A STUDY OF THE ISP FOOTPRINT

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In early 1987 a concentrated effort was undertaken to determine the SSC land requirements. A series of lattice calculations were done in order to prepare a "template" that could serve as a representation of the calculated lattice. The resulting template was then turned into a "footprint" to determine the spatial and land requirements. This information was used by DOE as they developed the *Invitation for Site Proposals* (ISP), issued in April 1987.

In support of these determinations, simplified lattice calculations were done by S. Peggs. A 90-degree lattice was used wherein an allowance was made for a possible beam by-passing the Far Cluster by including the required transition regions. The reference for the lattice calculations is an informal memorandum from S. Peggs dated January 22, 1987. The magnetic field assumptions made by Peggs were:

Dipole Field	6.586 T
Quadrupole Field	212 T/m

G. Drouet cast the lattice into a simplified representation (see SSC-N-495) by "fitting" the lattice with a minimum set of parameters, namely two radii (R and R'), two turning points (a and b) and the assumption that the tangents join smoothly at the points of intersection (PI). As seen in Figure 1, these parameters and conditions produce an "oval ring" that approximates the calculated lattice. The parameters behind the ISP representation are:

R = 11694 m or 38367 ft

R' = 27771 m or 91112 ft

a = 3037 m or 9964 ft from center

b = 15788 m or 51797 ft from center

The "oval" diagram is constructed by drawing the circular segments from the respective turning points. The segments are joined together at the four PI's — where the radii overlie each other.

For cryogenic purposes, the magnets in the upper (or lower) arc are formed into 4 sectors. A typical sector contains 36 cells of magnets, consisting of 12 dipoles, 2 quadrupoles, and 2 spool pieces. Figure 2 illustrates the arrangements of magnets in a progressive manner. Due to practical considerations the sector is further subdivided into sections. At this level one can note the location of instrumentation modules, electrical power transformers, and cryogenic disconnects.

The lattice representation is shown in somewhat more detail in Figure 3. The main elements consist of arcs, modules, and transition segments. For the ISP, the length of the segments are:

Arc Length		31965 m or 104872 ft
Module Length		2291.4 m or 7518 ft
Transition	T1 Length	802.0 m or 2631 ft
	T2 Length	916.6 m or 3007 ft

When all the segments are assembled together, a circumference of 85698 m, or 281162 ft, is determined. This leads to the approximate value of 53 miles used in the ISP for the collider circumference.

In preparing for the ISP template the transition segments are combined with the modules to form a cluster on each side of the oval. Each cluster is made up of four modules, with transitions of two types labelled T1 and T2. The details of the clusters are shown in Figures. 4 and 5. It is also convenient to change to the nomenclature of the layout to that used in the ISP. Note these changes in Figure 6.

The next task was to go from a line template into a footprint with extent. This develops from considering potential radiation conditions generated during operations and/or during upset conditions. Such considerations determine the widths, lengths, and depths of land needed around the collider tunnel and provide the acreage requirements for the SSC facilities. These

parameters determine the dimensions of the footprint drawing used in the ISP and reproduced here as Figure 7.

The "footprint" as used in the ISP is a complicated and somewhat cluttered diagram. The dimensions used are derived from the parameters described earlier supplemented by radiation protection considerations. The manner in which these considerations are folded together is expressed in this paper along with other dimensioning arguments.

First of all, it should be noted that a rectilinear coordinate system has been adopted with major and minor axes meeting at right angles in the center of the diagram. The units used are feet and the center is defined as x = 100,000 ft and y = 100,000 ft in order to avoid negative numbers for the coordinates of features around the footprint. Note that the previously defined a turning points lie along the x = +100,000 vertical axis at y = +90,036 and y = +109,964 ft. The corresponding b turning points are along the y = +100,000 horizontal axis at x = +48,203 ft and x = +151,797 ft.

For the ISP diagram in Figure 7, the radii used from the above turning points are based upon the ones used in the "simplified template" described earlier. However, there are now two radii for each turning point, one used to define an inner boundary and the other for an outer boundary of the land. The width of land so defined is 1000 ft in the arcs and provides adequate space for the collider tunnel, a surrounding restricted zone, and some allowance for flexibility in final positioning of the ring. In order to provide protection in the case of an accidental loss of beam, more shielding is needed towards the outside of the ring. Within the 1000-ft width the inner boundary of the land was assumed in the ISP to be 150 ft from the tunnel centerline. Consequently, the arc radii are:

$$R \text{ (inner)} = 38367 - 150 \text{ ft} = 38217 \text{ ft}$$

$$R \text{ (outer)} = 38367 + 850 \text{ ft} = 39217 \text{ ft}$$

In the near cluster the required land width is 1300 ft which leads to radii as follows:

$$R'\text{ (inner)} = 91112 - 150\text{ ft} = 90962\text{ ft}$$

$$R'\text{ (outer)} = 91112 + 1150\text{ ft} = 92262\text{ ft}$$

The far cluster is somewhat more complicated. In addition to the 1300 ft width, an allowance (at the x axis) of 625 ft is provided in the land requirements for the possibility of an adjacent tunnel for the proton beams to by-pass the experimental areas. This allowance flattens out the curvature of the inner boundary and leads to the need for a third turning point and radius:

