULAR SHAPE, 75'-0" LONG x 50'-0" WIDE HIGH BAY WITH 20'-0" CLEAR INTERIOR HEIGHT AND 350'-0" LONG x 25'-0" WIDE LOW BAY (WITH EL.) WITH 12'-0" CLEAR INTERIOR HEIGHT. TOTAL 16,875 SF.
CONSTRUCTION: NON-COMBUSTIBLE, INSULATED METAL SIDING ON STEEL FRAME, BUILT-UP ROOF, CONCRETE FLOOR.
BRIDGE CRANE: 20 TON CRANE WITH 20'-0" CLEAR HOOK COVERAGE OVER ACCESS HATCH.
SHIELDING: 15'-0" TO MAIN INJECTOR ENCLOSURE BELOW.
MAIN INJECTOR COOLING PONDS
FUNCTION: PRIMARY HEAT REJECTION TO AIR. COLLECTION AND DETENTION OF STORM WATER RUNOFF.
HEAT LOAD: 12MW OF HEAT FROM MAGNETS, POWER SUPPLIES,AND OTHER EQUIPMENT VIA HEAT EXCHANGE TO THE LCW COOLING SYSTEM.
DIMENSIONS: 60'-0" WIDE, 7'-0" MAXIMUM DEPTH, 4'-6" AVERAGE DEPTH. 11,400' LONG. 15.7 ACRES.
FEATURES: TRANSVERSE CONCRETE DAMS FOR POND ELEVATION/FLOW CONTROL AND INTAKE/DISCHARGE SEPARATION. POND WATER PUMPS IN BELOW GRADE CONCRETE MANHOLES. RIP-RAP ON BANKS FOR SOIL EROSION CONTROL.
MAIN INJECTOR ROAD
FUNCTION: PROVIDE PERMANENT ROAD ACCESS FOR ALL MAIN INJECTOR SERVICE BUILDINGS, PONDS AND EQUIPMENT. PROVIDE CONSTRUCTION ACCESS DURING ALL PHASES OF CONSTRUCTION.
DIMENSIONS: 22'-0" WIDE WITH 4'-0" SHOULDER EACH SIDE. 8,500' LONG.
ELEVATIONS: VARIES 740.0' TO 745.0'
GRADE: 2% MAXIMUM ON ROAD. 7% ON SERVICE DRIVES.
CONSTRUCTION: 1'-6" GRANULAR SUB-BASE & BASE FOR CONSTRUCTION PHASE. REGRADING AND 3" ASPHALT PAVEMENT AFTER COMPLETION OF CONSTRUCTION.
PROJECT NORTH
1" = 200'-0"
200 0 200 400
Scale Feet
REV DATE DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
COLLIDER UPGRADE : MAIN INJECTOR
CRITERIA SITE PLAN
JAN. 1990
DRAWING NO. 6-6-1
CDR-7
REV.