c turning point at $x = 27{,}375$, $y = 100{,}000$

R' (inner for bypass) = 111,165 ft

R' (outer) = 92,262 ft

Note that a procedure similar to that described earlier is used in drawing the "thick ovals" and the points of intersection, marked "PI" on the drawing; these are the matching points for R (inner) and R' (inner). The overall length of land in the far cluster is determined in order to provide an adequate distance for the attenuation of muons arising from the interaction regions. In the near cluster the lengths are derived from calculations on muon attenuation from the beam absorbers. Because of the different physical processes involved, the near cluster is longer than the far cluster. The different lengths for the arcs are also shown by the distances along the arcs as noted in the values indicated from the apex of the drawing. Note that the outer radii are not matched at separate interaction points, but are simply the inner radii plus a constant distance in each case.

The azimuthal positions of the service areas (marked "F" on the drawing) were determined at the below-ground location of the center of each sector. As described in the CDR, this allows for the electrical and cryogenic connections to be routed from the service building to the collider tunnel at the point of attachment which is assumed to be at the mid-point of the sector. Measured along the collider ring alignment the circumferential distance from the apex

of the oval to the attachment point is 13533 ft. When measured along the inner boundary of the arc, the distance from the apex to the center of the service area is 13480 ft. This is the value shown on the ISP drawing.

This pattern is followed for the four areas on the upper arc and the four areas on the lower arc. The remaining two service areas are shown on the y axis of the oval in the middle of the respective clusters. Coordinate values have been calculated for the location of the service areas and exits as measured along the nominal lattice. The x,y values above the lattice at the service areas and intermediate exits are displayed in Table 1.

Provided that the tunnel centerline is 50 ft or more below the surface of the ground, the land for the tunnel arcs can be acquired in stratified fee estate. This means that, except at the service areas (F) or exits (E), current surface land usage and ownership can continue. For the cluster areas, the surface land is to be acquired in fee simple. This will permit the development of the central laboratory, support buildings, injector complex and experimental areas. A table of the required acreage for the ISP example is shown in Table 2 and the land represented in Figure 8.

Table 1. ISP land areas: coordinates of points on lattice.

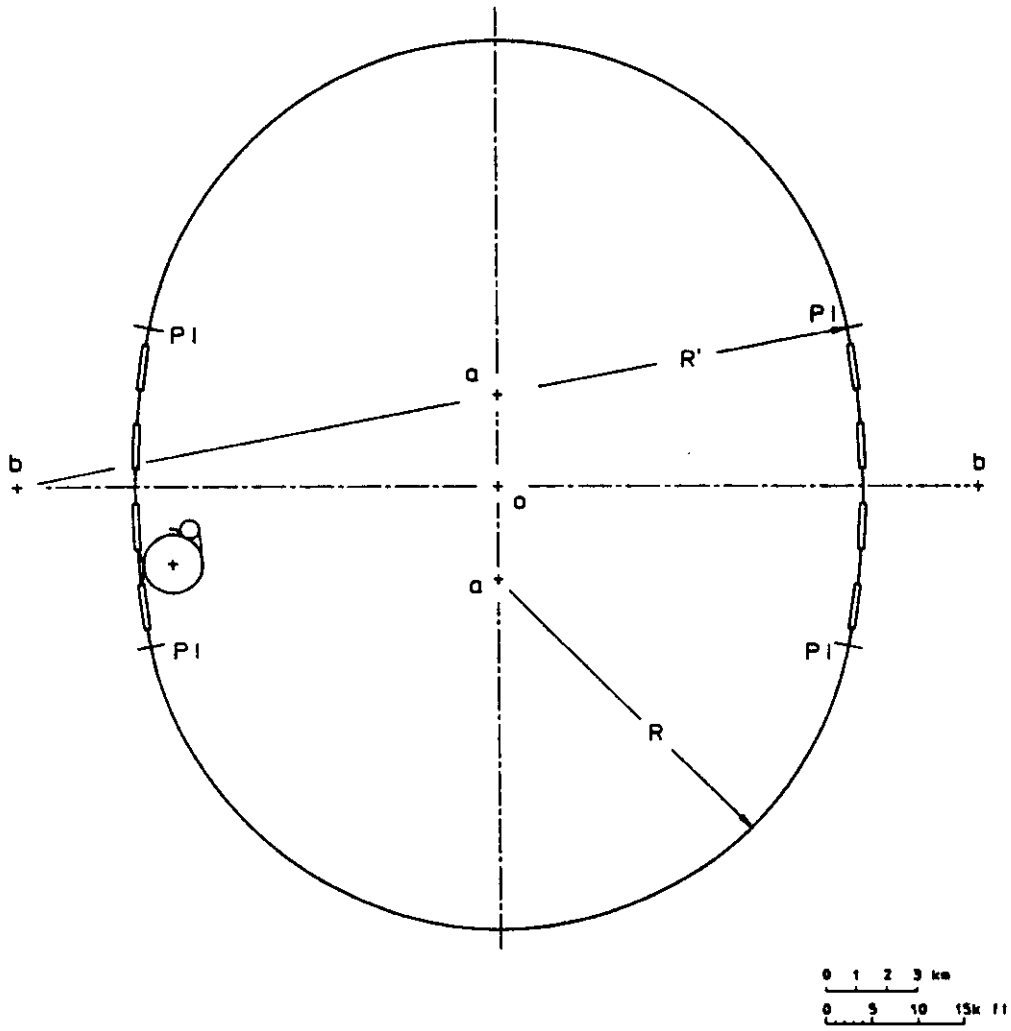
(x = 100.000′, y = 100.000′ at center of ISP ellipse.