TYPICAL SECTION THRU MAIN INJECTOR RING
NEW SERVICE BLDG.
60' WIDE COOLING PONDS
TYPICAL WATER ELEV. 739.0
BANKS LINED W/ RIP-RAP (BOTH SIDES)
SLOPE TO PONDS
4'-0" SHOULDER (TYP. BOTH SIDES)
22' ASPHALT PAVEMENT
HARDSTAND SERVICE DRIVE TO BUILDING (MAX. 7% SLOPE - ROAD TO BLDG.)
T/BERM ELEV. VARIES - 744.50 to 747.50
TYPICAL FLR ELEV VARIES 743.50 to 746.50
SUITABLE BACKFILL MAT'L.
2'-0" GRANULAR BACKFILL MAT'L ON SIDES OF ENCL.
BASE SLAB ELEV. 719.50
UNDERDRAIN (TYP.)
STAIRWAY TO ENCLOSURE (IN BACKGROUND)
℄ MAIN INJECTOR BEAMLINE
℄ MAIN INJECTOR ROAD
100'-0" (TYPICAL)
150'-0" (TYPICAL)
SECTION A THRU F-0/MI-70 CONSTRUCTION
EXISTING RF BUILDING
FLR ELEV 742.50
FLR ELEV 745.50
MAIN INJECTOR ENCLOSURE CONSTRUCTED
EXIST. GRADE 742.0
EXIST. TEVATRON (F-0) ENCLOSURE AND CONCRETE ENCASED PENETRATIONS
EXIST. BASE SLAB ELEV 722.50
LIMITS OF EXCAVATION
BASE SLAB ELEV. 719.50
SHEET PILING DRIVEN PRIOR TO EXCAVATION FOR ENCLOSURE
INSTALL CONC. PENETRATIONS AND BACKFILL NEW ENCLOSURE
CONSTRUCT MAIN INJECTOR POWER SUPPLY BUILDING
FLR ELEV 741.0
CABLE TRENCH
MAIN INJECTOR ENCLOSURE
SHEET PILING REMAINS IN PLACE
PHASE 2 CONSTRUCTION
EXIST. RF BLDG. TO BE DEMOLISHED
EXIST. TEVATRON (F-0) ENCL. TO BE DEMOLISHED
TEMP BERM ELEV 740.0
MAIN INJECTOR BEAMLINE POWER SUPPLIES & CONTROL RACKS (INST'D)
SHEET PILING TO BE DRIVEN AFTER DEMOLITION OF RF BLDG IS COMPLETE
BASE SLAB ELEV. 722.50
BASE SLAB ELEV 719.50
CONC. ENCASED STL. TUBE PENETRATION
MAIN INJECTOR BEAMLINE ELEV 721.50 (INSTALLATION PHASE)
LIMITS OF EXCAVATION
TEVATRON ENCL. (CONSTRUCTION)
SHEET PILING
WORKROOM
TEVATRON BEAMLINE POWER SUPPLIES & CONTROLS
T/BERM ELEV 752.0
FLR ELEV 745.50
FLR ELEV 742.50
RF CAVITY PENETRATION
MAIN INJECTOR BEAMLINE POWER SUPPLIES & CONTROL RACKS
FLR ELEV 741.0
MAIN INJECTOR BEAMLINE ELEV 721.50
BASE SLAB ELEV. 719.50
TEVATRON ENCLOSURE
PHASE 3 CONSTRUCTION
EXIST. 22' PAVT.
ASPHALT DRIVE & PARKING LOT
℄ INDIAN ROAD
PRECAST CONC. WALL PANELS
T/FLOOR SLAB ELEV 746.50
STAIR TO ENCLOSURE BELOW
LIMITS OF EXCAVATION
DRILLED PIER
8 GeV BEAMLINE ELEV. 728.00
BASE SLAB ELEV 722.50
SECTION B NORTH HATCH BUILDING
CRYOGENIC PIPES TO BE ENCLOSED IN ARCH PIPE SECTIONS AFTER BACKFILLING ENCL. TO GRADE
TEMPORARY SUPPORT STRUCTURE FOR EXIST. ABOVE GRADE CRYOGENIC PIPE LINE
T/BERM ELEV. 750.00
EXIST. CRYOGENIC PIPING FROM MAIN RING
EXIST. BELOW GRADE STRUCTURE FOR CRYOGENIC PIPES
LIMITS OF EXCAVATION
BASE SLAB ELEV. 722.50
SECTION C SECTION THRU 8 GeV BEAMLINE AT CRYOGENIC PIPE CROSSING
EXIST. SOUTHWEST BOOSTER PARKING LOT
SOUTHWEST BOOSTER BLDG.
EXIST. FLR. ELEV 744.00
LIMITS OF EXCAVATION
EXIST. BOOSTER ENCL. (IN BACKGROUND)
NEW SHIELDING STEEL OVER 8 GeV ENCL.
8 GeV BEAM ENCL.
2'-0 GRANULAR BACKFILL
BASE SLAB ELEV. 722.50
UNDERDRAINS
SECTION D THRU 8 GeV AT SOUTHWEST BOOSTER LAB
KEY PLAN
SCALE
1" = 10'-0"
DESIGNED C. FEDEROWICZ
DRAWN C. FEDEROWICZ
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
EXCAVATION SECTIONS
DRAWING NO. 6-6-1
CDR-9
1 SEPT. 89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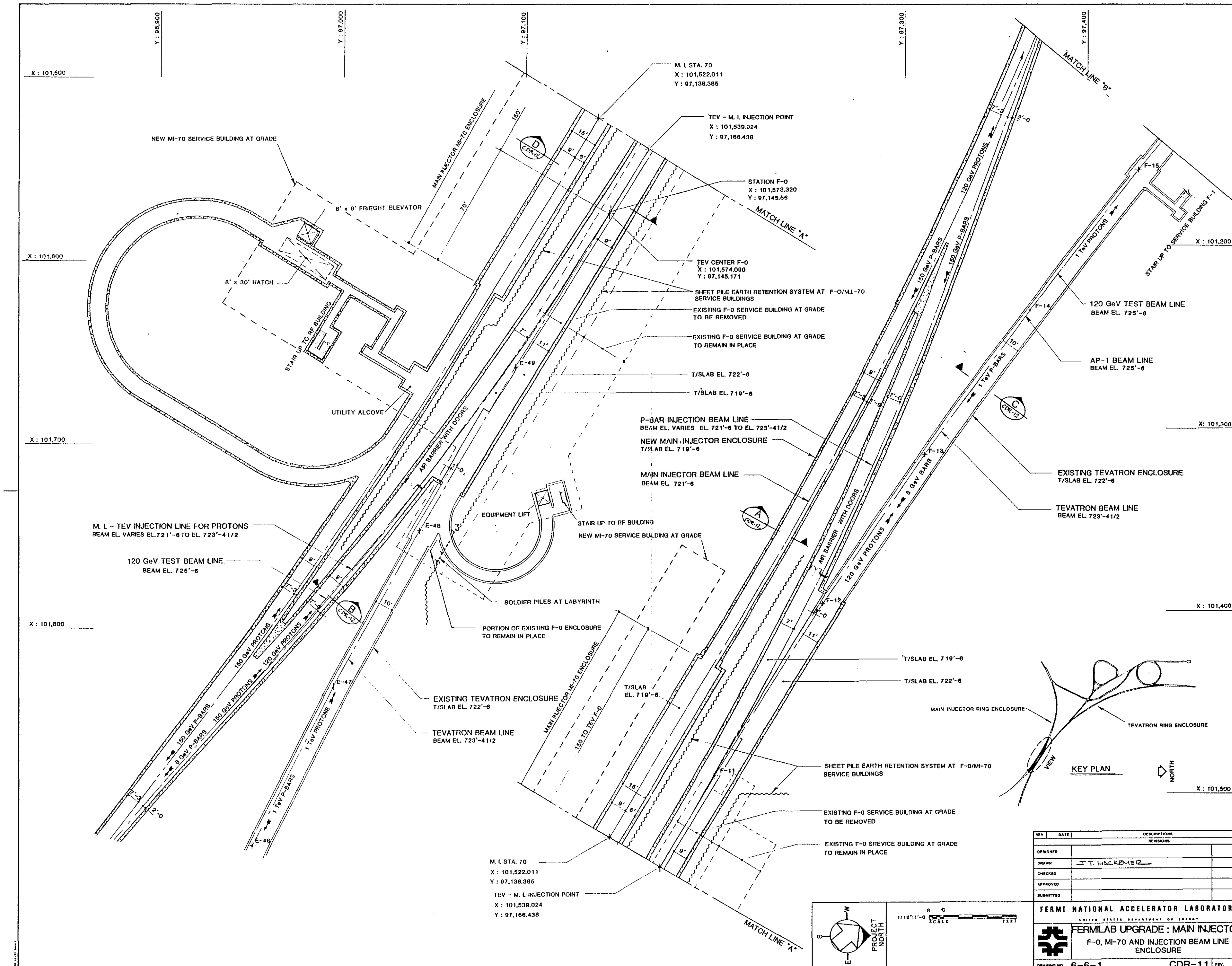
Y:95,000
Y:96,000
Y:97,000
Y:98,000
Y:99,000
Y:100,000
X:99,000
X:100,000
X:101,000
X:102,000
X:103,000
X:104,000
MI-20
X: 99,184.2473
Y: 95,148.8905
MI-30
X: 99,821.3298
Y: 94,611.1214
MI-10
X: 99,699.3399
Y: 97,354.6738
MAIN INJECTOR BEAMLINE
BEAM EL. 721'-6"
MI-40
X:100,593.0508
Y: 94,295.5564
MI-80
X:100,982.6612
Y: 97,409.2284
MI-70
X:101,522.011
Y: 97,138.385
MI-50
X:101,666.4045
Y: 94,431.376
MI-60
X:102,011.4785
Y: 96,785.3060
8 GeV ANTI-PROTONS
BEAM EL. 726'-6"
CENTER OF ANTI-PROTON RINGS
X:99,727.040
Y:98,494.448
LINAC
200 MeV PROTONS
COCKCROFT-WALTON
PRE-ACCELERATOR
BEAM EL. 728'-1"
CENTER OF BOOSTER ACCELERATOR
X:99,727.040
Y:99,430.644
8 GeV PROTONS
8 GeV PROTON TO M.I.
8 GeV BEAMLINE
120 GeV TEST BEAM
1 TeV PROTONS
STATION F-42
X:100,055.010
Y: 99,217.048
STATION A-0
X:100,000.000
Y:100,000.000
STATION F-32
X:100,304.849
Y: 98,479.763
STATION F-21
X:100,800.945
Y: 97,758.846
150 GeV P-BAR INJECTION
STATION F-0
X:101,573.320
Y: 97,146.580
F-0/MI-70 AND 150 GeV
INJECTION BEAM ENCLOSURES
150 GeV PROTON INJECTION
8 GeV P-BARS BEAM EL. 728'-0"
120 GeV PROTONS BEAM EL. 728'-0"
150 GeV PROTONS BEAM EL. 723'-4 1/2" TO 724'-4 1/2"
STATION E-42
X:102,278.882
Y: 96,901.725
150 GeV P-BARS
150 GeV PROTONS
1 TeV P-BARS
1 TeV PROTONS
STATION E-32
X:103,042.308
Y: 96,646.449
STATION E-21
X:103,814.689
Y: 96,718.622
CENTER OF TeV RINGS
X:103,258.6778
Y: 99,935.3154
8 GeV BEAM ENCLOSURE
FUNCTION: TRANSPORT 8 GeV PROTONS FROM THE BOOSTER ACCELERATOR TO THE MAIN INJECTOR ACCELERATOR NEAR MI-10.
CONTENTS: BEAM TRANSPORT MAGNETS. SERVICES. AND UTILITIES.
ELEVATIONS: BEAM CENTER FROM ELEV. 721'-6" TO 728'-0". FLOOR @ ELEV. 719'-6" TO 722'-6".
DIMENSIONS: 10'-0" WIDE AT STRAIGHTS. 11'-0" WIDE AT BENDS. 8'-0" HIGH. 2,060' LONG.
EXIT DISTANCE: 580' MAXIMUM TO STAIRS.
EQUIP. ACCESS: 7'-0" WIDE. 24'-2" LONG SHIELDED HATCH UNDER CRANE COVERAGE IN NORTH SERVICE BUILDING.
CONSTRUCTION: PRECAST CONCRETE WALLS/ROOF ON A CAST BASE SLAB. UNDERDRAINS AND MOISTURE PROTECTION.
SHIELDING: 19'-6" EARTH EQUIVALENT TO TOP OF BERM.
120 GeV TEST BEAM
FUNCTION: TRANSPORT 120 GeV PROTONS FROM THE MAIN INJECTOR ACCELERATOR THRU THE SWITCHYARD TO THE FIXED TARGET AREA.
CONTENTS: BEAM TRANSPORT MAGNETS. SERVICES AND UTILITIES.
ELEVATION: BEAM CENTER AT ELEV. 725'-6" DIRECTLY ABOVE TEVATRON AT ELEV. 723'-4.5". FLOOR @ ELEV. 722'-6".
EXIT DISTANCE: SAME AS EXISTING.
EQUIP.ACCESS: EXISTING A-0 AND D-0 MAIN RING HATCH BUILDINGS.
CONSTRUCTION: NO NEW ADDITIONAL CONSTRUCTION REQUIRED.
SHIELDING: 21'-0" EARTH EQUIVALENT TO TOP OF BERM.
MAIN INJECTOR RING ENCLOSURE
FUNCTION: ACCELERATE 8 GeV PROTONS TO 120 OR 150 GeV; ACCELERATE 8 GeV ANTIPROTONS TO 150 GeV.
CONTENTS: MAIN INJECTOR MAGNETS. SERVICES AND UTILITIES.
ELEVATIONS: BEAM CENTER @ ELEV. 721'-6". FLOOR SLAB AT ELEV. 719'-6".
DIMENSIONS: 9'-0" WIDE. 8'-0" HIGH. 10,900 FEET LONG. 98,100 S.F. 9'-0" HIGH AT UTILITY ALCOVES UNDER SERVICE BUILDINGS.
EXIT DISTANCE: 1,125' MAXIMUM TO STAIRS.
EQUIP. ACCESS: 8'-0" WIDE. 30'-0" LONG HATCH AND CURVED VEHICLE ACCESS LABYRINTH UNDER CRANE COVERAGE IN MI-70 BEAM ENCLOSURE. STAIRS AT ALL SERVICE BUILDINGS.
CONSTRUCTION: PRECAST CONCRETE WALLS/ROOF ON CAST BASE SLAB. CAST-IN-PLACE CONCRETE UNDER SERVICE BUILDINGS AND AT ENCLOSURE BRANCHES AND HATCHES. UNDERDRAINS AND MOISTURE PROTECTION.
SHIELDING: 17'-0" EARTH EQUIVALENT TO TOP OF BERM SURFACE ABOVE.
CONSTRUCTION: CAST-IN-PLACE CONCRETE. UNDERDRAINS AND MOISTURE PROTECTION. PENETRATIONS TO F-0/MI-70 SERVICE BUILDING ABOVE.
SHIELDING: 15'-0" EARTH EQUIVALENT TO F-0/MI-70 SERVICE BUILDINGS ABOVE. 17'-0" EARTH EQUIVALENT TO TOP OF BERM.
F-0/MI-70 AND 150 GeV INJECTION BEAM ENCLOSURES
FUNCTION: INJECT 150 GeV PROTONS AND ANTIPROTONS FROM MAIN INJECTOR TO TEVATRON. INJECT 8 GeV ANTIPROTONS INTO MAIN INJECTOR; EXTRACT 120 GeV PROTONS FROM MAIN INJECTOR FOR TEST BEAM TO FIXED TARGET AREAS AND AP-1 BEAMLINE AT F17 FOR P-BAR PRODUCTION.
CONTENTS: TEVATRON. MAIN INJECTOR AND BEAM TRANSFER MAGNETS. RF CAVITIES FOR BOTH RINGS. PRIMARY EXTRACTION SEPTUM FOR FIXED TARGET PROGRAM. INJECTION AND EXTRACTION KICKERS.
ELEVATIONS: BEAM CENTERS: MAIN INJECTOR @ ELEV. 721'-6". TEVATRON @ ELEV. 723'-4.5". TEST BEAM @ ELEV. 725'-6". FLOOR @ ELEV. 719'-6" AND 722'-6".
DIMENSIONS: WIDTH VARIES. 8'-0" HIGH. 10'-0" HIGH AT M.I. RF. 13'-0" HIGH TANGENT TO TEVATRON. 740' LONG.
EXIT DISTANCE: 450' MAXIMUM TO STAIRS.
EQUIP. ACCESS: EXISTING LABYRINTH 6'-0" WIDE. 7'-0" HIGH. EXISTING ELEVATOR 6' WIDE. 9' DEEP IN RF/F-0 SERVICE BUILDING. NEW 8'-0" WIDE. 30'-0" LONG HATCH UNDER CRANE COVERAGE AND 8' WIDE. 9' DEEP ELEVATOR WITH CURVED VEHICLE LABYRINTH IN RF/MI-70 SERV. BLDG.
PROJECT NORTH
SCALE
1" = 200'-0"
200 0 200 400
Scale Feet
REV. DATE DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN L. EVEN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE: MAIN INJECTOR
BEAMLINE PLAN
1.SEPT. 89
DRAWING NO. 6-6-1 CDR-10 REV.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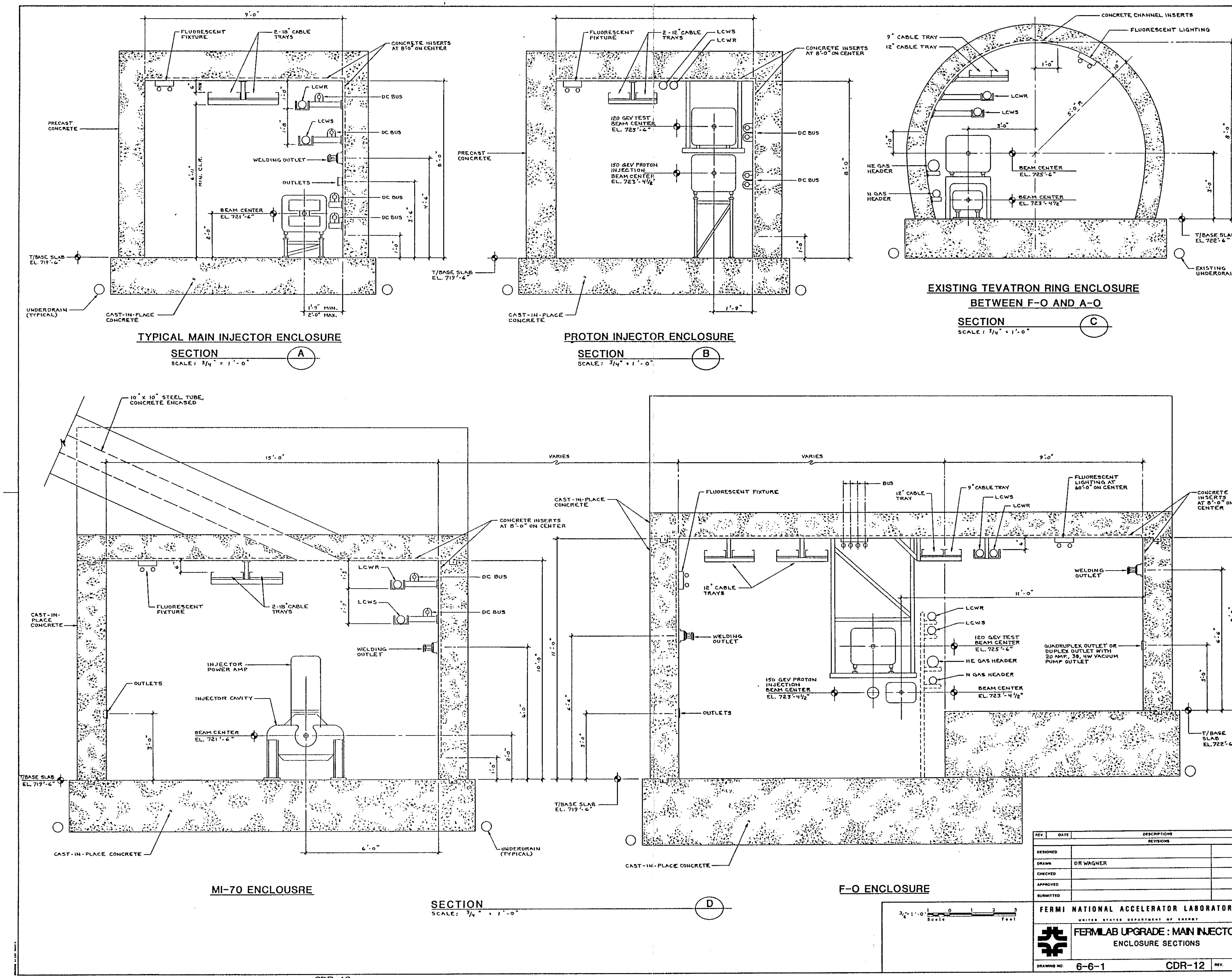
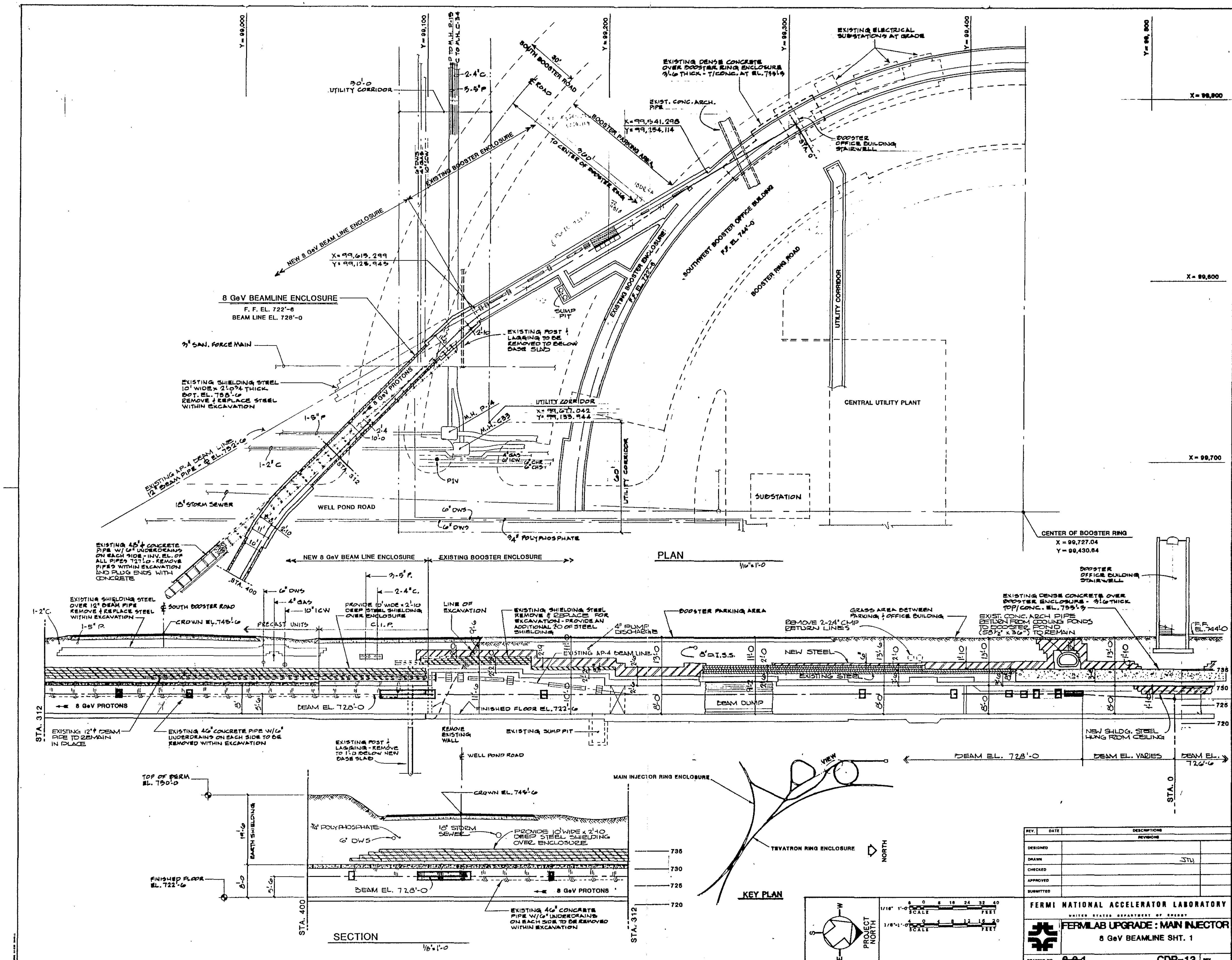
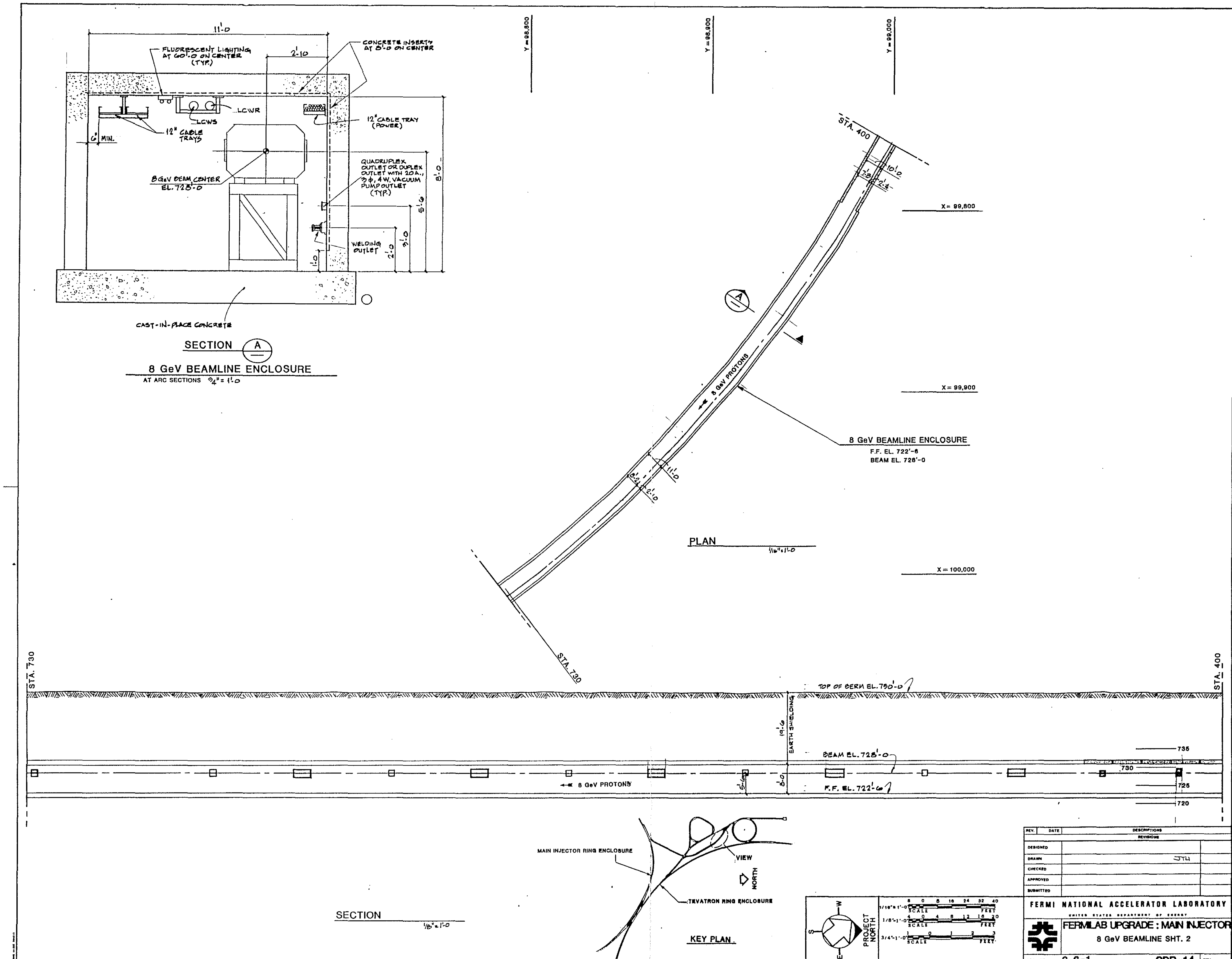
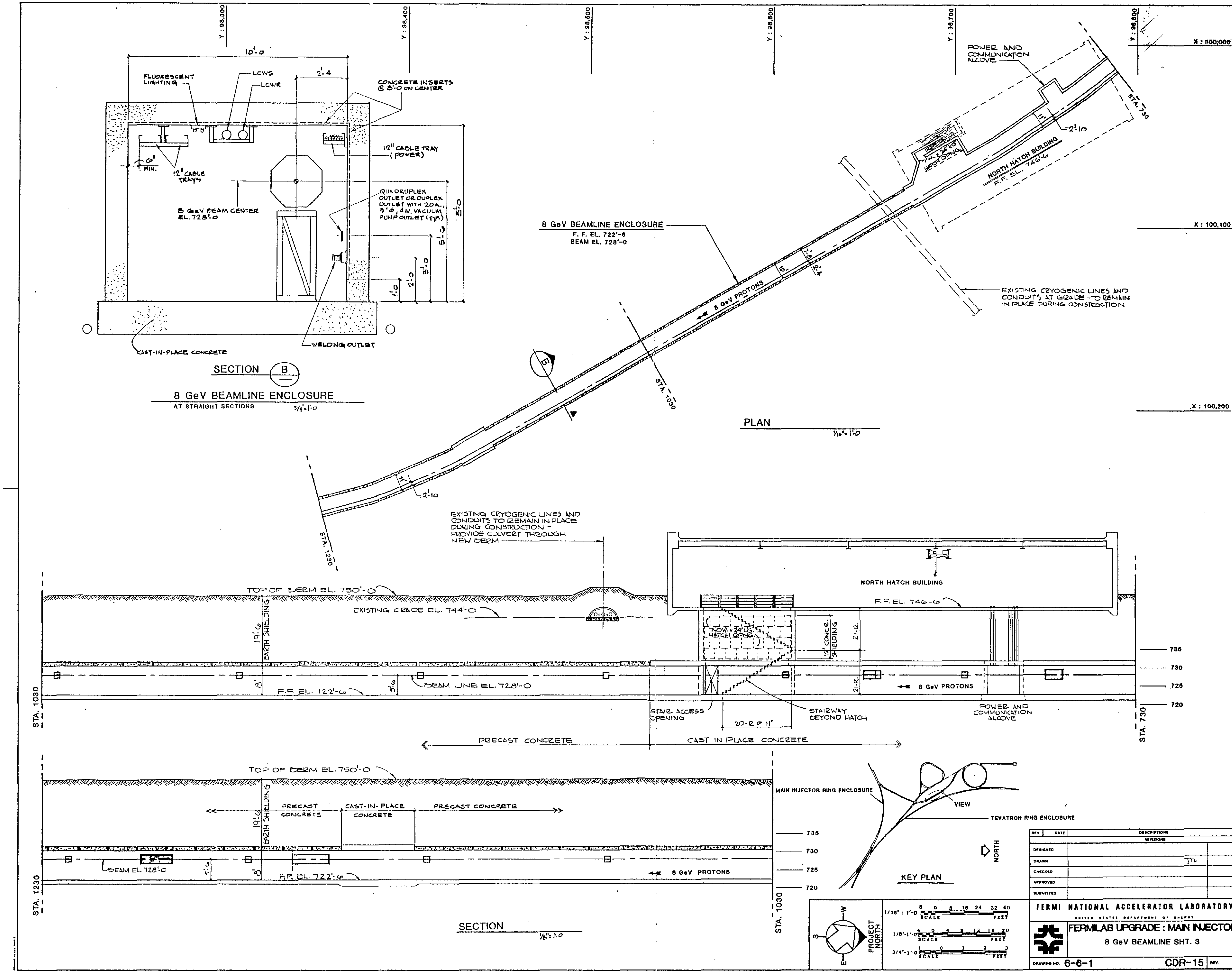
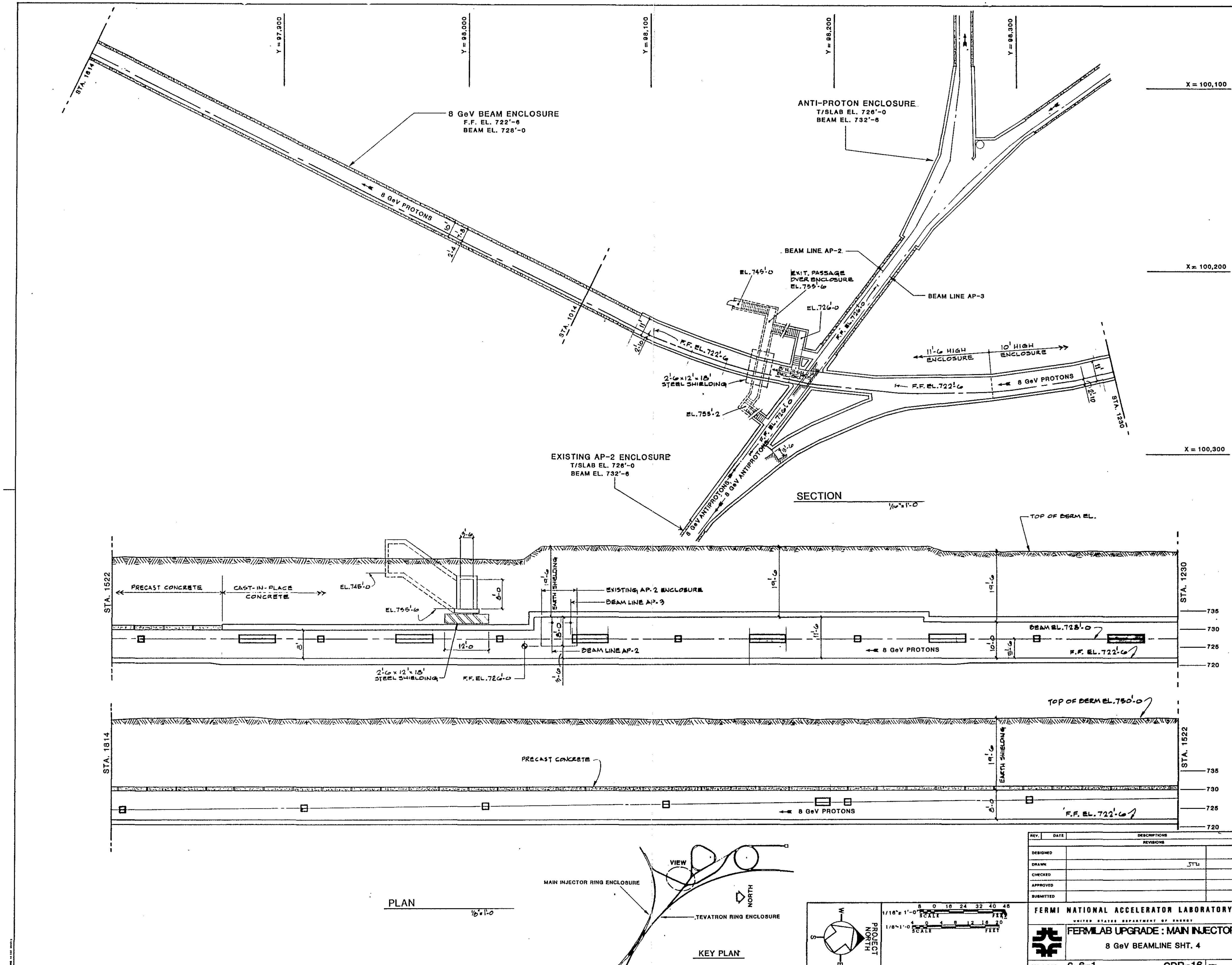
Y : 97,000
Y : 97,100
Y : 97,300
Y : 97,400
X : 101,500
X : 101,600
X : 101,700
X : 101,800
X : 101,200
X : 101,300
X : 101,400
X : 101,500
M. I. STA. 70
X : 101,522.011
Y : 97,138.385
TEV - M. I. INJECTION POINT
X : 101,539.024
Y : 97,166.436
STATION F-0
X : 101,573.320
Y : 97,145.56
TEV CENTER F-0
X : 101,574.090
Y : 97,145.171
MATCH LINE "A"
MATCH LINE "B"
NEW MI-70 SERVICE BUILDING AT GRADE
MAIN INJECTOR MI-70 ENCLOSURE
8' x 9' FRIEGHT ELEVATOR
8' x 30' HATCH
STAIR UP TO RF BUILDING
UTILITY ALCOVE
SHEET PILE EARTH RETENTION SYSTEM AT F-0/M.I.-70 SERVICE BUILDINGS
EXISTING F-0 SERVICE BUILDING AT GRADE TO BE REMOVED
EXISTING F-0 SERVICE BUILDING AT GRADE TO REMAIN IN PLACE
T/SLAB EL. 722'-6
T/SLAB EL. 719'-6
P-BAR INJECTION BEAM LINE
BEAM EL. VARIES EL. 721'-6 TO EL. 723'-41/2
NEW MAIN INJECTOR ENCLOSURE
T/SLAB EL. 719'-6
MAIN INJECTOR BEAM LINE
BEAM EL. 721'-6
EQUIPMENT LIFT
STAIR UP TO RF BUILDING
NEW MI-70 SERVICE BUILDING AT GRADE
AIR BARRIER WITH DOORS
M. I. - TEV INJECTION LINE FOR PROTONS
BEAM EL. VARIES EL.721'-6 TO EL. 723'-41/2
120 GeV TEST BEAM LINE
BEAM EL. 725'-6
SOLDIER PILES AT LABYRINTH
PORTION OF EXISTING F-0 ENCLOSURE TO REMAIN IN PLACE
EXISTING TEVATRON ENCLOSURE
T/SLAB EL. 722'-6
TEVATRON BEAM LINE
BEAM EL. 723'-41/2
150 GeV PROTONS
120 GeV PROTONS
150 GeV P-BARS
8 GeV P-BARS
1 TeV PROTONS
1 TeV P-BARS
150 TO TEV F-0
MAIN INJECTOR MI-70 ENCLOSURE
T/SLAB EL. 719'-6
E-46
E-47
E-48
E-49
F-11
F-12
F-13
F-14
F-15
STAIR UP TO SERVICE BUILDING F-1
120 GeV TEST BEAM LINE
BEAM EL. 725'-6
AP-1 BEAM LINE
BEAM EL. 725'-6
EXISTING TEVATRON ENCLOSURE
T/SLAB EL. 722'-6
TEVATRON BEAM LINE
BEAM EL. 723'-41/2
T/SLAB EL. 719'-6
T/SLAB EL. 722'-6
MAIN INJECTOR RING ENCLOSURE
TEVATRON RING ENCLOSURE
VIEW
KEY PLAN
NORTH
SHEET PILE EARTH RETENTION SYSTEM AT F-0/MI-70 SERVICE BUILDINGS
EXISTING F-0 SERVICE BUILDING AT GRADE TO BE REMOVED
EXISTING F-0 SREVICE BUILDING AT GRADE TO REMAIN IN PLACE
M. I. STA. 70
X : 101,522.011
Y : 97,138.385
TEV - M. I. INJECTION POINT
X : 101,539.024
Y : 97,166.436
MATCH LINE "A"
PROJECT NORTH
1/16":1'-0
SCALE
FEET
REV
DATE
DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
J. T. HACKEMER
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
F-0, MI-70 AND INJECTION BEAM LINE ENCLOSURE
1.SEPT. 89
DRAWING NO. 6-6-1
CDR-11
REV.