ISP Designation	CDG Designation	x	y
Upper Arc			
E1	Exit NC/A	62122	116073
F1	Service Area A	66565	128782
E2	Exit A/B	75124	139174
F2	Service Area B	86746	145969
E3	Exit B/C	100000	148331
F3	Service Area C	113254	145969
E4	Exit C/D	124876	139174
F4	Service Area D	133435	128782
E5	Exit D/FC	137878	116073
Lower Arc			
E6	Exit FC/E	137878	83927
F6	Service Area E	133435	71218
E7	Exit E/F	124876	60826
F7	Service Area F	113254	54031
E8	Exit F/G	100000	51669
F8	Service Area G	86746	54031
E9	Exit G/H	75124	60826
F9	Service Area H	66565	71218
E10	Exit H/NC	62122	83927
Near Cluster			
F10	Service Area NC	60685	100000
K1	IR S	60763	103760
K2	IR T	61382	111250
Far Cluster			
F5	Service Area FC	139315	100000
K3	IR W	138618	111250
K4	IR X	139237	103760
K5	IR Y	139237	96240
K6	IR Z	138618	88750
External Area			
J1		61035	136250
J2		61035	123750
J3		61035	76250
J4		61035	63750
J5		61035	111250
J6		61035	88750

Table 2. SSC land requirements (Figures 7 and 8)

Area	Letter Designation	No. of Locations	Width (ft)	Length (ft)	Area per Location (acres)	Total area Locations (acres rounded)
CAMPUS	A	1	2,100	7,200	--	350
INJECTOR	B	1	7,200	10,300	--	1,700
FUTURE EXPANSION	C	1	7,200	8,800	--	1,450
COLLIDER ARCS						
Upper & Lower	D	2	1,000	83,520	1,895	3,790
Intermediate Access	E	6	200	200	0.9	6[b]
Service Areas	F	6	500	500	5.7	34[b]
CLUSTERS						
Near Cluster	G	1	1,300	68,250	--	2,010
Far Cluster	H	1	1,300	51,870	--	1,540
Far Cluster Bypass	H	1	0-625	42,880	--	440
BUFFER AREA AND BURIED BEAM ZONE	I	2	0-10,100	38,680	2,268	4,550
BURIED BEAM ZONE ACCESS AREA	J	6[c]	1,320	1,320	40	240[d]
INTERACTION	K	6[e]				
BEAM ABSORBERS	L	2[f]				
TOTAL						15,830

[a] A stratified fee estate for these areas may be sufficient (see section B3 of the ISP).
[b] Acreage included in Area D.
[c] Unconditional fee simple title is required for Area J1 through J4.
[d] Acreage included in Areas G and I.
[e] Included within Areas G and H.
[f] Included within Area G.



SIMPLIFIED RING TEMPLATE

90° OPTION #4
90(4)

ARC RADIUS, R ..... 11.694 km = 38366 ft
ARC CENTER SEPARATION, oo ..... 3.037 km = 9964 ft

CLUSTER RADIUS, R' ..... 27.771 km = 91112 ft
CLUSTER CENTER SEPARATION, ob ....15.788 km = 51797 ft

SSC CENTRAL DESIGN GROUP
SSC COLLIDER RING TEMPLATE
90° OPTION #4 90(4)
84A302

XBL 884-1305

Figure 1. Simplified ring template.