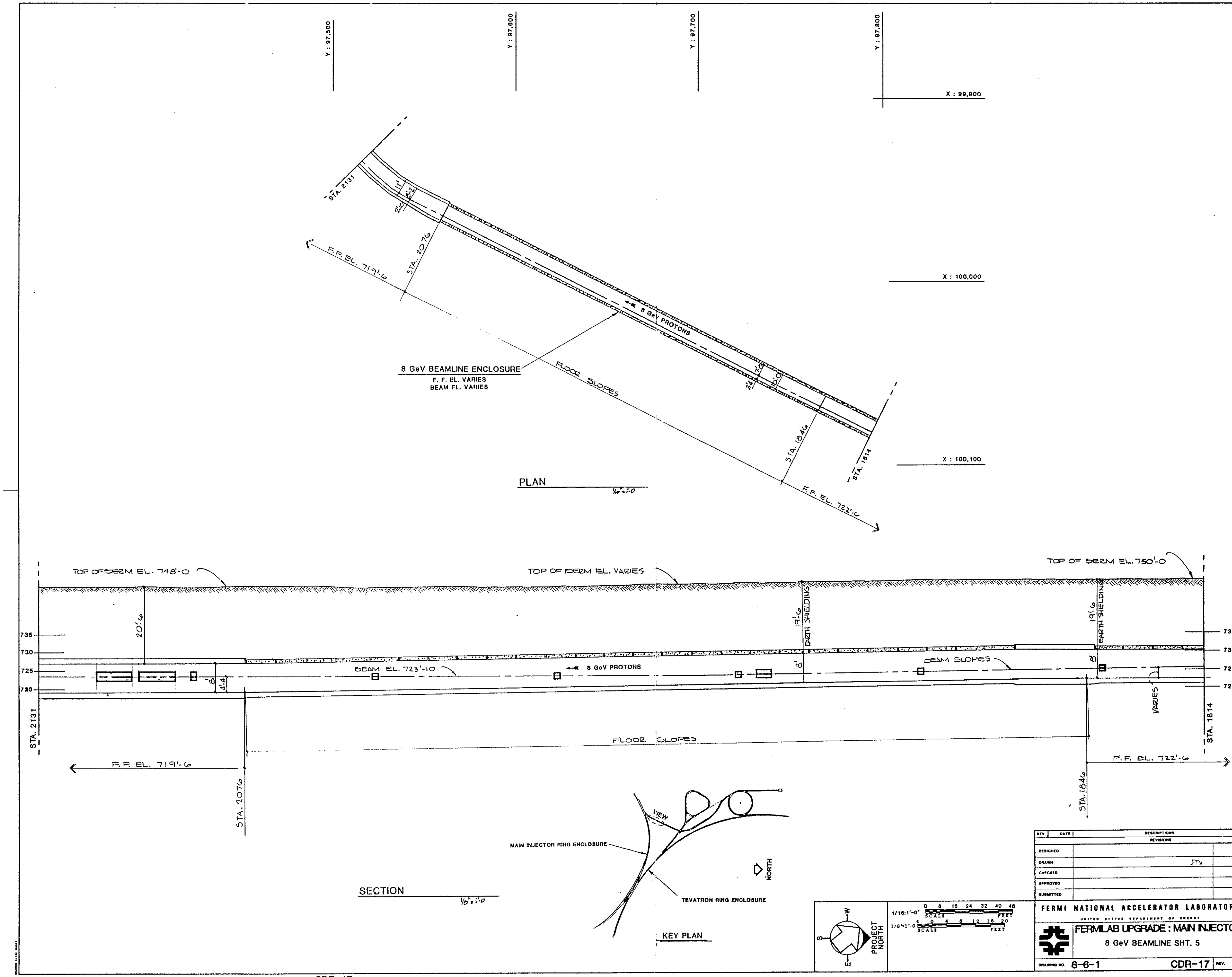

TYPICAL MAIN INJECTOR ENCLOSURE
SECTION A
SCALE: 3/4" = 1'-0"
FLUORESCENT FIXTURE
2-18" CABLE TRAYS
CONCRETE INSERTS AT 8'-0" ON CENTER
PRECAST CONCRETE
LCWR
LCWS
DC BUS
WELDING OUTLET
OUTLETS
BEAM CENTER EL. 721'-6"
MIN. CLR.
T/BASE SLAB EL. 719'-6"
UNDERDRAIN (TYPICAL)
CAST-IN-PLACE CONCRETE
1'-9" MIN.
2'-0" MAX.
9'-0"
PROTON INJECTOR ENCLOSURE
SECTION B
SCALE: 3/4" = 1'-0"
2-12" CABLE TRAYS
120 GEV TEST BEAM CENTER EL. 725'-6"
150 GEV PROTON INJECTION BEAM CENTER EL. 723'-4 1/2"
EXISTING TEVATRON RING ENCLOSURE
BETWEEN F-O AND A-O
SECTION C
SCALE: 3/4" = 1'-0"
CONCRETE CHANNEL INSERTS
FLUORESCENT LIGHTING
9" CABLE TRAY
12" CABLE TRAY
HE GAS HEADER
N GAS HEADER
BEAM CENTER EL. 725'-6"
BEAM CENTER EL. 723'-4 1/2"
T/BASE SLAB EL. 722'-6"
EXISTING UNDERDRAIN
10" x 10" STEEL TUBE, CONCRETE ENCASED
15'-0"
VARIES
CAST-IN-PLACE CONCRETE
INJECTOR POWER AMP
INJECTOR CAVITY
BEAM CENTER EL. 721'-6"
T/BASE SLAB EL. 719'-6"
UNDERDRAIN (TYPICAL)
6'-0"
MI-70 ENCLOUSRE
SECTION D
SCALE: 3/4" = 1'-0"
F-O ENCLOSURE
BUS
12" CABLE TRAY
9" CABLE TRAY
FLUORESCENT LIGHTING AT 60'-0" ON CENTER
12" CABLE TRAYS
QUADRUPLEX OUTLET OR DUPLEX OUTLET WITH 20 AMP, 30, 4W VACUUM PUMP OUTLET
11'-0"
T/BASE SLAB EL. 722'-6"
T/BASE SLAB EL. 719'-6"
DESIGNED
DRAWN DR WAGNER
CHECKED
APPROVED
SUBMITTED
REV. DATE DESCRIPTIONS REVISIONS
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
ENCLOSURE SECTIONS
DRAWING NO 6-6-1 CDR-12 REV.
1 SEPT. 89

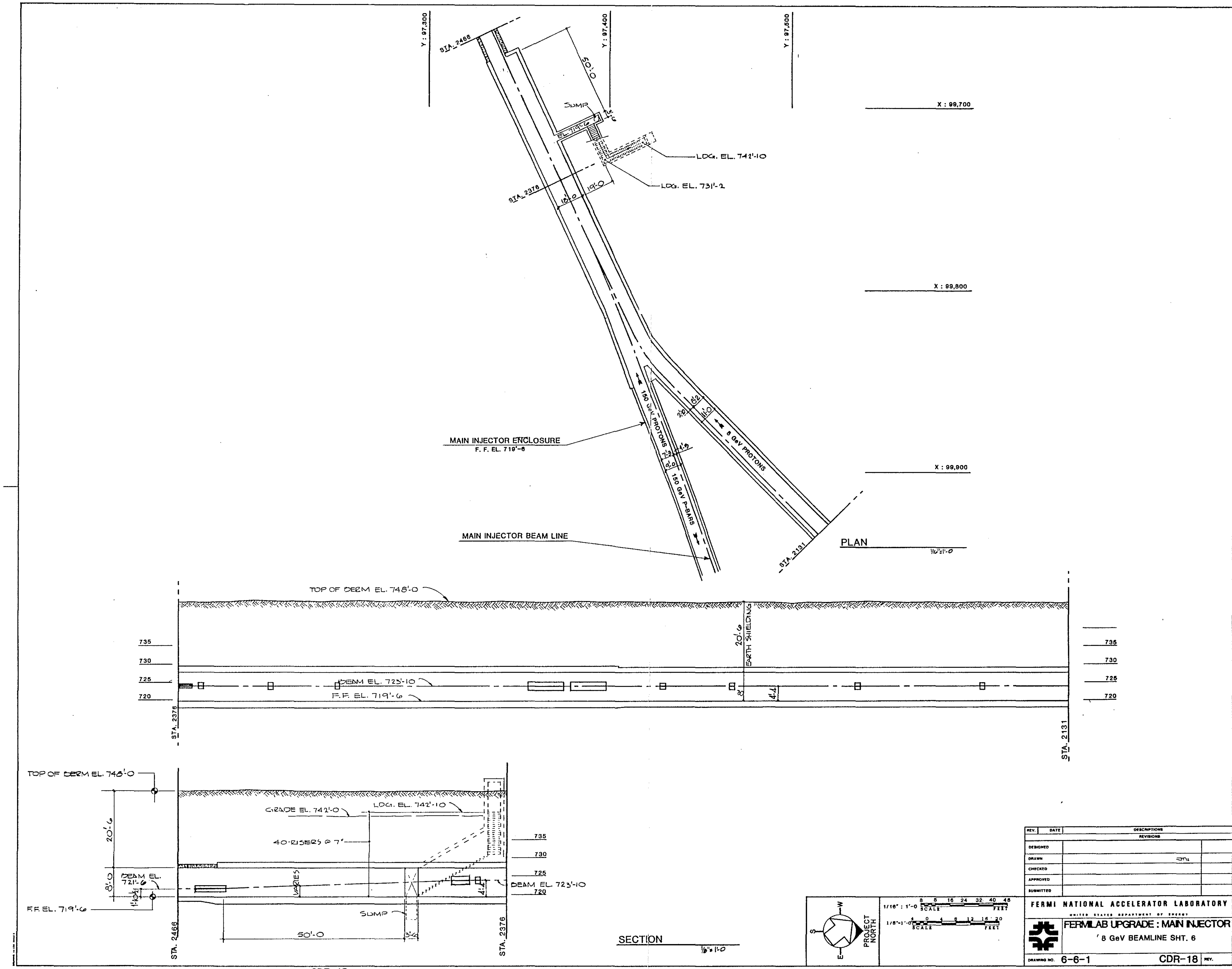

PLAN
SECTION
KEY PLAN
8 GeV BEAMLINE ENCLOSURE
NEW 8 GeV BEAM LINE ENCLOSURE
EXISTING BOOSTER ENCLOSURE
CENTRAL UTILITY PLANT
SUBSTATION
UTILITY CORRIDOR
WELL POND ROAD
BEAM DUMP
8 GeV PROTONS
CENTER OF BOOSTER RING
X = 99,727.04
Y = 99,430.64
MAIN INJECTOR RING ENCLOSURE
TEVATRON RING ENCLOSURE
PROJECT NORTH
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
8 GeV BEAMLINE SHT. 1
CDR-13
1 SEPT. 89


SECTION A
8 GeV BEAMLINE ENCLOSURE
AT ARC SECTIONS 3/4" = 1'-0
11'-0
2'-10
FLUORESCENT LIGHTING AT 60'-0 ON CENTER (TYP.)
CONCRETE INSERTS AT 5'-0 ON CENTER
LCWR
LCWS
12" CABLE TRAYS
12" CABLE TRAY (POWER)
6" MIN.
8 GeV BEAM CENTER EL. 728'-0
QUADRUPLEX OUTLET OR DUPLEX OUTLET WITH 20A., 3φ, 4W, VACUUM PUMP OUTLET (TYP.)
WELDING OUTLET
CAST-IN-PLACE CONCRETE
Y = 98,800
Y = 98,900
Y = 99,000
X = 99,800
X = 99,900
X = 100,000
STA. 400
STA. 730
8 GeV PROTONS
8 GeV BEAMLINE ENCLOSURE
F.F. EL. 722'-6
BEAM EL. 728'-0
PLAN
1/16" = 1'-0
TOP OF BERM EL. 750'-0
EARTH SHIELDING
BEAM EL. 728'-0
F.F. EL. 722'-6
735
730
725
720
SECTION
1/8" = 1'-0
MAIN INJECTOR RING ENCLOSURE
TEVATRON RING ENCLOSURE
VIEW
NORTH
KEY PLAN
PROJECT NORTH
SCALE
FEET
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
8 GeV BEAMLINE SHT. 2
DRAWING NO. 6-6-1
CDR-14
1.SEPT. 89

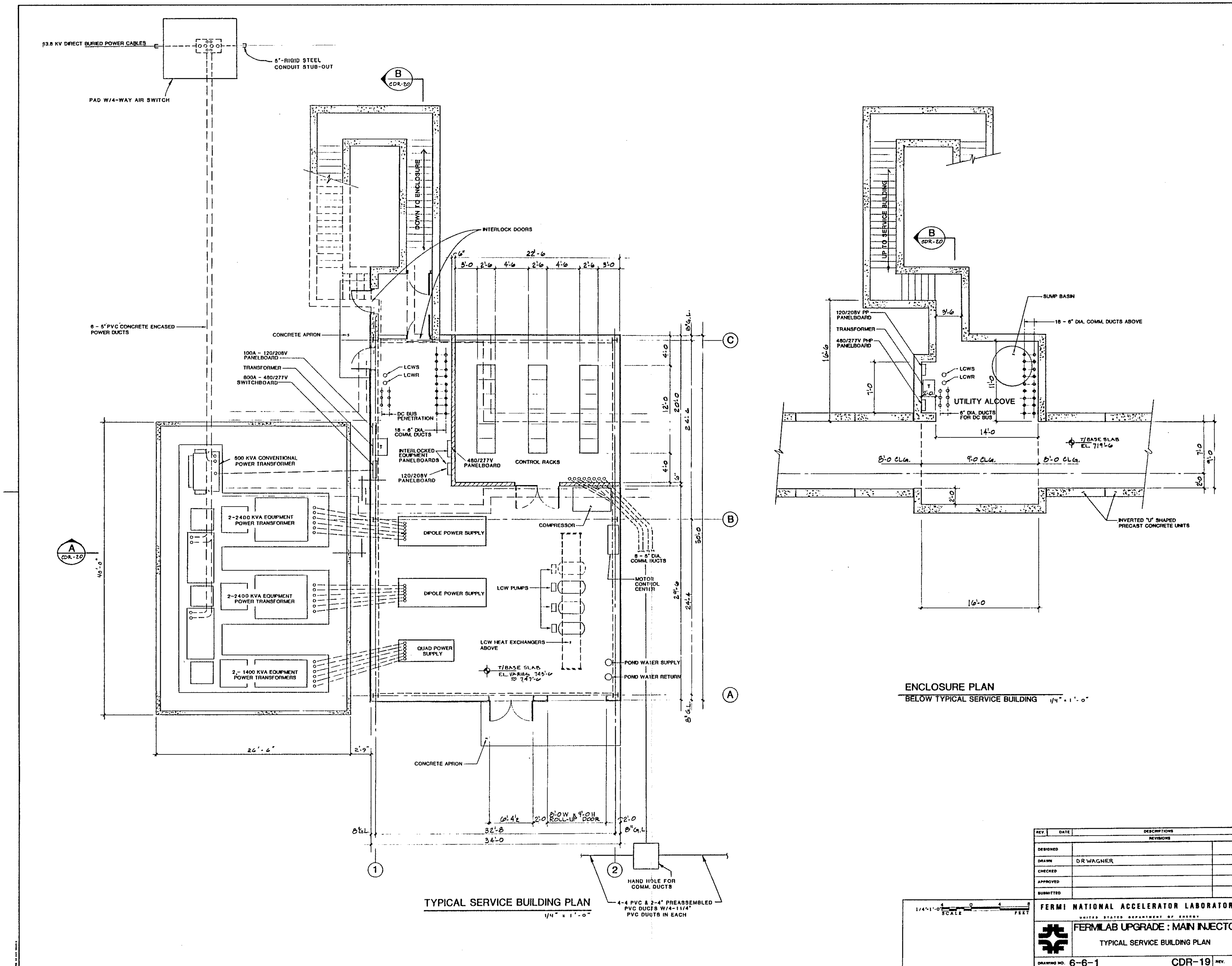

SECTION B
8 GeV BEAMLINE ENCLOSURE
AT STRAIGHT SECTIONS
FLUORESCENT LIGHTING
LCWS
LCWR
CONCRETE INSERTS @ 8'-0 ON CENTER
12" CABLE TRAY (POWER)
12" CABLE TRAYS
8 GeV BEAM CENTER EL. 728'-0
QUADRUPLEX OUTLET OR DUPLEX OUTLET WITH 20A., 3Ø 4W. VACUUM PUMP OUTLET (TYP.)
CAST-IN-PLACE CONCRETE
WELDING OUTLET
PLAN
8 GeV BEAMLINE ENCLOSURE
F. F. EL. 722'-6
BEAM EL. 728'-0
POWER AND COMMUNICATION ALCOVE
NORTH HATCH BUILDING
F.F. EL. 746'-6
8 GeV PROTONS
EXISTING CRYOGENIC LINES AND CONDUITS AT GRADE - TO REMAIN IN PLACE DURING CONSTRUCTION
EXISTING CRYOGENIC LINES AND CONDUITS TO REMAIN IN PLACE DURING CONSTRUCTION - PROVIDE CULVERT THROUGH NEW BERM
STA. 730
STA. 1030
STA. 1230
X : 100,000
X : 100,100
X : 100,200
Y : 98,300
Y : 98,400
Y : 98,500
Y : 98,600
Y : 98,700
Y : 98,800
TOP OF BERM EL. 750'-0
EXISTING GRADE EL. 744'-0
EARTH SHIELDING
F.F. EL. 722'-6
BEAM LINE EL. 728'-0
NORTH HATCH BUILDING
F.F. EL. 746'-6
CONCR. SHIELDING
STAIR ACCESS OPENING
STAIRWAY BEYOND HATCH
POWER AND COMMUNICATION ALCOVE
PRECAST CONCRETE
CAST IN PLACE CONCRETE
PRECAST CONCRETE
CAST-IN-PLACE CONCRETE
BEAM EL. 728'-0
SECTION
MAIN INJECTOR RING ENCLOSURE
VIEW
TEVATRON RING ENCLOSURE
KEY PLAN
NORTH
PROJECT NORTH
SCALE
FEET
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
8 GeV BEAMLINE SHT. 3
DRAWING NO. 6-6-1
CDR-15
1 SEPT. 89


8 GeV BEAM ENCLOSURE
F.F. EL. 722'-6
BEAM EL. 728'-0
8 GeV PROTONS
ANTI-PROTON ENCLOSURE
T/SLAB EL. 726'-0
BEAM EL. 732'-6
Y = 97,900
Y = 98,000
Y = 98,100
Y = 98,200
Y = 98,300
X = 100,100
X = 100,200
X = 100,300
STA. 1814
STA. 1014
STA. 1230
BEAM LINE AP-2
BEAM LINE AP-3
EXIT. PASSAGE OVER ENCLOSURE EL. 755'-6
EL. 745'-0
EL. 726'-0
F.F. EL. 722'-6
2'-6 x 12' x 18' STEEL SHIELDING
EL. 755'-2
11'-6 HIGH ENCLOSURE
10' HIGH ENCLOSURE
EXISTING AP-2 ENCLOSURE
T/SLAB EL. 726'-0
BEAM EL. 732'-6
8 GeV ANTIPROTONS
SECTION
1/16"=1'-0
TOP OF BERM EL.
STA. 1522
PRECAST CONCRETE
CAST-IN-PLACE CONCRETE
EL. 745'-0
EL. 755'-6
EXISTING AP-2 ENCLOSURE
BEAM LINE AP-3
BEAM LINE AP-2
BEAM EL. 728'-0
F.F. EL. 722'-6
F.F. EL. 726'-0
EARTH SHIELDING
735
730
725
720
TOP OF BERM EL. 750'-0
PRECAST CONCRETE
PLAN
1/16"=1'-0
MAIN INJECTOR RING ENCLOSURE
TEVATRON RING ENCLOSURE
VIEW
NORTH
KEY PLAN
PROJECT NORTH
SCALE
FEET
REV. DATE DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
8 GeV BEAMLINE SHT. 4
1, SEPT. 89
DRAWING NO. 6-6-1
CDR-16
REV.

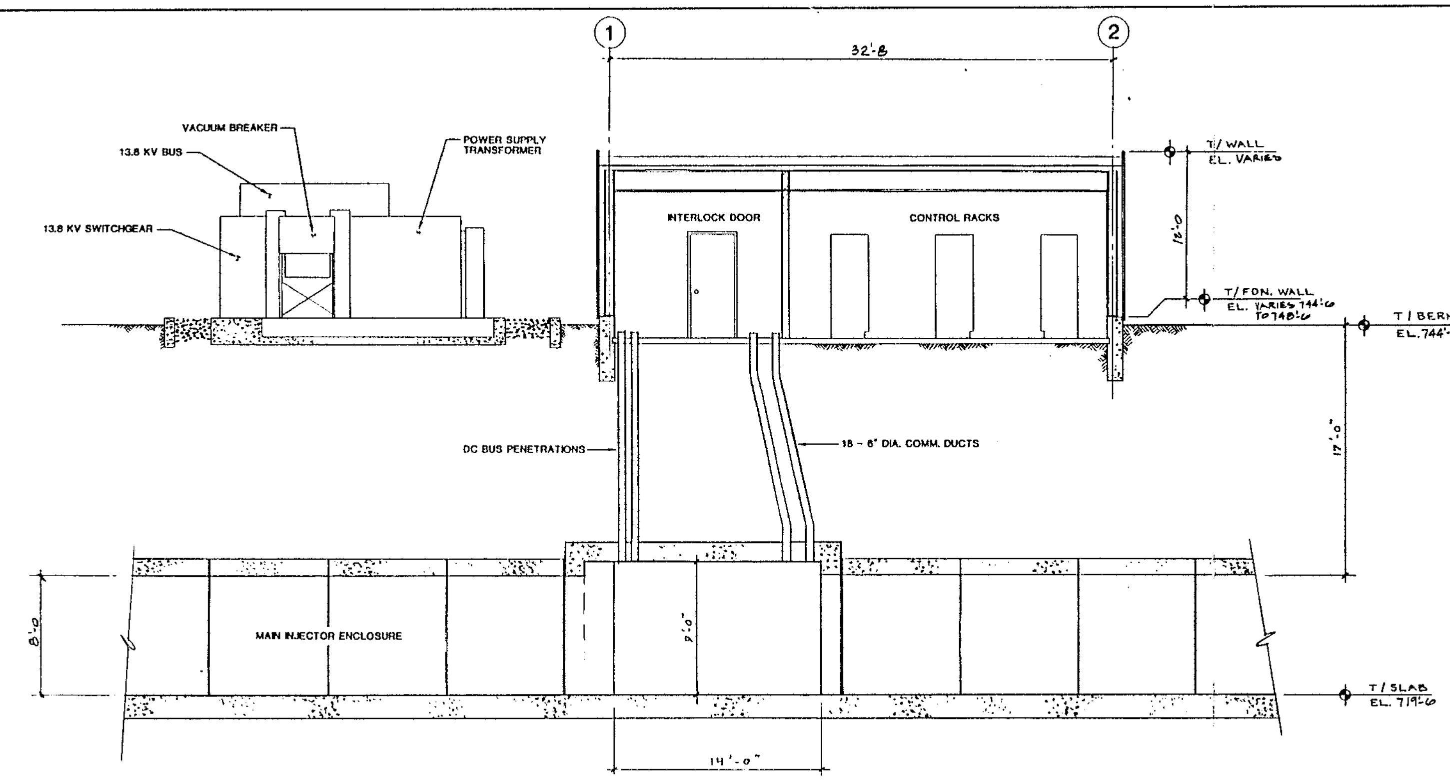

Y : 97,500
Y : 97,600
Y : 97,700
Y : 97,800
X : 99,900
X : 100,000
X : 100,100
STA. 2131
STA. 2076
STA. 1846
STA. 1814
F.F. EL. 719'-6
F.F. EL. 722'-6
8 GeV PROTONS
8 GeV BEAMLINE ENCLOSURE
F. F. EL. VARIES
BEAM EL. VARIES
FLOOR SLOPES
PLAN
1/16"=1'-0
TOP OF BERM EL. 748'-0
TOP OF BERM EL. VARIES
TOP OF BERM EL. 750'-0
EARTH SHIELDING
BEAM EL. 723'-10
BEAM SLOPES
VARIES
SECTION
1/8"=1'-0
MAIN INJECTOR RING ENCLOSURE
TEVATRON RING ENCLOSURE
VIEW
NORTH
KEY PLAN
PROJECT NORTH
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
8 GeV BEAMLINE SHT. 5
DRAWING NO. 6-6-1
CDR-17
1.SEPT. 89



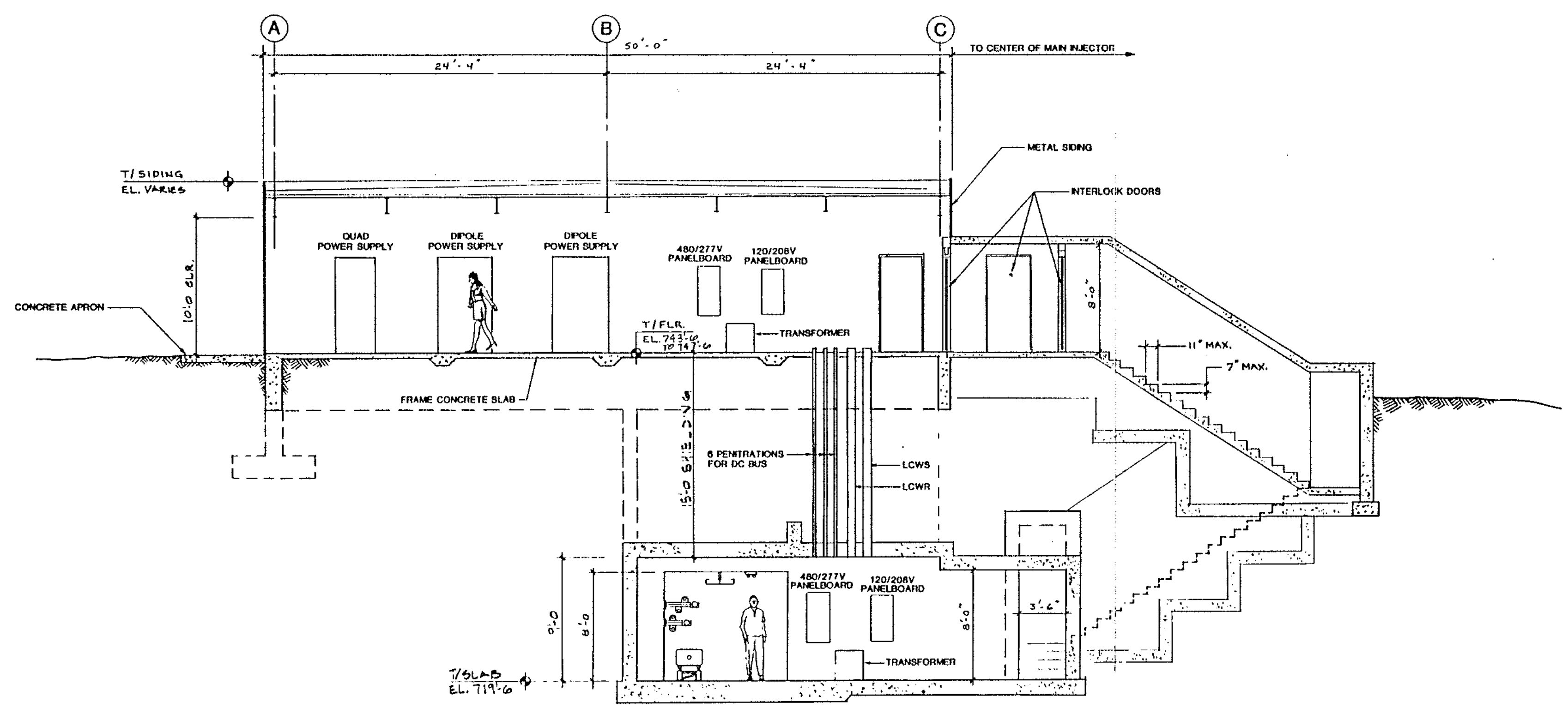
Y : 97,300
Y : 97,400
Y : 97,500
X : 99,700
X : 99,800
X : 99,900
STA. 2466
STA. 2376
STA. 2131
SUMP
LDG. EL. 742'-10
LDG. EL. 731'-2
EL. 719'-6
MAIN INJECTOR ENCLOSURE
F. F. EL. 719'-6
MAIN INJECTOR BEAM LINE
150 GeV PROTONS
150 GeV P-BARS
8 GeV PROTONS
PLAN
TOP OF BERM EL. 748'-0
EARTH SHIELDING
BEAM EL. 723'-10
F.F. EL. 719'-6
735
730
725
720
GRADE EL. 742'-0
40-RISERS @ 7"
VARIES
50'-0
SECTION
1/16" : 1'-0
1/8"=1'-0
SCALE
FEET
PROJECT NORTH
REV.
DATE
DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
8 GeV BEAMLINE SHT. 6
DRAWING NO. 6-6-1
CDR-18
1.SEPT. 89



13.8 KV DIRECT BURIED POWER CABLES
5"-RIGID STEEL CONDUIT STUB-OUT
PAD W/4-WAY AIR SWITCH
6 - 5" PVC CONCRETE ENCASED POWER DUCTS
DOWN TO ENCLOSURE
INTERLOCK DOORS
CONCRETE APRON
100A - 120/208V PANELBOARD
TRANSFORMER
800A - 480/277V SWITCHBOARD
LCWS
LCWR
DC BUS PENETRATION
18 - 6" DIA. COMM. DUCTS
INTERLOCKED EQUIPMENT PANELBOARDS
120/208V PANELBOARD
480/277V PANELBOARD
CONTROL RACKS
500 KVA CONVENTIONAL POWER TRANSFORMER
2-2400 KVA EQUIPMENT POWER TRANSFORMER
2-2400 KVA EQUIPMENT POWER TRANSFORMER
2 - 1400 KVA EQUIPMENT POWER TRANSFORMERS
DIPOLE POWER SUPPLY
DIPOLE POWER SUPPLY
QUAD POWER SUPPLY
COMPRESSOR
8 - 6" DIA. COMM. DUCTS
MOTOR CONTROL CENTER
LCW PUMPS
LCW HEAT EXCHANGERS ABOVE
T/BASE SLAB EL. VARIES 743'-6 TO 747'-6
POND WATER SUPPLY
POND WATER RETURN
CONCRETE APRON
8'-0W x 9'-0H ROLL-UP DOOR
HAND HOLE FOR COMM. DUCTS
4-4 PVC & 2-4" PREASSEMBLED PVC DUCTS W/4-1 1/4" PVC DUCTS IN EACH
TYPICAL SERVICE BUILDING PLAN
1/4" = 1'-0"
UP TO SERVICE BUILDING
SUMP BASIN
18 - 6" DIA. COMM. DUCTS ABOVE
120/208V PP PANELBOARD
TRANSFORMER
480/277V PHP PANELBOARD
UTILITY ALCOVE
6" DIA. DUCTS FOR DC BUS
T/BASE SLAB EL. 719'-6
INVERTED "U" SHAPED PRECAST CONCRETE UNITS
ENCLOSURE PLAN
BELOW TYPICAL SERVICE BUILDING
1/4" = 1'-0"
DRAWN DR WAGNER
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
TYPICAL SERVICE BUILDING PLAN
DRAWING NO. 6-6-1
CDR-19
1 SEPT. 89



SECTION A
1/4" = 1'-0" CDR-19



SECTION B
1/4" = 1'-0" CDR-19

REV.	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED		
DRAWN	DR WAGNER	
CHECKED		
APPROVED		
SUBMITTED		

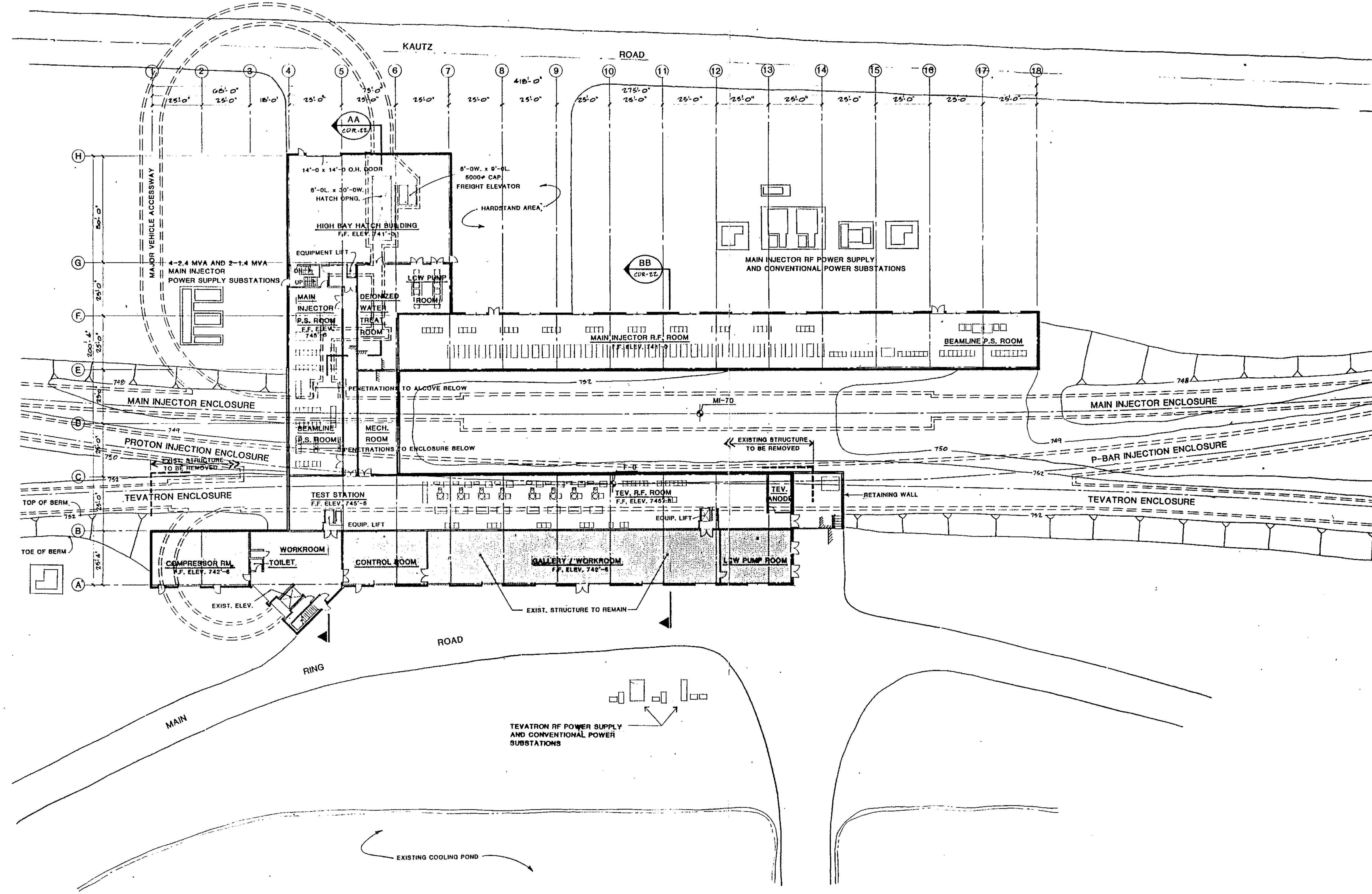
1/4"=1'-0" SCALE 4 0 4 8 FEET

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

FERMILAB UPGRADE : MAIN INJECTOR
TYPICAL SERVICE BUILDING SECTIONS

DRAWING NO. 6-6-1 CDR-20 REV.