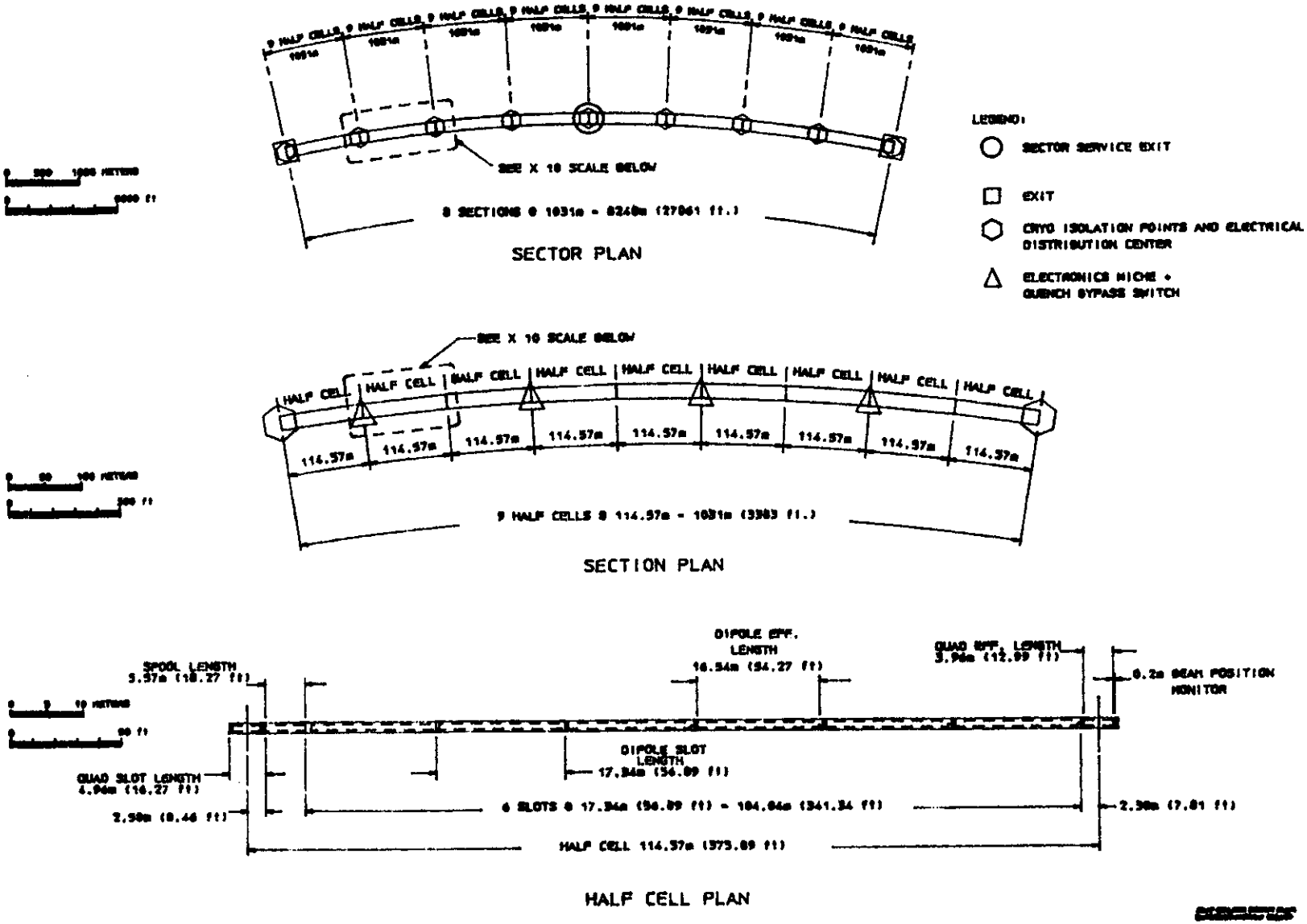