1, SEPT. 89



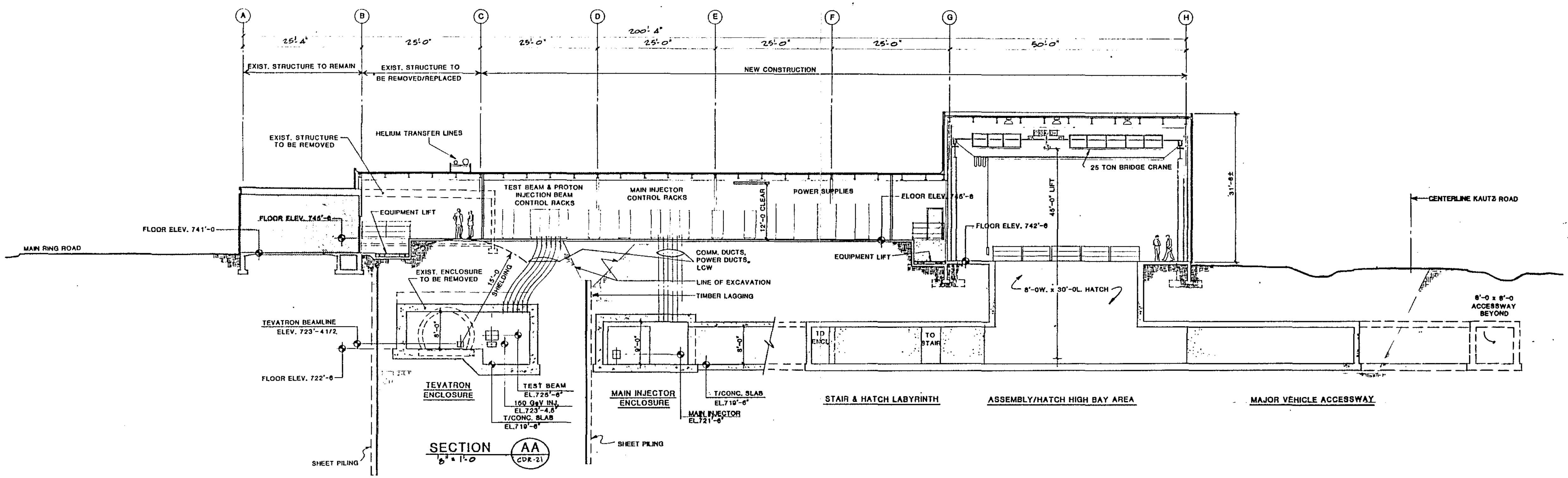
REV	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED

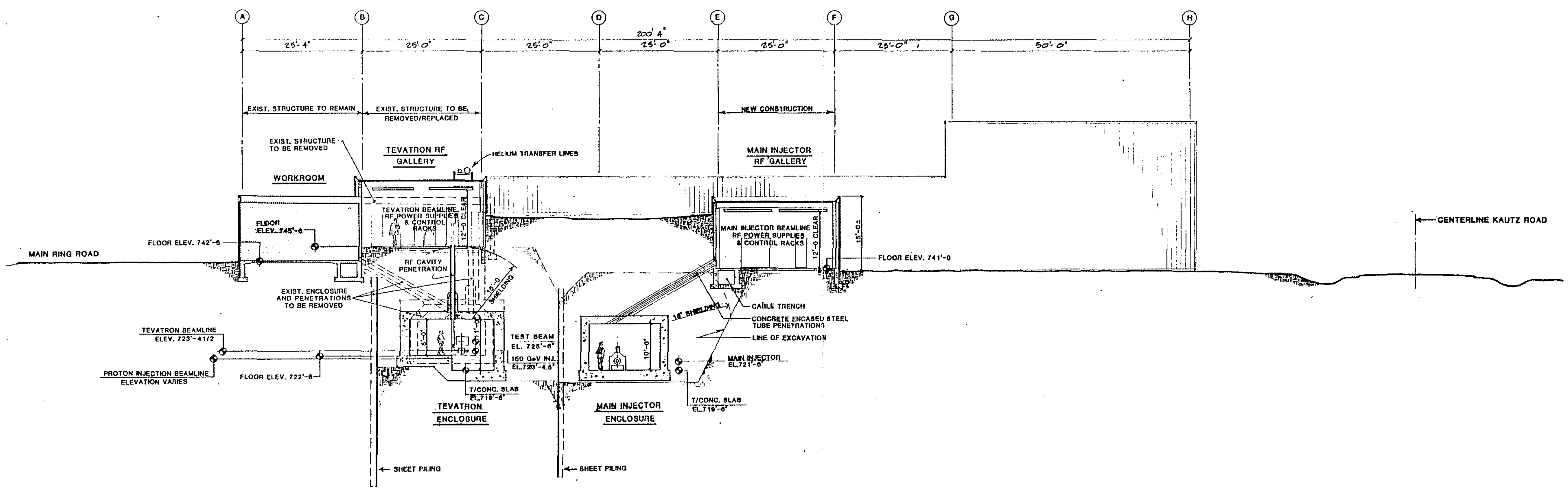
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

FERMILAB UPGRADE : MAIN INJECTOR
RF/F0 & RF/MI-70 SERVICE BUILDINGS
PLAN

DRAWING NO. 6-6-1 CDR-21 REV. JAN. 1990



SECTION AA
1/8" = 1'-0 (CDR-21)



SECTION BB
1/8" = 1'-0" (CDR-21)

REV.	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED

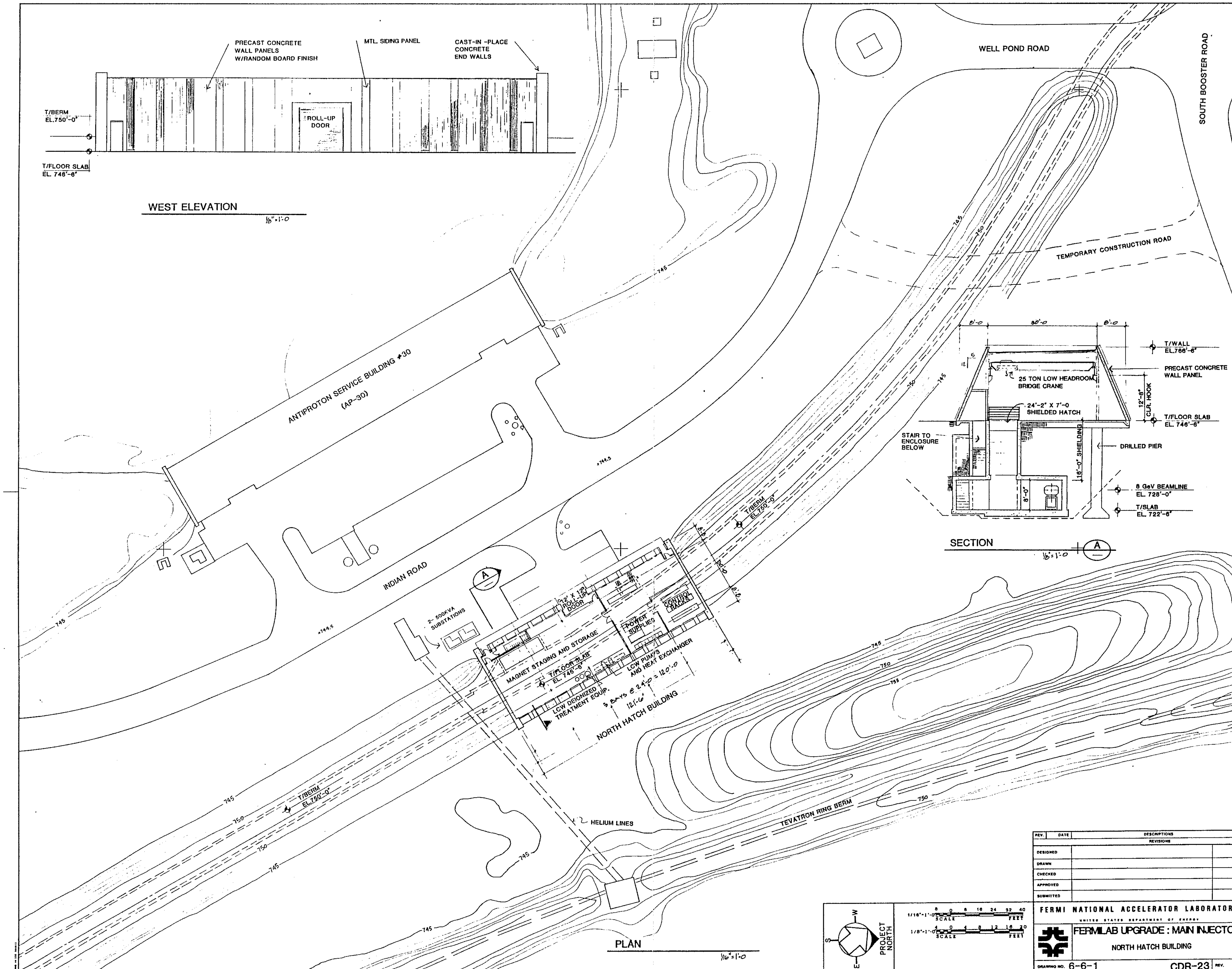
1/8" = 1'-0" Scale 8 0 4 8 12 16 20 Feet

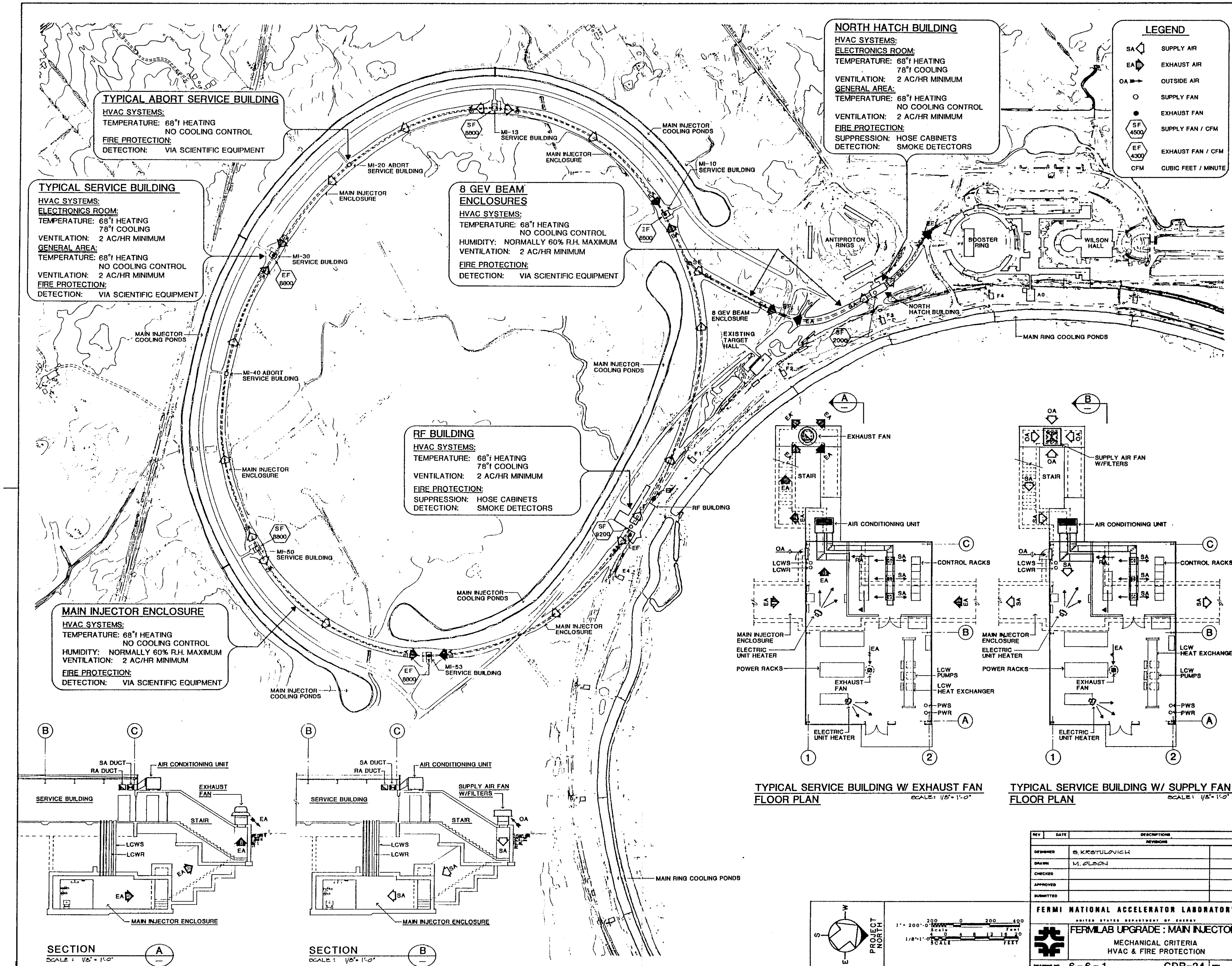
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

FERMILAB UPGRADE : MAIN INJECTOR
RF/F0 & RF/MI-70 SERVICE BUILDINGS
SECTIONS

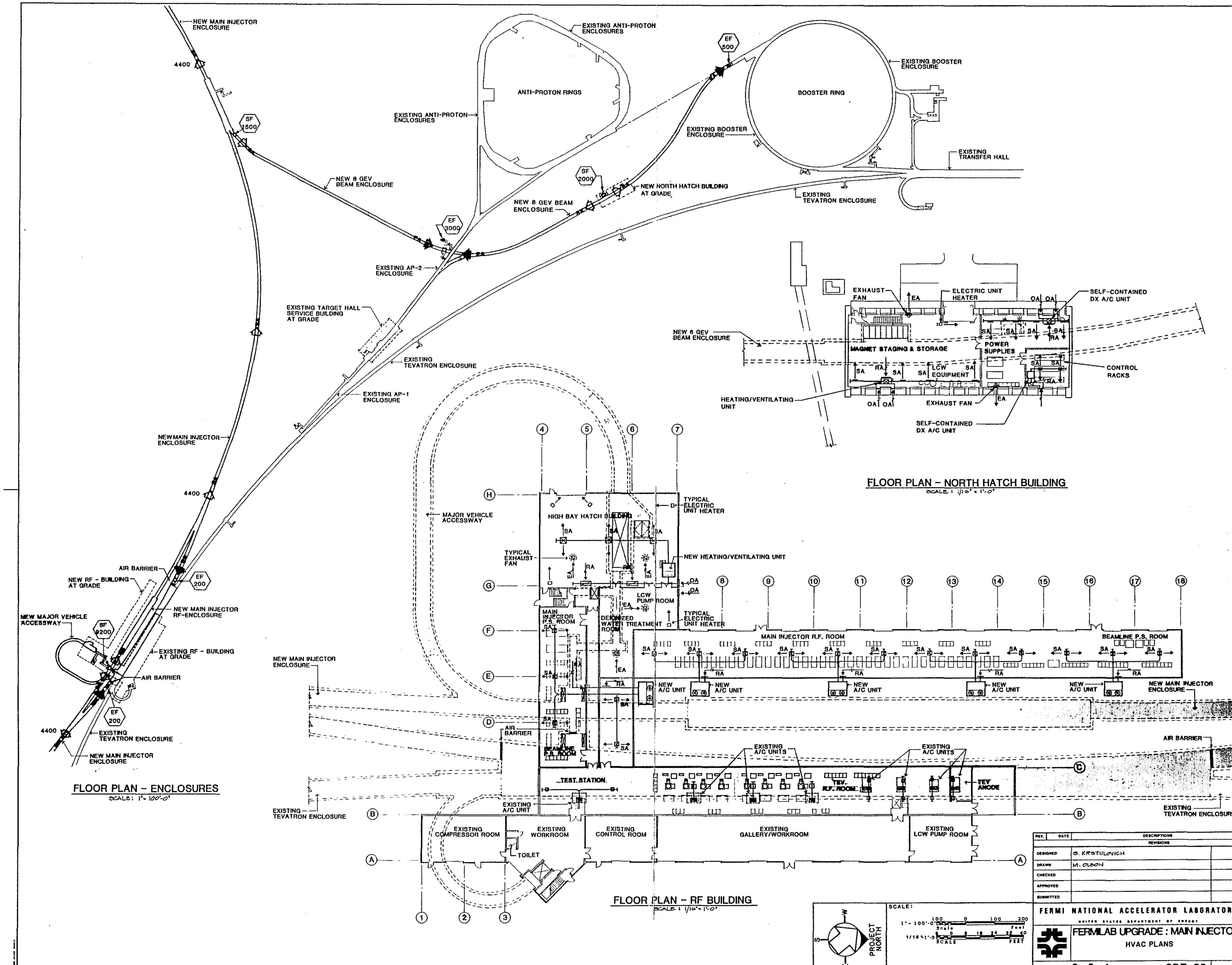
JAN. 1990

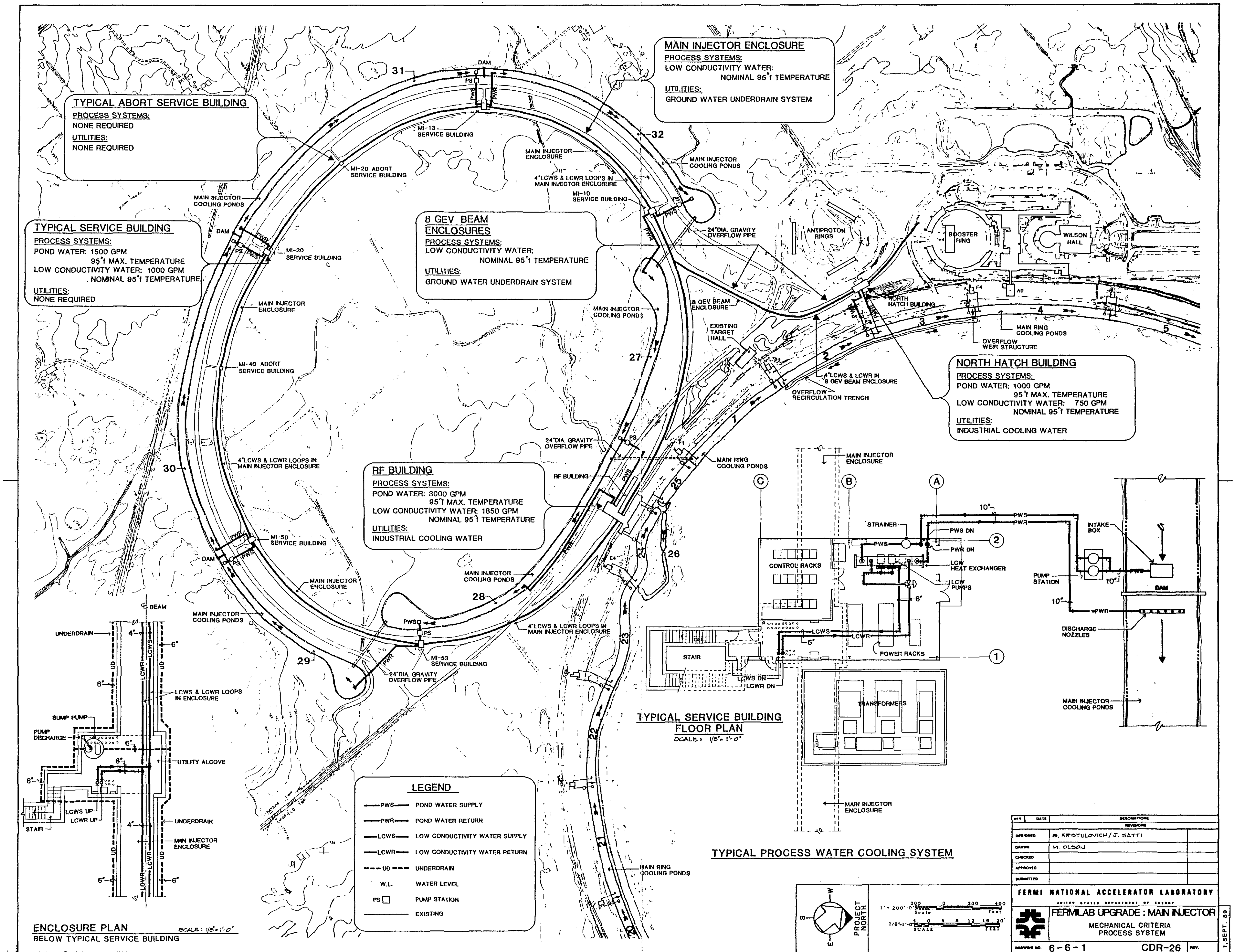
DRAWING NO. 6-6-1 CDR-22 REV.


PRECAST CONCRETE WALL PANELS W/RANDOM BOARD FINISH
MTL. SIDING PANEL
CAST-IN-PLACE CONCRETE END WALLS
T/BERM EL.750'-0"
ROLL-UP DOOR
T/FLOOR SLAB EL. 746'-6"
WEST ELEVATION
1/8"=1'-0
WELL POND ROAD
SOUTH BOOSTER ROAD
TEMPORARY CONSTRUCTION ROAD
ANTIPROTON SERVICE BUILDING #30
(AP-30)
INDIAN ROAD
2- 500KVA SUBSTATIONS
12' X 12' ROLL-UP DOOR
CONTROL RACKS
POWER SUPPLIES
MAGNET STAGING AND STORAGE
LCW PUMPS AND HEAT EXCHANGER
T/FLOOR SLAB EL. 746'-6"
LCW DEIONIZED TREATMENT EQUIP.
5 BAYS @ 24'-0 = 120'-0
121'-6"
NORTH HATCH BUILDING
T/BERM EL.750'-0"
HELIUM LINES
TEVATRON RING BERM
745
750
755
PLAN
1/16"=1'-0
T/WALL EL.766'-6"
PRECAST CONCRETE WALL PANEL
25 TON LOW HEADROOM BRIDGE CRANE
24'-2" X 7'-0 SHIELDED HATCH
12'-8" CLR. HOOK
T/FLOOR SLAB EL. 746'-6"
STAIR TO ENCLOSURE BELOW
DRILLED PIER
16'-0" SHIELDING
8 GeV BEAMLINE EL. 728'-0"
T/SLAB EL. 722'-6"
8'-0"
30'-0
8'-0
SECTION
1/8"=1'-0
A
PROJECT NORTH
1/16"=1'-0 SCALE FEET
1/8"=1'-0 SCALE FEET
REV. DATE DESCRIPTIONS
REVISIONS
DESIGNED
DRAWN
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
NORTH HATCH BUILDING
DRAWING NO. 6-6-1
CDR-23
REV.
JAN. 1990

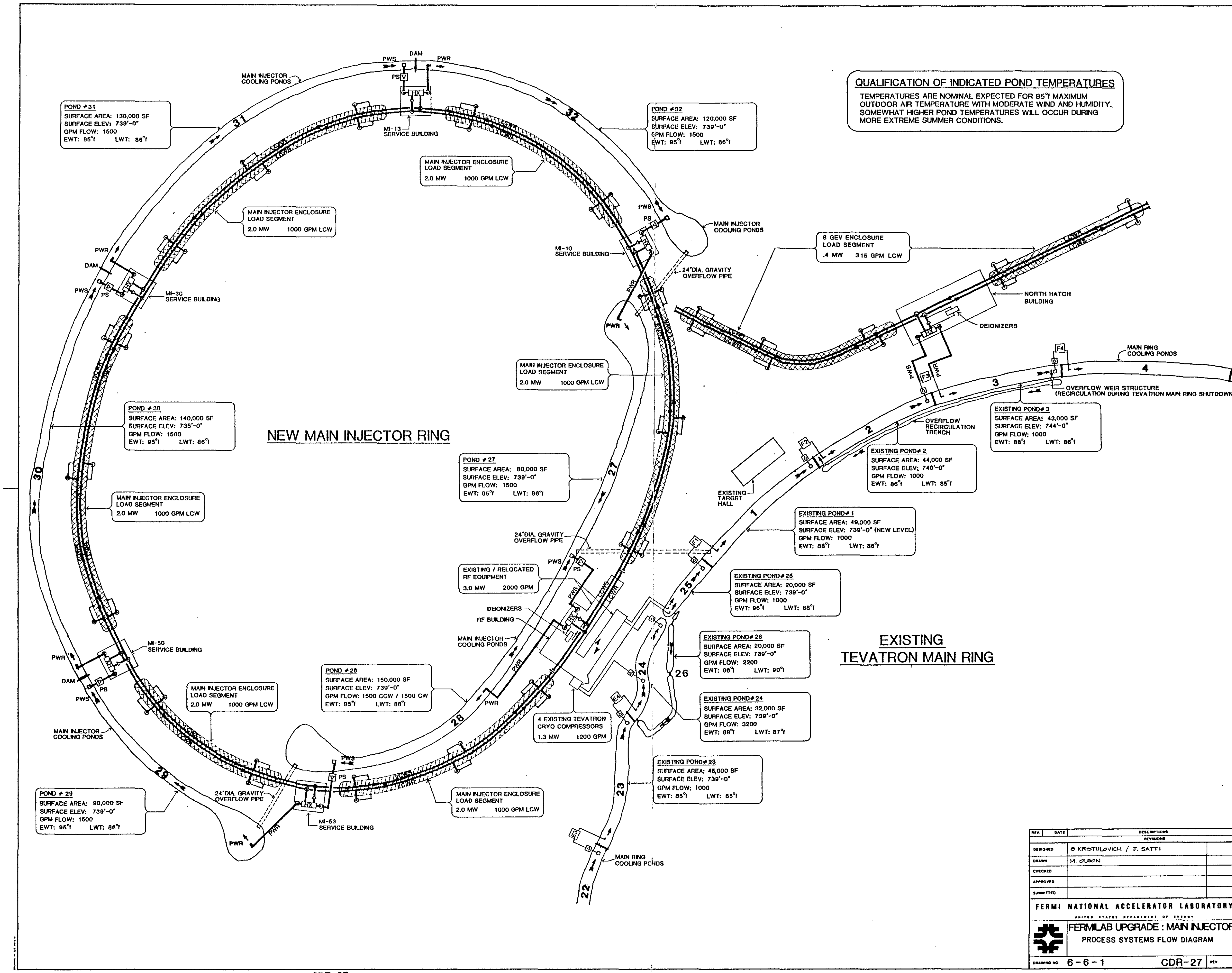


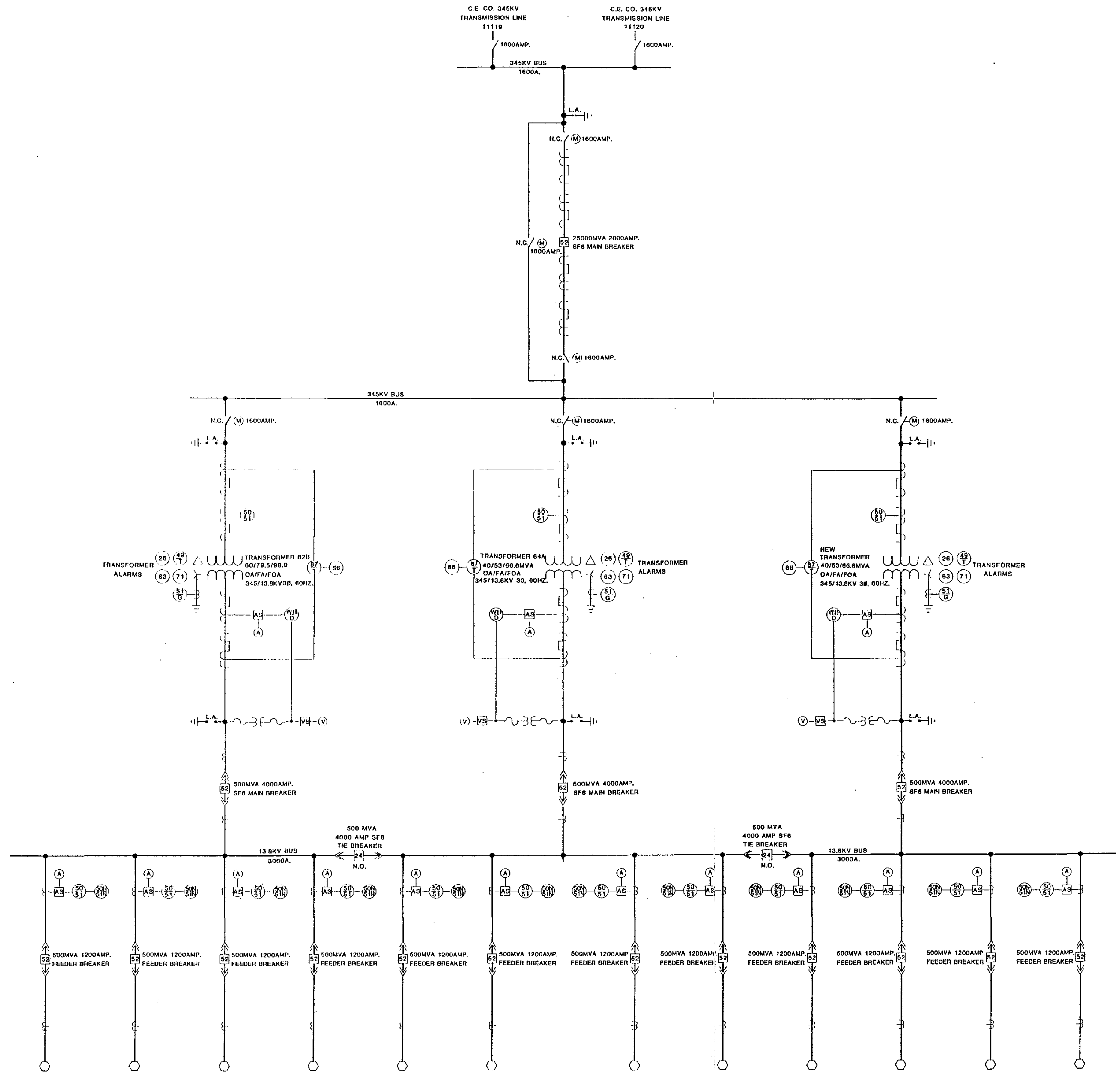
TYPICAL ABORT SERVICE BUILDING
HVAC SYSTEMS:
TEMPERATURE: 68°f HEATING
NO COOLING CONTROL
FIRE PROTECTION:
DETECTION: VIA SCIENTIFIC EQUIPMENT
TYPICAL SERVICE BUILDING
HVAC SYSTEMS:
ELECTRONICS ROOM:
TEMPERATURE: 68°f HEATING
78°f COOLING
VENTILATION: 2 AC/HR MINIMUM
GENERAL AREA:
TEMPERATURE: 68°f HEATING
NO COOLING CONTROL
VENTILATION: 2 AC/HR MINIMUM
FIRE PROTECTION:
DETECTION: VIA SCIENTIFIC EQUIPMENT
8 GEV BEAM ENCLOSURES
HVAC SYSTEMS:
TEMPERATURE: 68°f HEATING
NO COOLING CONTROL
HUMIDITY: NORMALLY 60% R.H. MAXIMUM
VENTILATION: 2 AC/HR MINIMUM
FIRE PROTECTION:
DETECTION: VIA SCIENTIFIC EQUIPMENT
NORTH HATCH BUILDING
HVAC SYSTEMS:
ELECTRONICS ROOM:
TEMPERATURE: 68°f HEATING
78°f COOLING
VENTILATION: 2 AC/HR MINIMUM
GENERAL AREA:
TEMPERATURE: 68°f HEATING
NO COOLING CONTROL
VENTILATION: 2 AC/HR MINIMUM
FIRE PROTECTION:
SUPPRESSION: HOSE CABINETS
DETECTION: SMOKE DETECTORS
LEGEND
SA SUPPLY AIR
EA EXHAUST AIR
OA OUTSIDE AIR
SUPPLY FAN
EXHAUST FAN
SF 4500 SUPPLY FAN / CFM
EF 4300 EXHAUST FAN / CFM
CFM CUBIC FEET / MINUTE
RF BUILDING
HVAC SYSTEMS:
TEMPERATURE: 68°f HEATING
78°f COOLING
VENTILATION: 2 AC/HR MINIMUM
FIRE PROTECTION:
SUPPRESSION: HOSE CABINETS
DETECTION: SMOKE DETECTORS
MAIN INJECTOR ENCLOSURE
HVAC SYSTEMS:
TEMPERATURE: 68°f HEATING
NO COOLING CONTROL
HUMIDITY: NORMALLY 60% R.H. MAXIMUM
VENTILATION: 2 AC/HR MINIMUM
FIRE PROTECTION:
DETECTION: VIA SCIENTIFIC EQUIPMENT
MI-20 ABORT SERVICE BUILDING
MI-13 SERVICE BUILDING
MI-10 SERVICE BUILDING
MI-30 SERVICE BUILDING
MI-40 ABORT SERVICE BUILDING
MI-50 SERVICE BUILDING
MI-53 SERVICE BUILDING
MAIN INJECTOR ENCLOSURE
MAIN INJECTOR COOLING PONDS
8 GEV BEAM ENCLOSURE
EXISTING TARGET HALL
NORTH HATCH BUILDING
MAIN RING COOLING PONDS
ANTIPROTON RINGS
BOOSTER RING
WILSON HALL
RF BUILDING
SF 8800
EF 8800
SF 2000
SF 8200
EXHAUST FAN
SUPPLY AIR FAN W/FILTERS
STAIR
AIR CONDITIONING UNIT
CONTROL RACKS
LCWS
LCWR
MAIN INJECTOR ENCLOSURE
ELECTRIC UNIT HEATER
POWER RACKS
LCW PUMPS
LCW HEAT EXCHANGER
PWS
PWR
TYPICAL SERVICE BUILDING W/ EXHAUST FAN FLOOR PLAN
SCALE: 1/8" = 1'-0"
TYPICAL SERVICE BUILDING W/ SUPPLY FAN FLOOR PLAN
SCALE: 1/8" = 1'-0"
SA DUCT
RA DUCT
AIR CONDITIONING UNIT
SERVICE BUILDING
EXHAUST FAN
SUPPLY AIR FAN W/FILTERS
MAIN INJECTOR ENCLOSURE
SECTION A
SCALE: 1/8" = 1'-0"
SECTION B
SCALE: 1/8" = 1'-0"
PROJECT NORTH
SCALE
DESIGNED B. KRSTULOVICH
DRAWN M. OLSON
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
MECHANICAL CRITERIA
HVAC & FIRE PROTECTION
DRAWING NO. 6-6-1
CDR-24


FLOOR PLAN - ENCLOSURES
SCALE: 1" = 100'-0"
NEW MAIN INJECTOR ENCLOSURE
EXISTING ANTI-PROTON ENCLOSURES
ANTI-PROTON RINGS
EXISTING BOOSTER ENCLOSURE
BOOSTER RING
EXISTING TRANSFER HALL
NEW 8 GEV BEAM ENCLOSURE
NEW NORTH HATCH BUILDING AT GRADE
EXISTING TEVATRON ENCLOSURE
EXISTING AP-2 ENCLOSURE
EXISTING TARGET HALL SERVICE BUILDING AT GRADE
EXISTING AP-1 ENCLOSURE
NEW RF - BUILDING AT GRADE
AIR BARRIER
NEW MAJOR VEHICLE ACCESSWAY
NEW MAIN INJECTOR RF-ENCLOSURE
EXISTING RF - BUILDING AT GRADE
FLOOR PLAN - NORTH HATCH BUILDING
SCALE: 1/16" = 1'-0"
EXHAUST FAN
ELECTRIC UNIT HEATER
SELF-CONTAINED DX A/C UNIT
MAGNET STAGING & STORAGE
POWER SUPPLIES
LCW EQUIPMENT
CONTROL RACKS
HEATING/VENTILATING UNIT
FLOOR PLAN - RF BUILDING
SCALE: 1/16" = 1'-0"
MAJOR VEHICLE ACCESSWAY
HIGH BAY HATCH BUILDING
TYPICAL ELECTRIC UNIT HEATER
TYPICAL EXHAUST FAN
NEW HEATING/VENTILATING UNIT
LCW PUMP ROOM
MAIN INJECTOR P.S. ROOM
DEIONIZED WATER TREATMENT ROOM
MAIN INJECTOR R.F. ROOM
BEAMLINE P.S. ROOM
NEW A/C UNIT
NEW MAIN INJECTOR ENCLOSURE
EXISTING A/C UNITS
TEST STATION
TEV. R.F. ROOM
TEV ANODE
EXISTING A/C UNIT
EXISTING TEVATRON ENCLOSURE
EXISTING COMPRESSOR ROOM
EXISTING WORKROOM
TOILET
EXISTING CONTROL ROOM
EXISTING GALLERY/WORKROOM
EXISTING LCW PUMP ROOM
PROJECT NORTH
SCALE:
DESIGNED S. KRSTULOVICH
DRAWN M. OLSON
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
HVAC PLANS
DRAWING NO. 6-6-1
CDR-25
1.SEPT. 89