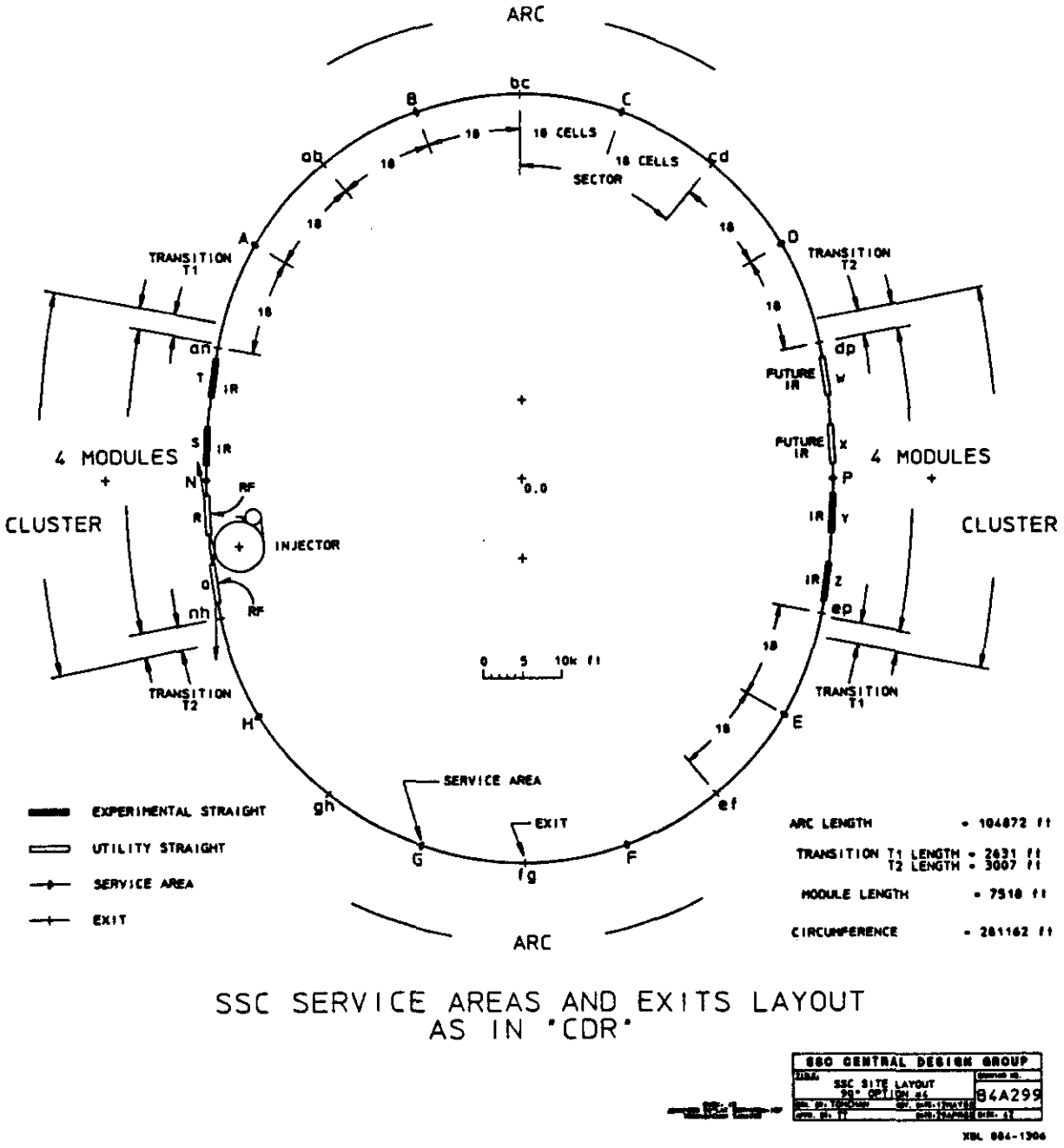