MAIN INJECTOR ENCLOSURE
PROCESS SYSTEMS:
LOW CONDUCTIVITY WATER:
NOMINAL 95°f TEMPERATURE
UTILITIES:
GROUND WATER UNDERDRAIN SYSTEM
TYPICAL ABORT SERVICE BUILDING
PROCESS SYSTEMS:
NONE REQUIRED
UTILITIES:
NONE REQUIRED
TYPICAL SERVICE BUILDING
PROCESS SYSTEMS:
POND WATER: 1500 GPM
95°f MAX. TEMPERATURE
LOW CONDUCTIVITY WATER: 1000 GPM
NOMINAL 95°f TEMPERATURE
UTILITIES:
NONE REQUIRED
8 GEV BEAM ENCLOSURES
PROCESS SYSTEMS:
LOW CONDUCTIVITY WATER:
NOMINAL 95°f TEMPERATURE
UTILITIES:
GROUND WATER UNDERDRAIN SYSTEM
NORTH HATCH BUILDING
PROCESS SYSTEMS:
POND WATER: 1000 GPM
95°f MAX. TEMPERATURE
LOW CONDUCTIVITY WATER: 750 GPM
NOMINAL 95°f TEMPERATURE
UTILITIES:
INDUSTRIAL COOLING WATER
RF BUILDING
PROCESS SYSTEMS:
POND WATER: 3000 GPM
95°f MAX. TEMPERATURE
LOW CONDUCTIVITY WATER: 1850 GPM
NOMINAL 95°f TEMPERATURE
UTILITIES:
INDUSTRIAL COOLING WATER
DAM
PS
PWS
PWR
31
32
MI-13 SERVICE BUILDING
MI-20 ABORT SERVICE BUILDING
MAIN INJECTOR ENCLOSURE
4"LCWS & LCWR LOOPS IN MAIN INJECTOR ENCLOSURE
MI-10 SERVICE BUILDING
MAIN INJECTOR COOLING PONDS
24"DIA. GRAVITY OVERFLOW PIPE
ANTIPROTON RINGS
BOOSTER RING
WILSON HALL
MI-30 SERVICE BUILDING
MI-40 ABORT SERVICE BUILDING
8 GEV BEAM ENCLOSURE
NORTH HATCH BUILDING
EXISTING TARGET HALL
MAIN RING COOLING PONDS
OVERFLOW WEIR STRUCTURE
4"LCWS & LCWR IN 8 GEV BEAM ENCLOSURE
OVERFLOW RECIRCULATION TRENCH
27
30
RF BUILDING
MI-50 SERVICE BUILDING
MI-53 SERVICE BUILDING
28
29
26
25
23
22
21
20
MAIN INJECTOR ENCLOSURE
C
B
A
10"
STRAINER
PWS DN
PWR DN
2
LCW HEAT EXCHANGER
LCW PUMPS
CONTROL RACKS
INTAKE BOX
PUMP STATION
DAM
DISCHARGE NOZZLES
6"
LCWS
LCWR
POWER RACKS
1
STAIR
LCWS DN
LCWR DN
TRANSFORMERS
MAIN INJECTOR COOLING PONDS
TYPICAL SERVICE BUILDING FLOOR PLAN
SCALE: 1/8" = 1'-0"
TYPICAL PROCESS WATER COOLING SYSTEM
BEAM
UNDERDRAIN
4"
UD
LCWR
LCWS
LCWS & LCWR LOOPS IN ENCLOSURE
SUMP PUMP
PUMP DISCHARGE
UTILITY ALCOVE
LCWS UP
LCWR UP
STAIR
MAIN INJECTOR ENCLOSURE
ENCLOSURE PLAN
SCALE: 1/8" = 1'-0"
BELOW TYPICAL SERVICE BUILDING
LEGEND
PWS — POND WATER SUPPLY
PWR — POND WATER RETURN
LCWS — LOW CONDUCTIVITY WATER SUPPLY
LCWR — LOW CONDUCTIVITY WATER RETURN
UD — UNDERDRAIN
W.L. WATER LEVEL
PS PUMP STATION
EXISTING
PROJECT NORTH
1" = 200'-0"
1/8"=1'-0"
DESIGNED G. KRSTULOVICH / J. SATTI
DRAWN M. OLSON
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
MECHANICAL CRITERIA
PROCESS SYSTEM
DRAWING NO. 6-6-1
CDR-26
1.SEPT. 89


QUALIFICATION OF INDICATED POND TEMPERATURES
TEMPERATURES ARE NOMINAL EXPECTED FOR 95°f MAXIMUM OUTDOOR AIR TEMPERATURE WITH MODERATE WIND AND HUMIDITY. SOMEWHAT HIGHER POND TEMPERATURES WILL OCCUR DURING MORE EXTREME SUMMER CONDITIONS.
NEW MAIN INJECTOR RING
EXISTING TEVATRON MAIN RING
MAIN INJECTOR COOLING PONDS
PWS
DAM
PWR
PS
HX
MI-13 SERVICE BUILDING
MI-10 SERVICE BUILDING
MI-30 SERVICE BUILDING
MI-50 SERVICE BUILDING
MI-53 SERVICE BUILDING
24"DIA. GRAVITY OVERFLOW PIPE
POND # 31 SURFACE AREA: 130,000 SF SURFACE ELEV: 739'-0" GPM FLOW: 1500 EWT: 95°f LWT: 86°f
POND # 32 SURFACE AREA: 120,000 SF SURFACE ELEV: 739'-0" GPM FLOW: 1500 EWT: 95°f LWT: 86°f
POND # 30 SURFACE AREA: 140,000 SF SURFACE ELEV: 735'-0" GPM FLOW: 1500 EWT: 95°f LWT: 86°f
POND # 27 SURFACE AREA: 80,000 SF SURFACE ELEV: 739'-0" GPM FLOW: 1500 EWT: 95°f LWT: 86°f
POND # 28 SURFACE AREA: 150,000 SF SURFACE ELEV: 739'-0" GPM FLOW: 1500 CCW / 1500 CW EWT: 95°f LWT: 86°f
POND # 29 SURFACE AREA: 90,000 SF SURFACE ELEV: 739'-0" GPM FLOW: 1500 EWT: 95°f LWT: 86°f
MAIN INJECTOR ENCLOSURE LOAD SEGMENT 2.0 MW 1000 GPM LCW
8 GEV ENCLOSURE LOAD SEGMENT .4 MW 315 GPM LCW
NORTH HATCH BUILDING
DEIONIZERS
MAIN RING COOLING PONDS
OVERFLOW WEIR STRUCTURE (RECIRCULATION DURING TEVATRON MAIN RING SHUTDOWN)
OVERFLOW RECIRCULATION TRENCH
EXISTING POND # 3 SURFACE AREA: 43,000 SF SURFACE ELEV: 744'-0" GPM FLOW: 1000 EWT: 88°f LWT: 86°f
EXISTING POND # 2 SURFACE AREA: 44,000 SF SURFACE ELEV: 740'-0" GPM FLOW: 1000 EWT: 86°f LWT: 85°f
EXISTING POND # 1 SURFACE AREA: 49,000 SF SURFACE ELEV: 739'-0" (NEW LEVEL) GPM FLOW: 1000 EWT: 88°f LWT: 86°f
EXISTING TARGET HALL
EXISTING / RELOCATED RF EQUIPMENT 3.0 MW 2000 GPM
RF BUILDING
EXISTING POND # 25 SURFACE AREA: 20,000 SF SURFACE ELEV: 739'-0" GPM FLOW: 1000 EWT: 95°f LWT: 88°f
EXISTING POND # 26 SURFACE AREA: 20,000 SF SURFACE ELEV: 739'-0" GPM FLOW: 2200 EWT: 96°f LWT: 90°f
EXISTING POND # 24 SURFACE AREA: 32,000 SF SURFACE ELEV: 739'-0" GPM FLOW: 3200 EWT: 88°f LWT: 87°f
4 EXISTING TEVATRON CRYO COMPRESSORS 1.3 MW 1200 GPM
EXISTING POND # 23 SURFACE AREA: 45,000 SF SURFACE ELEV: 739'-0" GPM FLOW: 1000 EWT: 85°f LWT: 85°f
1
2
3
4
22
23
24
25
26
27
28
29
30
31
32
DESIGNED B KRSTULOVICH / J. SATTI
DRAWN M. OLSON
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
PROCESS SYSTEMS FLOW DIAGRAM
DRAWING NO. 6-6-1 CDR-27
1.SEPT. 89



LEGEND

- DISCONNECT SWITCH
- L.A. LIGHTNING ARRESTER
- CURRENT TRANSFORMER-BUSHING TYPE
- 52 CIRCUIT BREAKER
- M MOTOR OPERATED DISCONNECT SWITCH
- TRANSFORMER
- THERMAL ELEMENT
- POTENTIAL TRANSFORMER
- CURRENT TRANSFORMER-STATION TYPE-WYE CONNECTED
- 52 SWITCHGEAR CIRCUIT BREAKER
- A AMMETER
- AS AMMETER SWITCH
- V VOLTMETER
- VS VOLTMETER SWITCH
- 24 BUS TIE BREAKER
- WH/D WATTHOUR DEMAND METER
- 26 OIL TEMPERATURE DEVICE
- 49/T WINDING TEMPERATURE RELAY
- 50 INSTANTANEOUS OVERCURRENT RELAY
- 51 TIME OVERCURRENT RELAY
- 63 PRESSURE RATE OF RISE RELAY
- 71 TRANSFORMER OIL LEVEL
- 86 LOCKING OUT RELAY
- 87/T TRANSFORMER DIFFERENTIAL RELAY
- FEEDER NUMBER
- N.C. NORMALLY CLOSED
- N.O. NORMALLY OPEN

REV	DATE	DESCRIPTIONS
		REVISIONS

DESIGNED	E.VALDES/A.R.FLOWERS
DRAWN	A.R.FLOWERS
CHECKED	
APPROVED	
SUBMITTED	

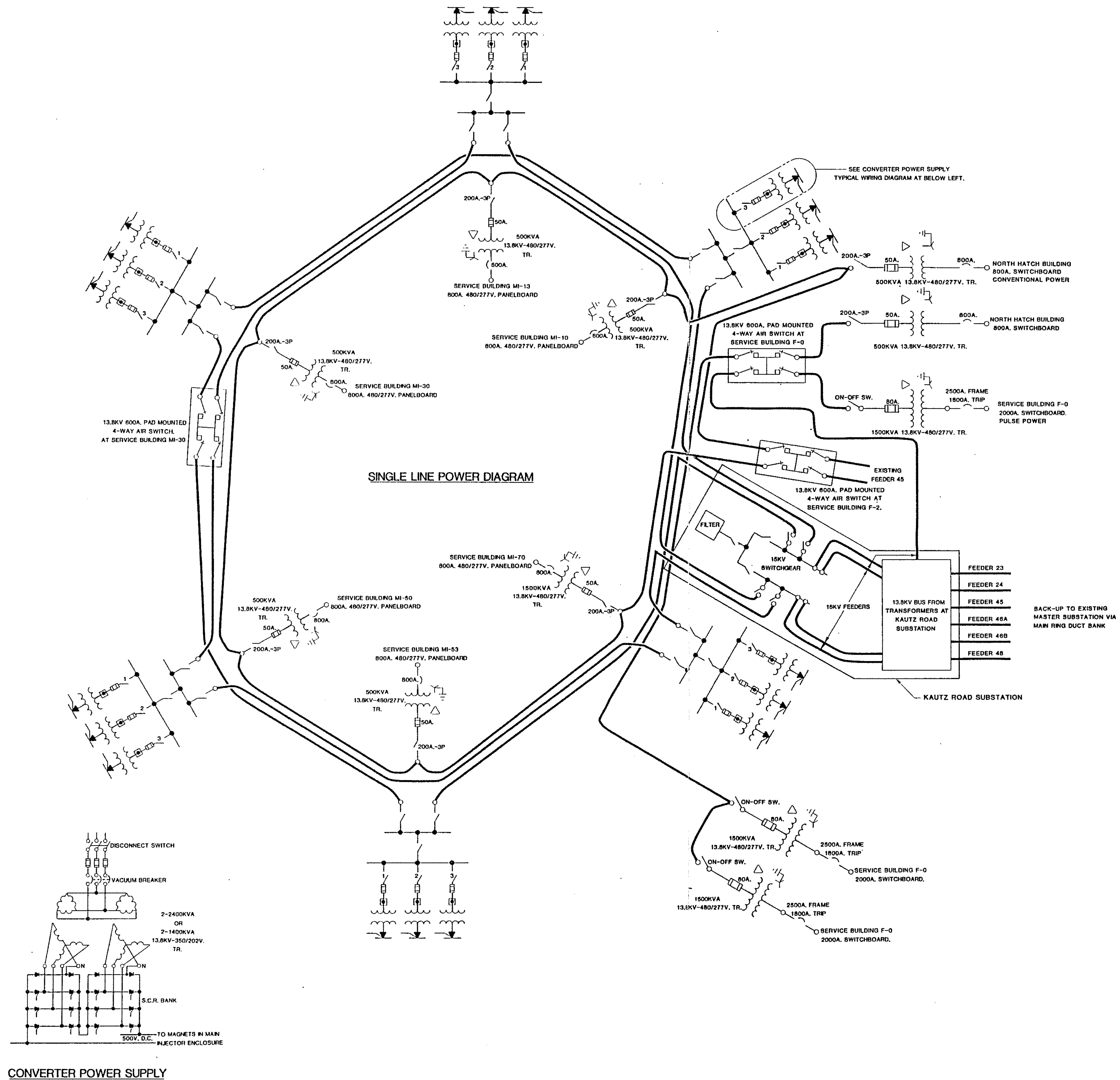
FERMI NATIONAL ACCELERATOR LABORATORY

UNITED STATES DEPARTMENT OF ENERGY

FERMILAB UPGRADE : MAIN INJECTOR

345-13.8KV SINGLE LINE DIAGRAM

DRAWING NO. 6-6-1 CDR-28 REV. JAN. 1990



CONVERTER POWER SUPPLY
(TYPICAL WIRING DIAGRAM)

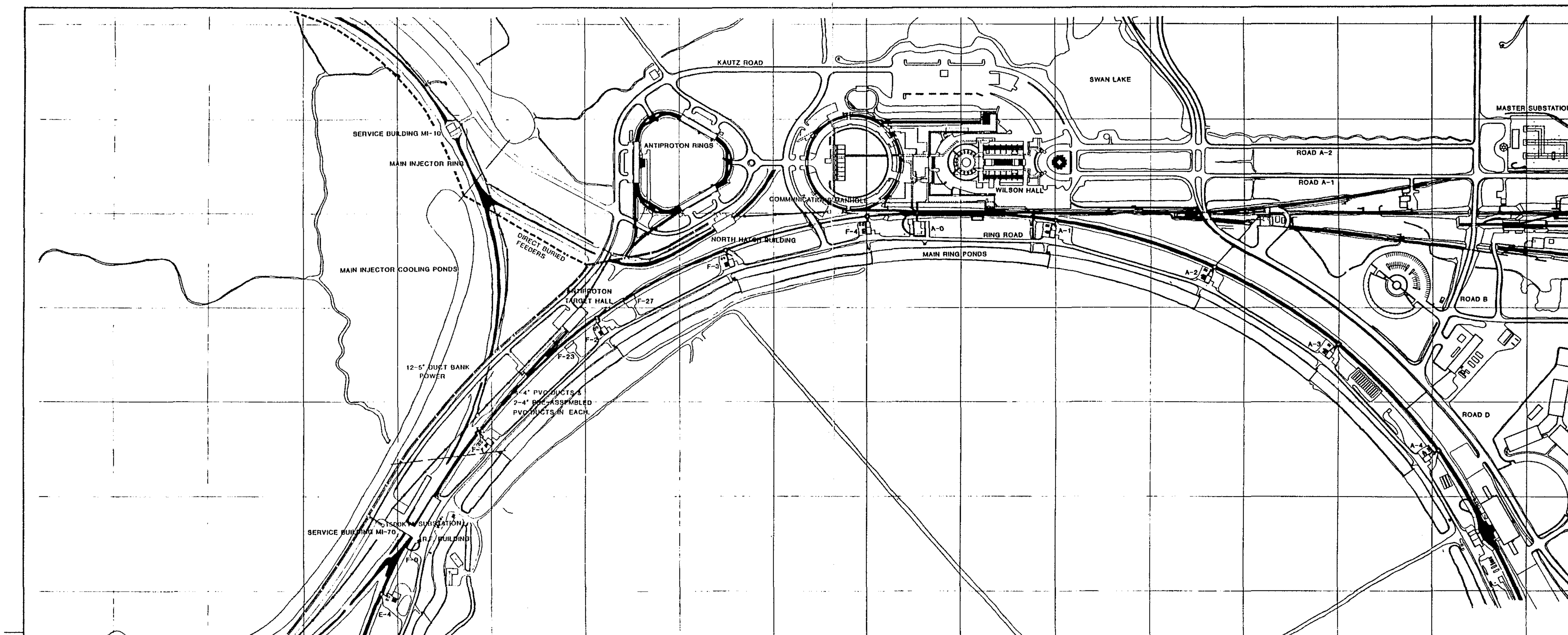
REV.	DATE	DESCRIPTIONS
		REVISIONS
DESIGNED	J.RYK/E.VALDES	
DRAWN	A.R.FLOWERS	
CHECKED		
APPROVED		
SUBMITTED		

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

FERMILAB UPGRADE : MAIN INJECTOR
SINGLE LINE POWER DISTRIBUTION DIAGRAM

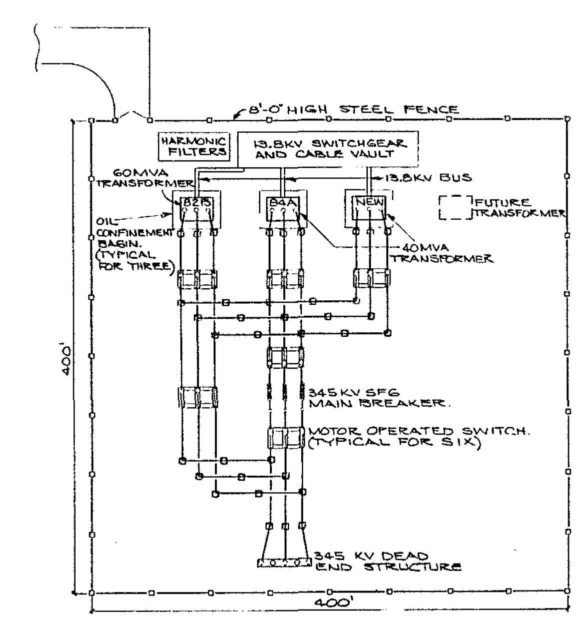
DRAWING NO. 6-6-1 CDR-29 REV.