Figure 2. Plans of cells, sections and sectors.



SSC SERVICE AREAS AND EXITS LAYOUT
AS IN "CDR"

Figure 3. Lattice representation: modules, sectors, transitions, clusters and arcs.

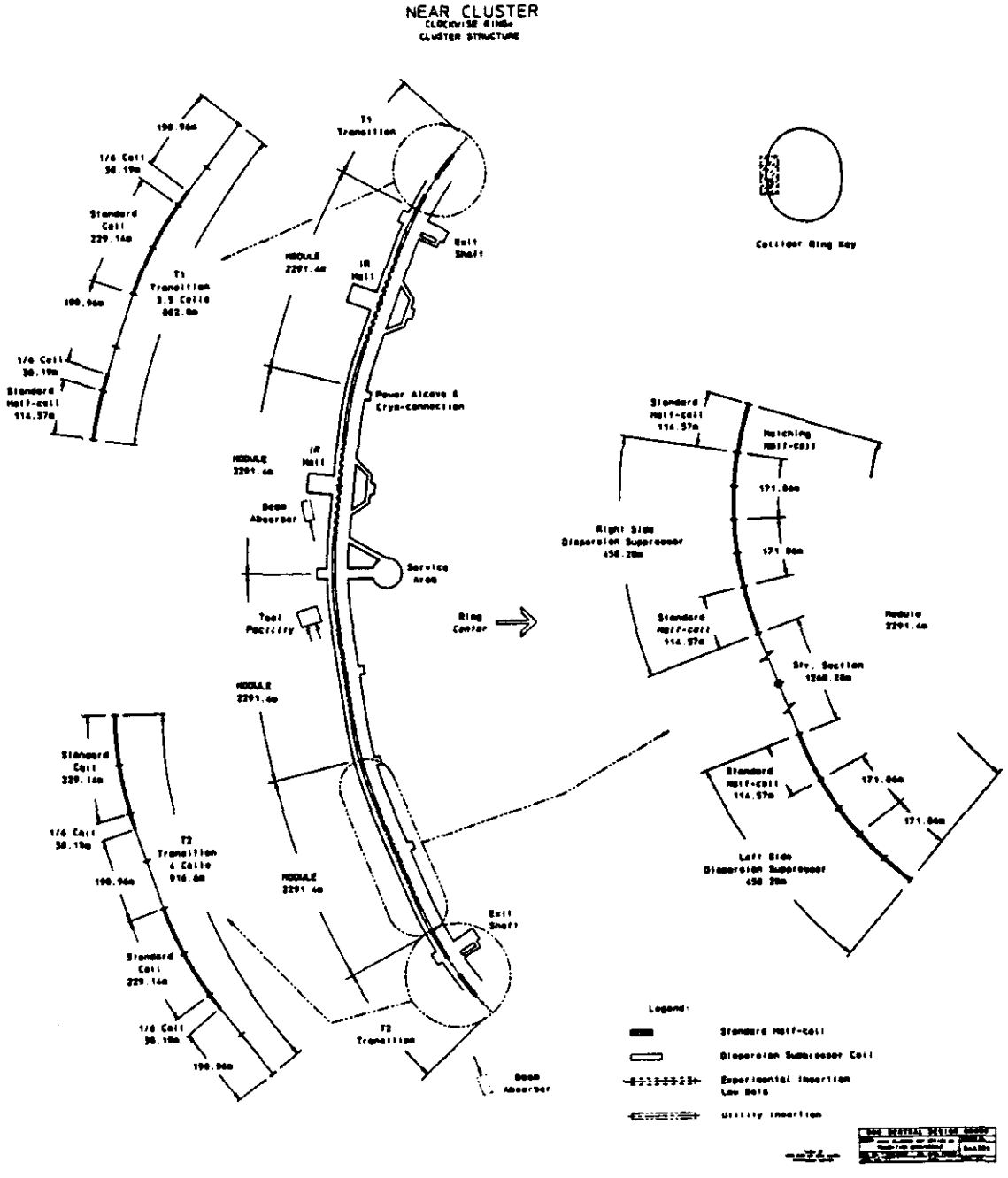


Figure 4. Near cluster details.

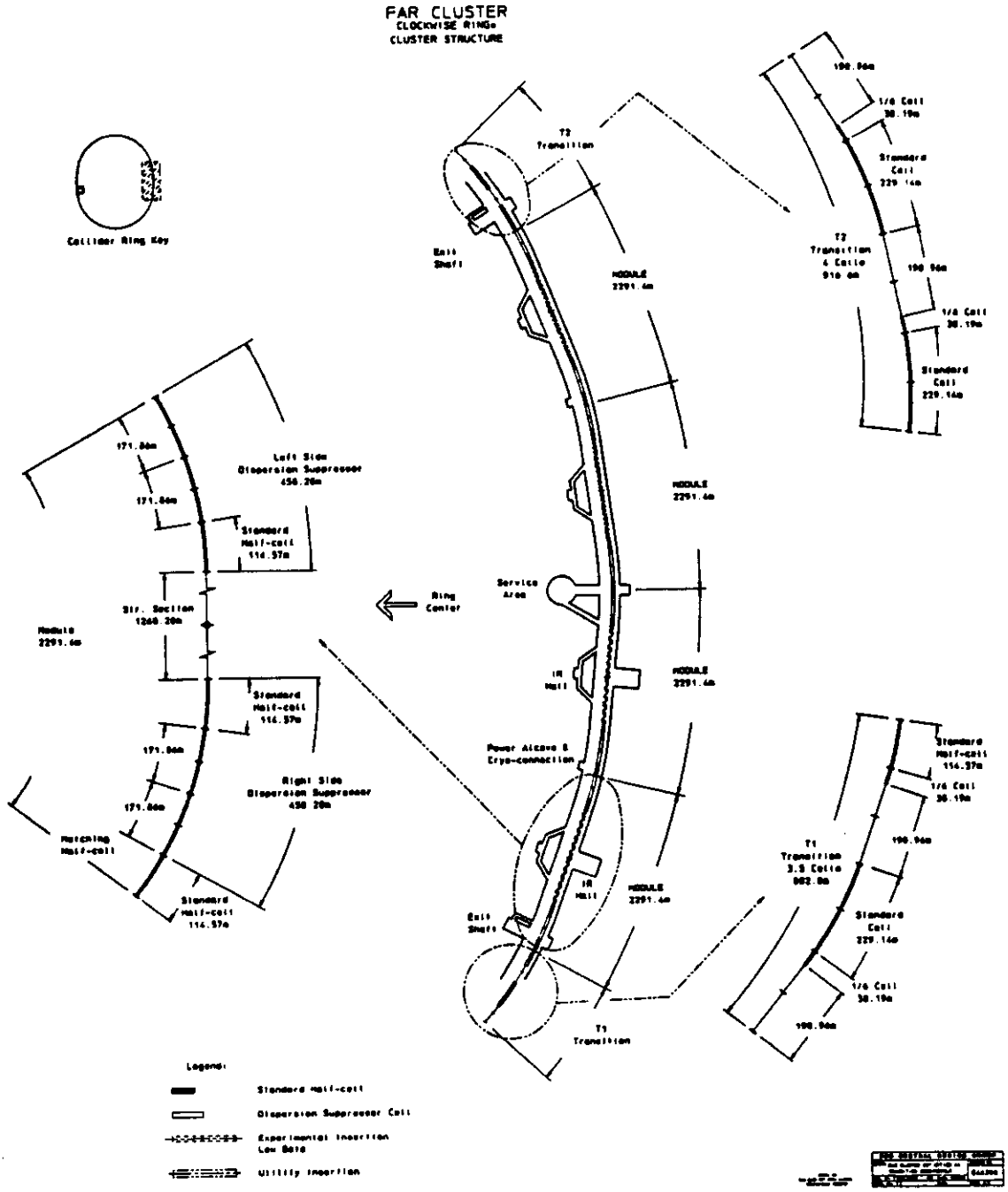
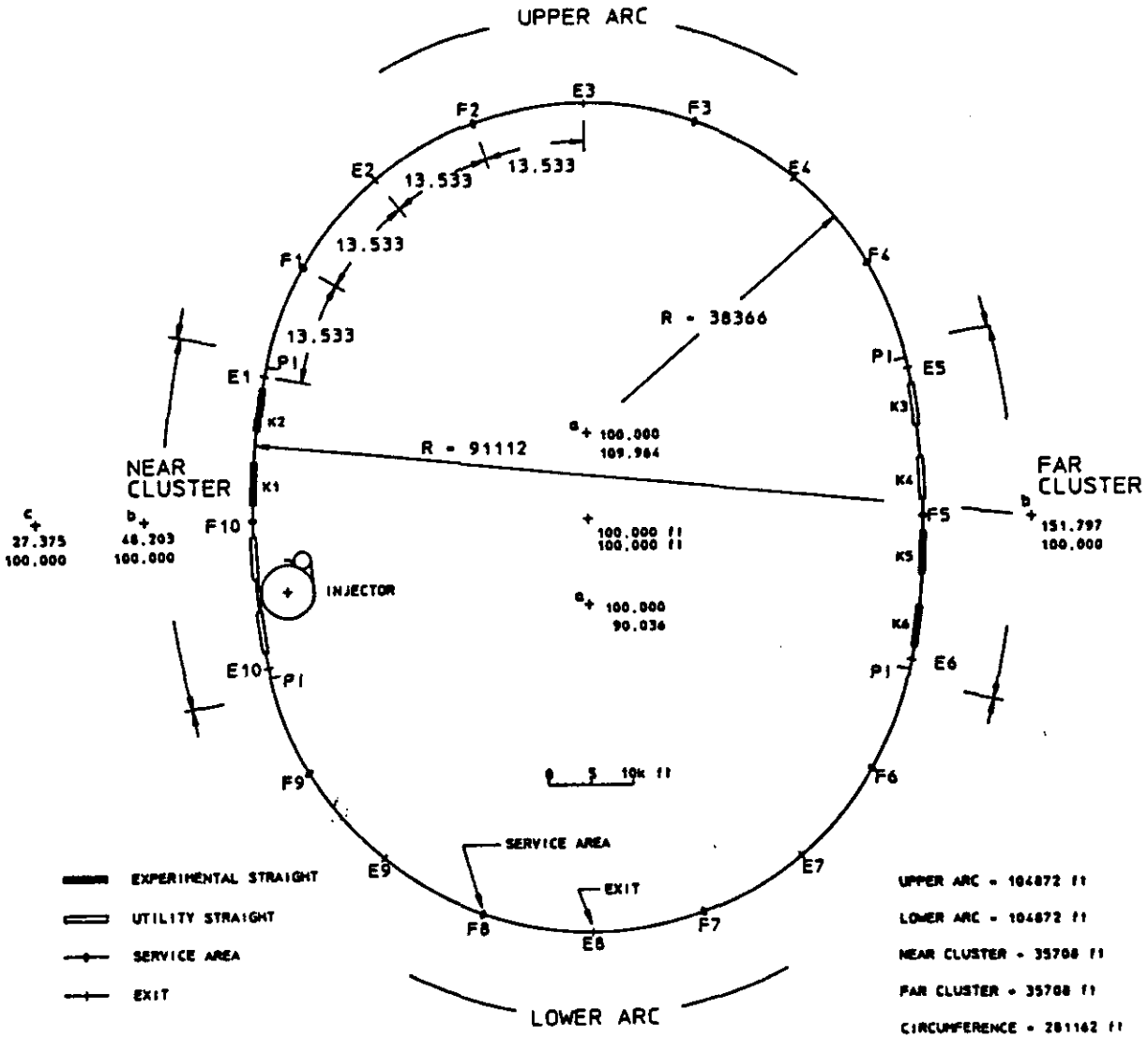