JAN. 1990



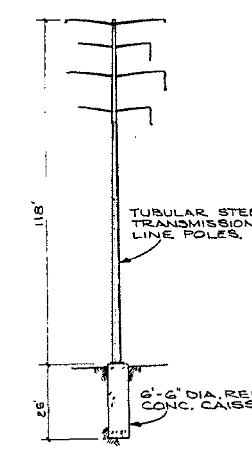
POWER AND COMMUNICATION DUCT PLAN

SCALE: 1" = 200'-0"



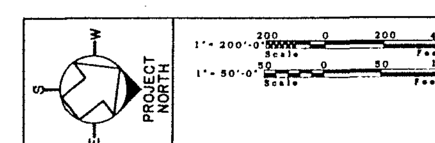
SUBSTATION SITE PLAN

SCALE: 1" = 50'-0"



TRANSMISSION POLE DETAIL

NO SCALE



REV	DATE	DESCRIPTIONS
		REVISIONS
DESIGNED	E.VALDES/A.R.FLOWERS	
DRAWN	A.R.FLOWERS	
CHECKED		
APPROVED		
SUBMITTED		

FERMI NATIONAL ACCELERATOR LABORATORY

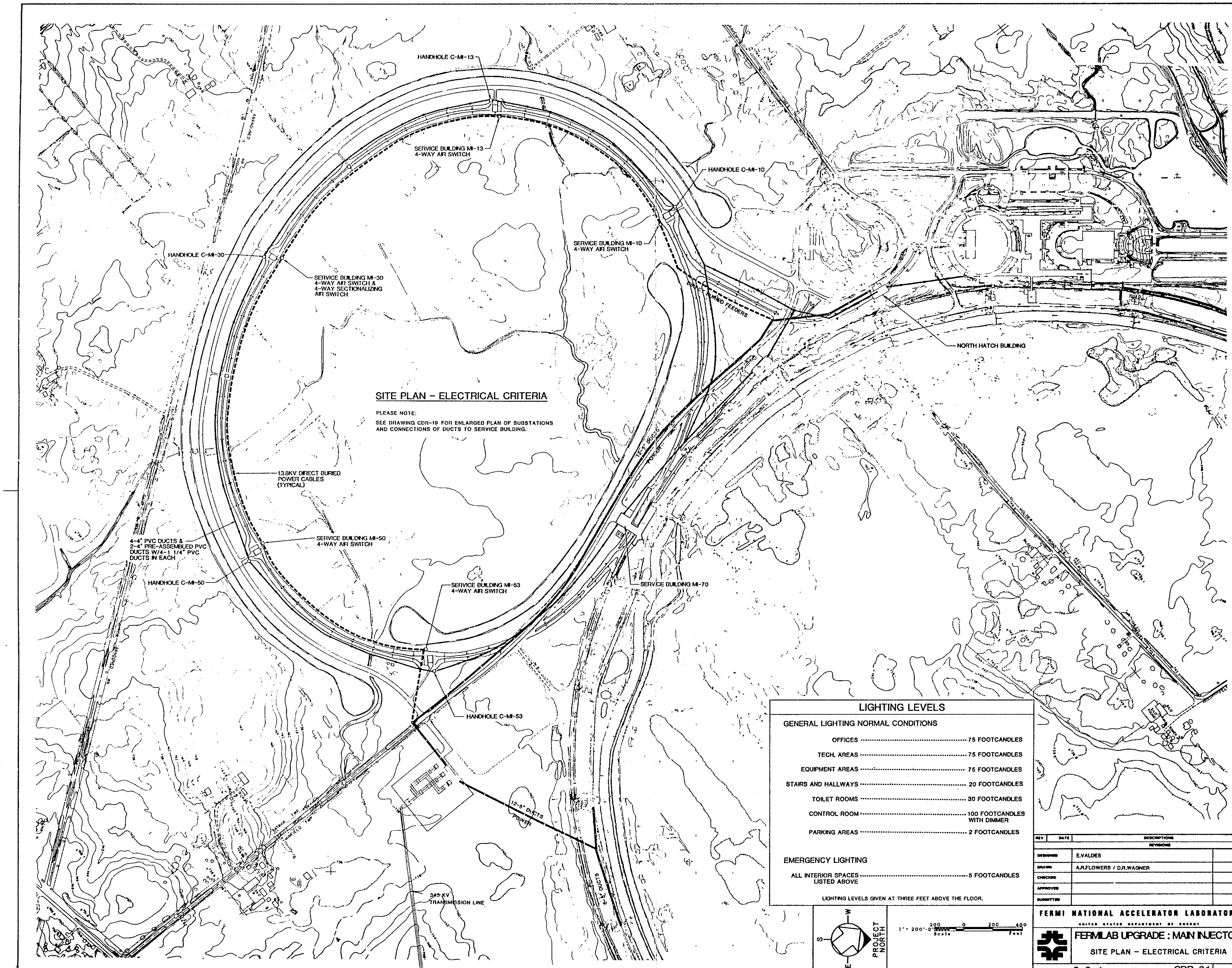
UNITED STATES DEPARTMENT OF ENERGY

FERMILAB UPGRADE : MAIN INJECTOR

POWER AND COMMUNICATION DUCT PLAN

JAN. 1990

DRAWING NO. 6-6-1 CDR-30 REV.



LIGHTING LEVELS

GENERAL LIGHTING NORMAL CONDITIONS

OFFICES	75 FOOTCANDLES
TECH. AREAS	75 FOOTCANDLES
EQUIPMENT AREAS	75 FOOTCANDLES
STAIRS AND HALLWAYS	20 FOOTCANDLES
TOILET ROOMS	30 FOOTCANDLES
CONTROL ROOM	100 FOOTCANDLES WITH DIMMER
PARKING AREAS	2 FOOTCANDLES

EMERGENCY LIGHTING

ALL INTERIOR SPACES LISTED ABOVE	5 FOOTCANDLES

LIGHTING LEVELS GIVEN AT THREE FEET ABOVE THE FLOOR.

REV.	DATE	DESCRIPTIONS
		REVISIONS

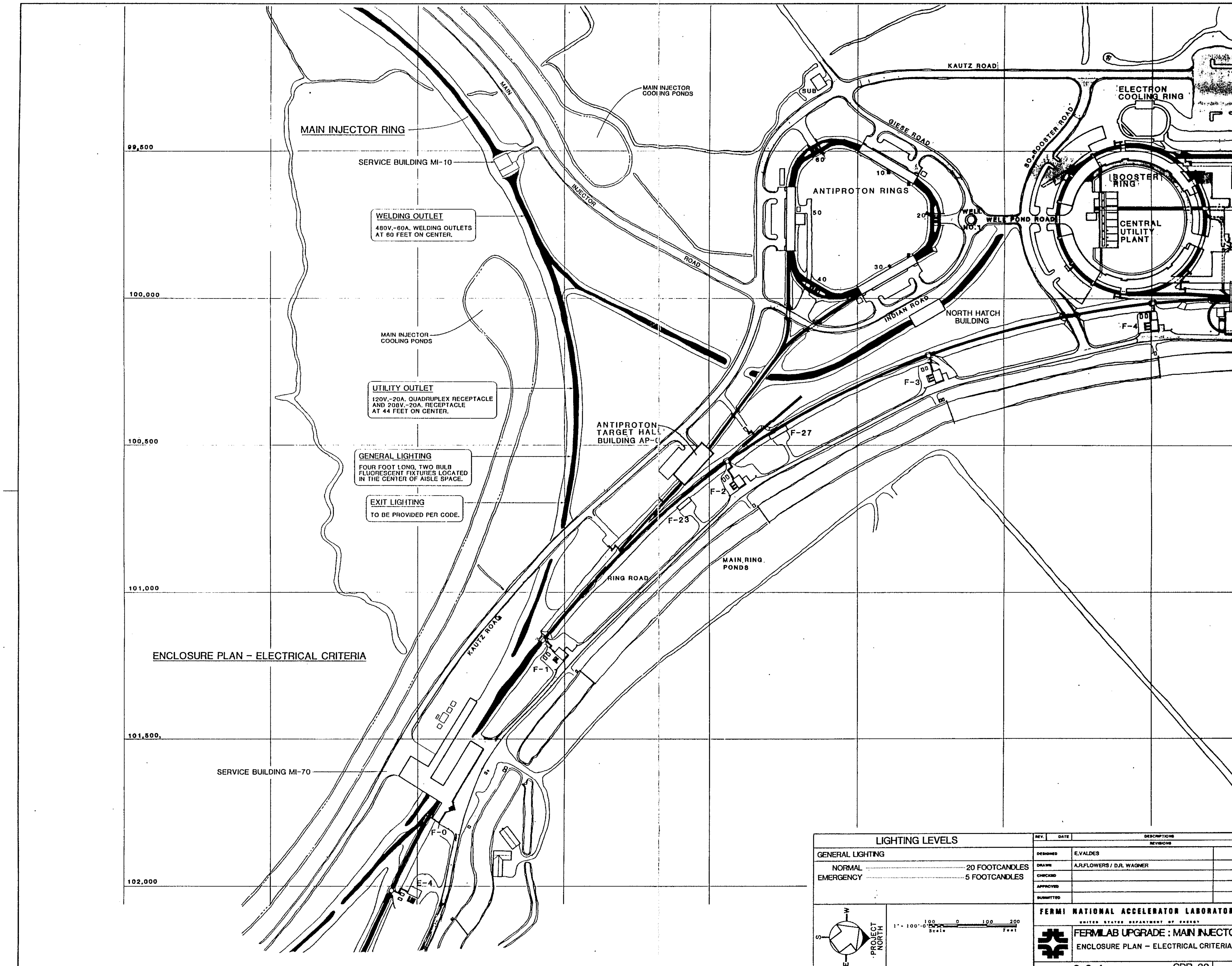
DESIGNED	E.VALDES
DRAWN	A.R.FLOWERS / D.R.WAGNER
CHECKED	
APPROVED	
SUBMITTED	

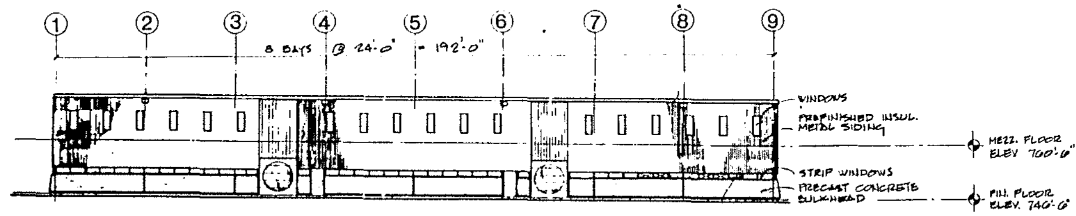
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

FERMILAB UPGRADE : MAIN INJECTOR
SITE PLAN - ELECTRICAL CRITERIA

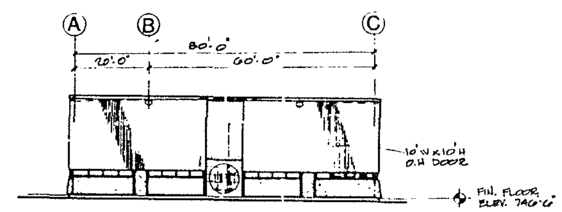
JAN. 1990

DRAWING NO. 6-6-1 CDR-31 REV.

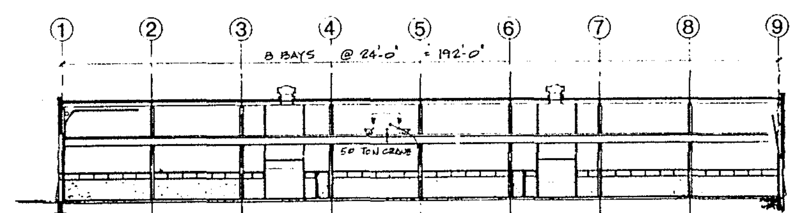

MAIN INJECTOR RING
SERVICE BUILDING MI-10
WELDING OUTLET
480V.-60A. WELDING OUTLETS AT 60 FEET ON CENTER.
MAIN INJECTOR COOLING PONDS
UTILITY OUTLET
120V.-20A. QUADRUPLEX RECEPTACLE AND 208V.-20A. RECEPTACLE AT 44 FEET ON CENTER.
GENERAL LIGHTING
FOUR FOOT LONG, TWO BULB FLUORESCENT FIXTURES LOCATED IN THE CENTER OF AISLE SPACE.
EXIT LIGHTING
TO BE PROVIDED PER CODE.
ENCLOSURE PLAN - ELECTRICAL CRITERIA
SERVICE BUILDING MI-70
99,500
100,000
100,500
101,000
101,500
102,000
MAIN INJECTOR ROAD
MAIN INJECTOR COOLING PONDS
KAUTZ ROAD
SUB
GIESE ROAD
ANTIPROTON RINGS
10
20
30
40
50
60
WELL NO. 1
WELL POND ROAD
ELECTRON COOLING RING
SO. BOOSTER ROAD
BOOSTER RING
CENTRAL UTILITY PLANT
INDIAN ROAD
NORTH HATCH BUILDING
F-4
F-3
F-27
ANTIPROTON TARGET HALL BUILDING AP-0
F-2
F-23
MAIN RING PONDS
RING ROAD
KAUTZ ROAD
F-1
F-0
E-4
LIGHTING LEVELS
GENERAL LIGHTING
NORMAL .... 20 FOOTCANDLES
EMERGENCY .... 5 FOOTCANDLES
PROJECT NORTH
N
S
E
W
1" = 100'-0"
Scale
Feet
100 0 100 200
REV. DATE DESCRIPTIONS
REVISIONS
DESIGNED E.VALDES
DRAWN A.R.FLOWERS / D.R. WAGNER
CHECKED
APPROVED
SUBMITTED
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
FERMILAB UPGRADE : MAIN INJECTOR
ENCLOSURE PLAN - ELECTRICAL CRITERIA
DRAWING NO. 6-6-1
CDR-32
REV.
JAN. 1990



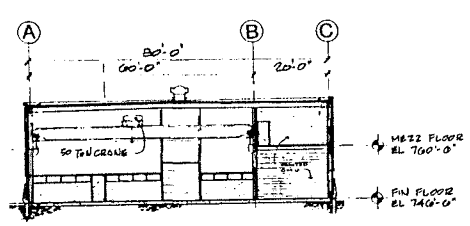
SOUTH ELEVATION
1/16" = 1'-0"



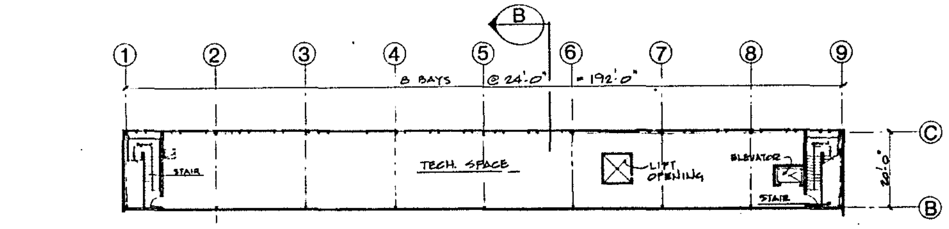
WEST ELEVATION
1/16" = 1'-0"



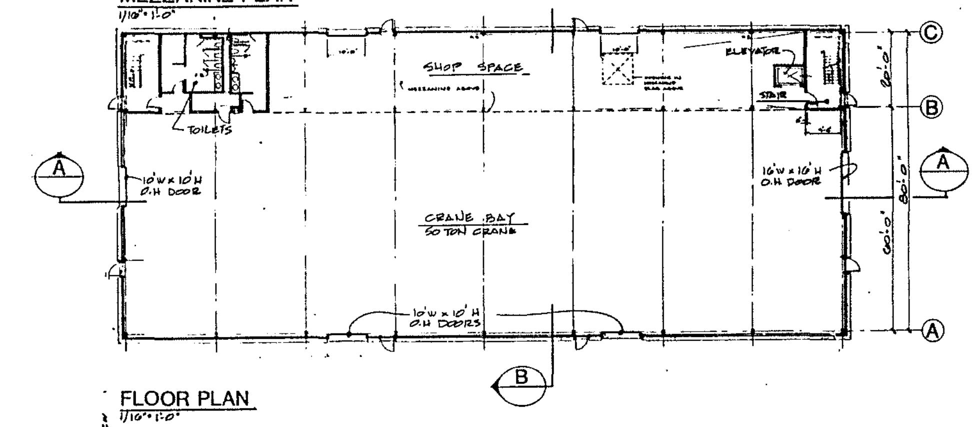
SECTION A-A
1/16" = 1'-0"



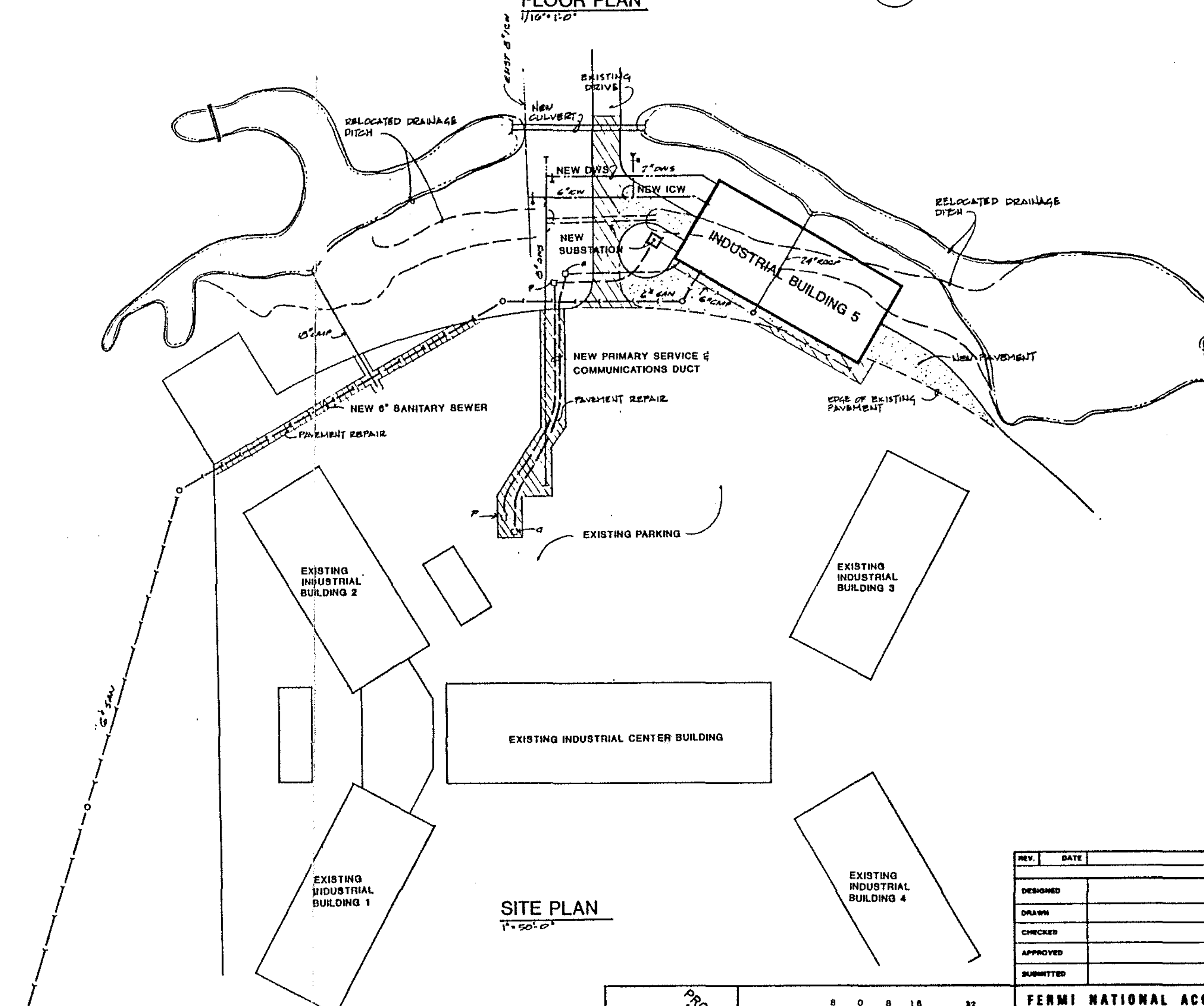
SECTION B-B
1/16" = 1'-0"



MEZZANINE PLAN
1/16" = 1'-0"



FLOOR PLAN
1/16" = 1'-0"



SITE PLAN
1" = 50'-0"

REV.	DATE	DESCRIPTIONS
		REVISIONS
DESIGNED		
DRAWN		
CHECKED		
APPROVED		
SUBMITTED		

PROJECT NORTH

1/16" = 1'-0" Scale 8 0 8 16 32 Feet

1/50" = 1'-0" Scale 50 0 50 100 Feet

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

FERMILAB UPGRADE: MAIN INJECTOR
INDUSTRIAL BUILDING NO.5

JAN. 1990

DRAWING NO. 6-6-1 CDR-33 REV.

APPENDIX F

Supplementary Project Data for Strategic Facilities

TITLE AND LOCATION OF PROJECT:

FERMILAB UPGRADE:
MAIN INJECTOR
FERMI NATIONAL ACCELERATOR LABORATORY

Project No: BAKALIA
92-CH-400
Line Item

Supplementary Project Data for Strategic Facilities

Site Wide Requirements/Assets for CATEGORY: 70, Research and Development

Other Projects Affecting this Category: None

Unit of Measure: Square Foot

	CURRENT	THIS PROJECT	RESULT
A. Total Existing Assets (in this category)	222,400	49,600	272,000
	-	-	-
B. less: Substandard assets (in this category)	0	0	0
	=	=	=
C. Amount Adequate: (in this category)	222,400	49,600	272,000
	-		-
D. less: Amount Required: (in this category)	285,000	XXXXXX	285,000
	=	+	=
E. Excess/(Deficiency) of Adequate Assets	(62,600)	49,600	(13,000)
			=
F. Excess/(Deficiency) of Total Assets (A-D)	(62,600)	49,600	(13,000)