Figure 5. Far cluster details.



SSC PRE-ISP LAYOUT

Figure 6. SSC pre-ISP layout.

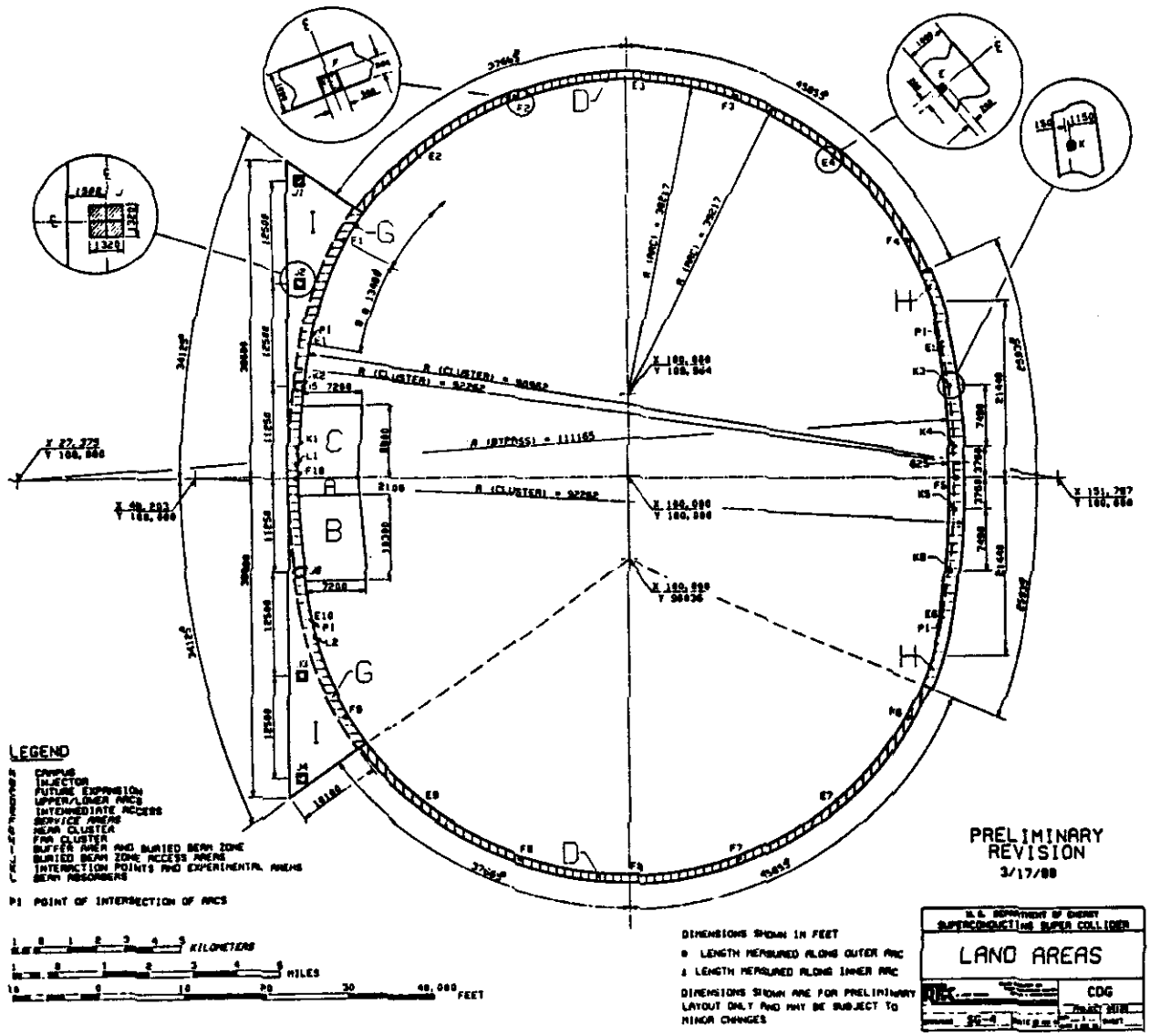
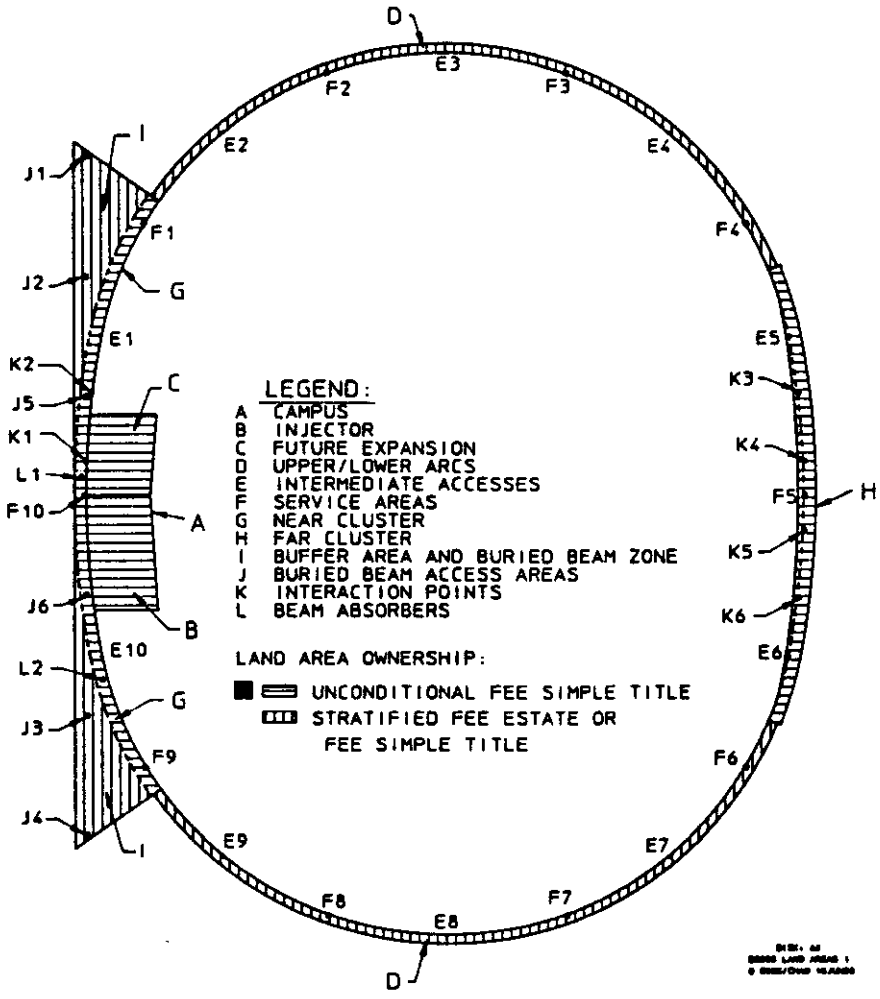


Figure 7. Land areas "footprint."



LAND REQUIRED FOR THE SSC

Figure 8. Land areas ownership.